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Research Article

Evaluation of Hikikomori Syndrome: Methodological Issues

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Abstract

Background: Hikikomori, characterized by extreme social withdrawal has become a global issue in mental health, public health, general societal concern and a silent epidemic. Better understanding of hikikomori behavior including pathophysiology and biological traits of hikikomori may help to prevent spread of hikikomori and stimulate economies of a country.

Method: The paper discusses methodological limitations of scales measuring hikikomori and suggests transforming raw item scores to equidistant scores and further transformations to normally distributed H-scores reflecting hikikomori status and satisfying desired properties including equivalent scores of two scales, statistical analysis and inferences along with better estimation of reliability, validity.

Results: Proposed method can include indicators in ratio or ordinal scale irrespective of scale formats, quantifies progress of hikikomori across time, and evaluates association with Quality-of-life for hikikomori sufferers. Empirical relationships may be established between *H*-scores and socio-economic-demographic impact.

Conclusions: Normally distributed *H*-scores helps to balance the supply and demand sides of hikikomori and is recommended. Future action required on evaluation of skills of hikikomori supporters including effective family interventions based on cognitive behavioral therapy and implementation of robust support system at national level.

Keywords: hikikomori, mental health, normal distribution, social withdrawal, theoretical reliability, factorial validity

Introduction

Hikikomori refers to the phenomenon of extreme social withdrawal of young adults for longer period resulting from complex interactions of psychological, social, and cultural factors. Individuals suffering from hikikomori often withdraw from social and work relationships, confining themselves in their homes. Hikikomori is an emerging issue in mental health, public health, and general societal concern (Kato et al. 2018). A number of bio-psychosocial factors are associated with hikikomori, including comorbidity with Autism Spectrum Disorder (ASD), psychiatric, anxiety and personality disorders, depression, Internet addiction, etc. (Kato et al. 2019; Teo et al. 2015). Prevalence of hikikomori in Japan, North America, Canada, Brazil, Europe, China, Asia (Li and Wong, 2015) is now a global concern. Hikikomori is often interlinked with loneliness and isolation and originally defined as complete social withdrawal for ≥ six months even if there is no evidence of psychosis (Saito, 1998). The expanded definition covers persons who may not have meaningful social interactions and may sometime go out of home environment (Satio, 2010). The duration part has also undergone changes and is taken as 3-6 months (Yong et al. 2020). Cases continuing for over 10 years have been reported (Figueiredo, 2024). Separate Ministry for Loneliness was announced by the British prime minister in 2020 to deal with the condition that affects nearly 14% of the UK's population. Causes of hikikomori syndrome include among others, academic pressure, bullying, conflicts in family and workplace, pressure to meet societal expectations, etc. resulting in feeling of "Not fitting" into rigid societal norms. To protect themselves from the perceived threats and pressures of the outside world, hikikomori behavior is a way for individuals similar to what was practiced during the COVID-19 pandemic. However, hikikomori was prevalent before the outbreak of COVID- 19. Hikikomori rates ranged between 0.87 % to 1.2 % in Japan (around 26.66% in student population), 6.6 % in China, 20.9 % in Singapore, 9.5 % in Nigeria, 9% in Taiwan, 2.7 % in the United States, 2.3 % in South Korea, 1.9 % in Hong Kong (Eckardt, 2023). As per estimates of Cabinet Office (2023), 1.46 million Japanese (one out of 50 populations investigated) suffer from hikikomori requiring increased social attention including enhancement of skills of hikikomori supporters. Thus, hikikomori phenomenon is much more than Japanese social problem, but a global silent epidemic. Proper treatment of hikikomori patients will help to stimulate economies of a number of countries (Takefuji, 2023). Economic consequences of hikikomori are significant since persons with hikikomori syndrome opt out of the workforce affecting productivity and economic growth in addition to burden on themselves