Interpersonal Risk for Suicidal Ideation using Multi-Level Models

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***Abstract*—Suicide is a major public health concern, with devastating consequences for individuals, families, and communities. This study examines the association of social, cultural, and psychological factors with thwarted belongingness and perceived burdensomeness, along with other interpersonal risk factors for suicide, among young adults from Turkey, the US and Korea. A cross-sectional online survey was conducted with young adults (mean age 26.28 years old). Measures assessed cultural orientation, socioeconomic status, social connectedness, depressive symptoms, perceived burdensomeness, and thwarted belongingness. Finding and highlighting the importance of individual-level factors and cultural orientations in understanding suicide risk is crucial for developing effective prevention strategies. Interventions targeting perceptions of belongingness, belief in supporting others, and valuing uniqueness while considering cultural context could be promising avenues for suicide prevention. Future research should replicate these findings in diverse populations and contexts. Understanding the intricate interplay between individual-level factors and cultural orientations is paramount in devising effective suicide prevention strategies. By recognizing the unique socio-cultural contexts in which suicidal ideation manifests, interventions can be tailored to address the specific needs and challenges faced by diverse populations.**

***Index Terms*—multi-level models; suicidal ideation; thwarted belongingness; perceived burdensomeness**

I. Introduction

Suicide and depression represent pressing public health challenges with profound implications for individuals and society. The pervasive nature of suicidal ideation underscores the critical need for in-depth research to interpret its determinants and inform effective prevention strategies. Likewise, the crippling impact of depression on mental well-being underscores the urgency of addressing these interconnected issues comprehensively. Understanding the complex interplay of psychological, social, and cultural factors underlying suicidal ideation is essential for developing targeted interventions and mitigating the adverse outcomes associated with these conditions.

Despite considerable research efforts, gaps persist in our understanding of the multifaceted nature of suicidal ideation and its associated risk factors. Previous studies have explored various aspects of this phenomenon; however, a comprehensive understanding of the specific mechanisms underlying thwarted belongingness and perceived burdensomeness remains difficult to track down. This study seeks to address this gap by examining the intersectionality of individual-level factors, cultural orientations, and psychosocial constructs in shaping suicidal ideation among young adults. By focusing on this understudied population and leveraging the framework of the interpersonal theory of suicide, we aim to provide novel insights into suicide risk assessment and prevention.

Guided by the interpersonal theory of suicide framework [1], our study adopts a multidimensional approach to explore the underlying mechanisms driving suicidal ideation among young adults. We investigate the relationships between individual-level factors such as cultural orientation, socioeconomic status, and perceived social connectedness and key psychological constructs of thwarted belongingness and perceived burdensomeness. Additionally, we examine the association between these factors and depressive symptoms, a well-established risk factor for suicide, to gain a comprehensive understanding of suicide risk among this population.

Through a rigorous analysis of survey data collected from 322 young adults, we uncover nuanced insights into the complex interplay of social, cultural, and psychological factors contributing to suicidal ideation. Our findings highlight the significance of individual-level factors and cultural orientations in shaping perceptions of belongingness and burdensomeness, shedding light on the pathways leading to suicidal ideation among this vulnerable population. Furthermore, we identify potential intervention targets and strategies to mitigate suicidal ideation, paving the way for culturally sensitive and socially informed prevention efforts.

This study contributes to the existing literature by offering novel insights into suicide risk assessment and prevention among young adults. By elucidating the specific mechanisms underlying suicidal ideation and identifying potential intervention targets, our findings inform the development of tailored prevention strategies to address the unique needs of this population. Additionally, our study underscores the importance of considering cultural context and individual-level factors in suicide prevention2 efforts, highlighting the need for further research in diverse populations and contexts.

The remainder of this paper is organized as follows: Section II provides a review of relevant literature and related work. Section III outlines the methodology employed in this study.

Section IV presents the results and findings, followed by a discussion and interpretation in Section V. Finally, Section VI concludes the paper with implications for practice and future research directions.

SYSTEM FLOW DIAGRAM

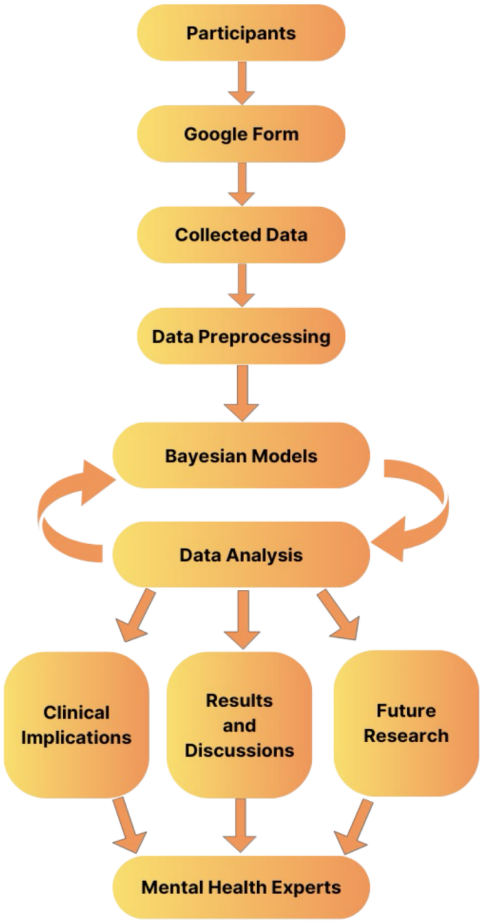

Fig. 1. Solution Sketch

II. LITERATURE REVIEW AND RELATED WORK

A. Introduction to Adolescent Self-Harm and Suicidality Interventions

Adolescent self-harm and suicidality present significant challenges in public health and clinical settings, with rates of self-harm and suicidal behavior among adolescents on the rise globally. Addressing this issue requires effective interventions tailored to the unique needs of this population. A meta-analysis examining interventions targeting adolescent self-harm and suicidality revealed mixed findings on their effectiveness [2]. While some interventions showed promise in reducing suicidal ideation, the impact varied across different settings, with school-based or ER-based interventions demonstrating more significant effects compared to clinic-based interventions. However, methodological limitations, including small sample sizes and gender bias, were noted, highlighting the need for greater diagnostic specificity in sample selection.

B. Understanding the Impact of Exposure to Suicide Events:

Exposure to suicide events has been shown to have a profound impact on subsequent suicidal behavior. A Multilevel Meta-Analysis investigated this relationship by analyzing data from numerous studies [3]. The findings underscored the increased odds of suicidal behavior following exposure to suicide-related events. However, distinct patterns emerged for different outcomes related to suicidal behavior. These findings have important implications for suicide prevention efforts, emphasizing the need for public health policies and research to differentiate between exposure to suicide and suicide attempt.

C. Role of Relationship Quality in Suicidal Ideation and Attempts among Youth with Bipolar Disorder:

The quality of relationships with parents and friends plays a crucial role in the suicidal ideation and attempts among youth with bipolar disorder (BD). A longitudinal study investigated this association, analyzing data from a cohort of participants [4]. The findings revealed that poorer overall relationship quality with parents and friends constitutes a distal risk factor for suicidal ideation. Moreover, recent declines in relationship quality with parents may serve as a proximal indicator of increased suicidal ideation risk. These findings highlight the importance of considering interpersonal factors in suicide risk assessment and mitigation for youth with BD.

D. Utility of Multilevel Models in Counseling Psychology Research:

Multilevel models have emerged as valuable tools in counseling psychology research for analyzing nested data structures and addressing complex phenomena. A paper exploring the application of Multilevel Models (MLMs) in various domains discusses its utility in enhancing statistical analysis and theory development [5]. By providing a framework to account for multiple levels of influence, such as therapist-client interactions and group dynamics, MLMs can improve the understanding of complex phenomena and facilitate the examination of within-person processes through repeated measures designs.

E. Application of Multilevel Models in Health Economics Research:

In health economics research, multilevel models offer versatile approaches for analyzing hierarchical data structures and capturing variation across different levels. A paper discussing the application of multilevel models in health economics research explores their utility in studying medical practice variations and resource allocation inequalities [6]. By offering insights into individual and contextual effects, multilevel models provide valuable tools for informing healthcare policies and interventions.

F. Advanced Techniques in Multilevel Modeling for Longitudinal and Clustered Data:

Advanced techniques in multilevel modeling provide researchers with powerful tools for analyzing continuous outcomes in longitudinal and clustered data settings. A research paper provides a comprehensive overview of these techniques, including extensions to traditional two-level models and incorporation of individual characteristics and time-varying covariates [7]. By highlighting the flexibility and applicability of multilevel models in capturing complex data structures, this paper serves as a valuable resource for researchers seeking to employ multilevel modeling techniques in diverse research contexts.

III. Methodology

A. Data Collection

The data utilized in this study was obtained through a cross-sectional online survey conducted with young adults from Turkey, the US, and Korea. The survey aimed to assess various social, cultural, and psychological factors associated with suicidal ideation. Participants demographic information, including age, birth sex, marital status, number of siblings, number of children, suicide lifetime experiences, amongst many other variables were collected.

B. Data Preprocessing

Upon data acquisition, the dataset underwent preprocessing steps to ensure its suitability for subsequent analysis. The first step involved importing the dataset into R, where attention was directed towards enhancing its interpretability and consistency. This was achieved by standardizing the column names to adhere to a uniform naming convention, facilitating ease of reference and interpretation throughout the analysis process.

Comprehensive data cleaning procedures were then implemented to address potential anomalies, inconsistencies, or missing values within the dataset. An initial exploratory data analysis (EDA) was conducted to identify any outliers, unusual patterns, or data quality issues that could affect the validity of the analysis results. Outliers, if detected, were carefully evaluated to determine whether they were genuine data points or erroneous entries.

In cases where outliers were deemed to be valid observations, they were retained in the dataset to preserve the integrity of the data. However, if outliers were found to be the result of data entry errors or measurement inaccuracies, they were either corrected or removed from the dataset, depending on the context and impact on the analysis.

Missing values, another common issue in real-world datasets, were addressed through appropriate imputation techniques. Depending on the nature and extent of missingness, missing values were either replaced with plausible estimates derived from other data points (e.g., mean imputation, median imputation) or handled using more sophisticated imputation methods such as multiple imputation or predictive modeling.

Normalization techniques were also applied judiciously to ensure that the data were scaled and distributed appropriately for the chosen statistical analysis methods. Normalization is particularly important when dealing with variables that have different scales or units of measurement, as it helps to mitigate the impact of scale differences on the analysis results and improve the stability and convergence of the statistical models.

This phase played a crucial role in optimizing the quality and reliability of the dataset for subsequent analysis. By systematically addressing data quality issues, standardizing variable names, and applying appropriate cleaning and normalization techniques, we were able to ensure that the dataset was well-suited for the statistical modeling and analysis tasks that followed.

C. Statistical Modeling

Five Bayesian models were constructed to investigate the association between predictor variables and suicidal ideation. Each model was designed to capture different aspects of the relationship between various demographic, socio-economic, and psychological factors and the likelihood of experiencing suicidal ideation.

The Bayesian models were fitted using the brms package in R, which provides a flexible framework for specifying and estimating Bayesian regression models. The choice of a cumulative probit link function was motivated by its suitability for modeling binary outcome variables, such as suicidal ideation, where the response is either present or absent. This approach allowed us to account for the inherent uncertainty in the outcome variable and estimate the probability of experiencing suicidal ideation based on the predictor variables.

Prior distributions for model parameters were carefully specified using informative priors based on previous research findings and theoretical considerations. By incorporating prior knowledge about the relationships between predictor variables and suicidal ideation, we were able to constrain the parameter estimates within plausible ranges and improve the stability and interpretability of the model results.

To assess the performance of the Bayesian models, several evaluation metrics were employed. These included measures of model fit, such as the widely applicable information criterion (WAIC) and the leave-one-out cross-validation (LOO) information criterion, which provide insights into the relative performance of competing models in terms of their predictive accuracy and complexity. Additionally, posterior predictive checks were conducted to assess the adequacy of the models in capturing the observed data patterns and identifying potential areas of model misspecification.

Overall, the Bayesian modeling approach allowed us to gain valuable insights into the complex interplay between predictor variables and suicidal ideation, enabling us to identify key risk factors and inform targeted intervention strategies for suicide prevention. The tables below summarize the population-level effects estimated by the Bayesian models, providing a detailed overview of the relationships between predictor variables and suicidal ideation in our study population.

D. Model Evaluation

Model 1

This model explored the effects of individual-level factors (e.g., birth sex, age, marital status, number of siblings, number of children) on suicidal ideation, with country-level random effects. This is a baseline model that considers the main effects of individual predictors without any interaction terms. The predictors included in this model are birth sex, age, marital status, number of siblings, and number of children.

The logistic regression model with a Bernoulli distribution is utilized to predict the probability of lifetime suicide attempts. The model incorporates a random intercept for country-level variation.

The performance is evaluated using several metrics, some of which are listed here:

- **Log Likelihood:** The log-likelihood measures the goodness-of-fit of the model to the observed data. Higher values indicate better fit.
- **Bayesian Information Criterion (BIC):** BIC penalizes model complexity to prevent overfitting. Lower BIC values indicate better model fit.
- **Leave-One-Out Cross-Validation (LOO):** LOO provides an estimate of predictive accuracy by evaluating the model's ability to generalize to new data.
- **WAIC (Watanabe-Akaike Information Criterion):** Similar to LOO, WAIC is another measure of out-of-sample predictive accuracy.

The coefficients of the predictors are interpreted as the log-odds of the outcome variable (suicide lifetime attempts). For example, a positive coefficient for a predictor indicates that an increase in that predictor's value is associated with higher odds of lifetime suicide attempts.

Model 2

This model investigated interactions between birth sex and demographic variables (e.g., age, marital status) on suicidal ideation, with country-level random effects. This model extends Model 1 by including interaction terms between birth sex and demographic factors, such as age and marital status.

Similar to the previous model, Model 2 utilizes logistic regression with a Bernoulli distribution and incorporates a random intercept for country-level variation. However, it introduces interaction terms to capture potential non-linear relationships between predictors.

TABLE I
MODEL 1: GROUP-LEVEL EFFECTS FOR FORMULA $suicide\_lifetime \sim gender + age + marital + num\_siblings + num\_children + (1|country)$

Parameter	Estimate	Est. Error	Lower CI	Upper CI	Rhat
sd(Intercept)	0.71	0.44	0.20	1.86	1.00
Intercept	0.63	0.60	-0.52	1.83	1.00
gender	0.06	0.16	-0.27	0.37	1.00
age	-0.03	0.01	-0.06	-0.01	1.00
marital_status	0.11	0.09	-0.07	0.30	1.00
num_siblings	0.15	0.06	0.04	0.26	1.00
num_children	-0.05	0.09	-0.22	0.12	1.00

The evaluation metrics for Model 2 are identical to those used for the previous model, including log likelihood, BIC, LOO, and WAIC. In addition to interpreting the main effects of predictors, Model 2 allows for the interpretation of interaction effects. Interaction terms reveal how the relationship between birth sex and other predictors varies depending on the levels of those predictors.

TABLE II
MODEL 2: GROUP-LEVEL EFFECTS FOR FORMULA $suicide\_lifetime \sim gender * (age + marital) + (1|country)$

Parameter	Estimate	Est. Error	Lower CI	Upper CI	Rhat
sd(Intercept)	0.76	0.45	0.23	2.01	1.00
Intercept	-0.19	0.86	-1.91	1.49	1.00
gender	0.70	0.42	-0.12	1.52	1.00
age	-0.00	0.03	-0.06	0.06	1.00
marital	0.34	0.29	-0.23	0.94	1.00
gender:age	-0.02	0.02	-0.05	0.01	1.00
gender:marital	-0.13	0.16	-0.45	0.18	1.00

Model 3

This model examined country-level random effects on suicidal ideation, without incorporating individual-level predictors. The model simplifies the previous models by considering only the intercept and random effects for country-level variation. This model is a hierarchical logistic regression model that includes a random intercept for each country. It does not include any fixed effects or interaction terms.

The evaluation of this model focuses on assessing the variability of random effects across countries and comparing the model fit to that of the previous models using LOO and WAIC. The main interpretation of this model revolves around understanding the extent of country-level variation in the probability of lifetime suicide attempts.

Model 4

This model expanded Model 1 by including additional demographic variables (e.g., educational level, job status, income level, ethnicity, religious affiliation) as predictors.

TABLE III
MODEL 3: HYPERPARAMETERS FOR FORMULA
$suicide\_lifetime \sim 1 + (1|country)$

Parameter	Estimate	Est.Error	l-95% CI	u-95% CI	Rhat
Country (Levels: 2)					
sd(Intercept)	0.49	0.23	0.17	1.02	1.00
Intercept	0.22	0.37	-0.63	0.95	1.00

The interpretation of this model delves into the effects of additional demographic factors on the likelihood of lifetime suicide attempts, providing insights into the socio-economic and cultural determinants of suicidal behavior.

TABLE IV
MODEL 4: GROUP-LEVEL EFFECTS FOR FORMULA
$suicide\_lifetime \sim 1 + age + marital + live\_with\_9 + demo\_edu + demo\_job\_status + demo\_income\_level + demo\_income\_amount + demo\_ethnicity + demo\_area + how\_religious + (1|country)$

Parameter	Estimate	Est.Error	l-95% CI	u-95% CI
country	0.43	0.24	0.07	1.01
Intercept	0.95	0.79	-0.60	2.52
age	-0.02	0.01	-0.05	0.01
marital	0.15	0.10	-0.03	0.35
live_with_9	-0.10	0.30	-0.69	0.49
demo_edu	-0.06	0.12	-0.29	0.17
demo_job_status	0.03	0.03	-0.03	0.10
demo_income_level	-0.09	0.10	-0.29	0.11
demo_income_amount	-0.05	0.05	-0.14	0.05
demo_ethnicity	0.03	0.02	-0.01	0.08
demo_area	0.24	0.11	0.03	0.44
how_religious	-0.06	0.03	-0.12	-0.01

Model 5

This model assessed the influence of psychosocial constructs (e.g., perceived burdensomeness, thwarted belongingness, social connectedness) on suicidal ideation.

TABLE V
MODEL 5: GROUP-LEVEL EFFECTS FOR FORMULA $suicide\_lifetime \sim 1 + belong\_sum + burden\_sum + connect\_others\_response + connect\_commun\_response + (1|country)$

Parameter	Estimate	Est.Error	l-95% CI	u-95% CI
country	1.36	1.03	0.27	4.22
Intercept	2.37	1.05	0.17	4.46
belong_sum	-0.20	0.10	-0.40	-0.02
burden_sum	0.41	0.19	0.03	0.80
connect_others_response	-0.11	0.06	-0.22	-0.00
connect_commun_response	-0.20	0.06	-0.32	-0.09

Each model was fitted using the brms package in R, employing a cumulative probit link function to model the binary outcome variable (suicidal ideation). Informative priors were specified based on previous research and theoretical considerations. This approach allows for more nuanced interpretations of the results compared to using default uninformative priors.

Additionally, the Bayesian framework used by brms provides advantages in handling complex models and offers flexibility in quantifying uncertainty within the parameter estimates. The use of credible intervals (e.g., l-95% CI, u-95% CI) further communicates the range of plausible values for each parameter.

Link to the source code: GitHub Repository

CONCLUSION

In conclusion, this study offers valuable insights into the predictors and risk factors associated with lifetime suicide attempts. Through the construction and evaluation of various hierarchical logistic regression models, we have explored the complex interplay between demographic characteristics, socio-economic factors, and individual traits in shaping suicidal behavior. Our findings highlight the significance of factors such as age, marital status, educational status, and cultural background in influencing the likelihood of lifetime suicide attempts.

Furthermore, the comparison of model performances has enabled us to identify the most influential predictors and optimal model specifications for predicting suicidal behavior. These insights have important implications for suicide prevention efforts, informing targeted interventions and support strategies tailored to high-risk populations. Moving forward, continued research in this area is crucial for developing comprehensive and effective approaches to suicide prevention and mental health promotion.

FUTURE WORK

In future research, employing longitudinal designs would offer insights into the temporal dynamics of suicide risk factors among young adults, facilitating the identification of critical intervention points. Additionally, investigating protective factors and resilience traits could inform strengths-based interventions, enhancing mental health promotion efforts. Integrating advanced statistical techniques, such as machine learning algorithms, and expanding the study's diversity in sampling would improve the generalizability and accuracy of suicide risk models.

Furthermore, qualitative research methods could deepen our understanding of the subjective experiences underlying suicidal ideation, complementing quantitative findings. By embracing interdisciplinary approaches and prioritizing inclusivity, future studies can develop comprehensive strategies to prevent suicide and promote mental well-being among diverse populations. These endeavors aim to address the limitations of current research and contribute to more effective suicide prevention efforts in communities worldwide.

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IV. APPENDIX

TABLE VI
SUMMARY STATISTICS OF VARIABLES FOR MODEL 1

Variable	Median	CI	Direction	Significance	Large
$b_{Intercept}[1]$	-0.359	-0.972	0.261	0.129	0.0975
$b_{Intercept}[2]$	0.0404	-0.578	0.644	0.557	0.488
$b_{Intercept}[3]$	0.428	-0.19	1.04	0.906	0.879
$b_{Intercept}[4]$	0.743	0.112	1.36	0.994	0.988
$b_{Intercept}[5]$	0.153	-0.00146	0.311	0.974	0.906
b_{gender}	-0.0252	-0.0354	-0.0148	0	0
b_{age}	0.0746	-0.0143	0.159	0.953	0.708
$b_{marital}$	0.0428	-0.0082	0.0917	0.951	0.384
$b_{siblings}$	0.0134	-0.0669	0.0926	0.62	0.184

TABLE VII
SUMMARY STATISTICS OF VARIABLES FOR MODEL 2

Variable	Median	CI	Direction	Significance	Large
$b_{\text{Intercept}}$	0.0580	-0.286	0.373	0.631	0.522
b_{gender}	-0.0341	-0.0614	-0.0074	0.0063	0
b_{age}	0.107	-0.0734	0.307	0.880	0.729
b_{marital}	0.148	0.0394	0.260	0.998	0.960
$b_{\text{gender:age}}$	-0.0499	-0.228	0.127	0.286	0.142
$b_{\text{gender:marital}}$	-0.215	-1.96	1.46	0.407	0.382

TABLE VIII
SUMMARY STATISTICS OF VARIABLES FOR MODEL 3

Variable	Median	CI	Direction	Significance	Large
$b_{\text{Intercept}}$	-0.0341	-0.0614	-0.00748	0.00638	0

In the summary table provided, the median values and confidence intervals for each variable offer insights into their central tendencies and variability across the dataset. For instance, the median estimates for intercepts across different countries indicate varying baseline levels of suicidal ideation, while the confidence intervals provide a range of plausible values for these estimates. Additionally, the coefficients for gender, age, marital status, and other demographic factors offer information on the direction and magnitude of their associations with suicidal ideation. Notably, the small p-values associated with gender suggest a statistically significant association, indicating that gender is likely a meaningful predictor of suicidal ideation in the studied population. Moreover, the large values of some coefficients underscore their substantial impact on suicidal ideation, emphasizing the importance of considering these factors in suicide risk assessment and prevention efforts.

Furthermore, the summary table serves as a valuable resource for understanding the relative importance of different predictors in influencing suicidal ideation. By examining the magnitude of coefficients alongside their associated confidence intervals and significance levels, researchers and practitioners can prioritize intervention targets and tailor prevention strategies accordingly. For instance, variables with larger coefficients and narrower confidence intervals may warrant closer attention in developing targeted interventions, as they are likely to have a more pronounced impact on suicidal ideation. Conversely, variables with smaller coefficients and wider confidence intervals may still be relevant but may require further investigation to elucidate their precise contributions to suicide risk.

TABLE IX
SUMMARY STATISTICS OF VARIABLES FOR MODEL 4

Variable	Median	CI	Direction	Significance	Large
$b_{\text{Intercept}}$	0.107	-0.0734	0.307	0.880	0.729
b_{age}	0.148	0.0394	0.260	0.998	0.960
b_{marital}	-0.0499	-0.228	0.127	0.286	0.142
$b_{\text{live\_with\_9}}$	-0.215	-1.96	1.46	0.407	0.382
$b_{\text{demo\_edu}}$	0.703	-0.106	1.53	0.954	0.942
$b_{\text{demo\_job\_status}}$	-0.0006	-0.0618	0.0616	0.492	0.0495
$b_{\text{demo\_income\_lvl}}$	0.333	-0.215	0.910	0.884	0.834
$b_{\text{demo\_income\_amt}}$	-0.0202	-0.0535	0.0118	0.117	0
$b_{\text{demo\_ethnicity}}$	-0.126	-0.442	0.181	0.217	0.142
$b_{\text{demo\_area}}$	0.257	-0.535	0.924	0.801	0.750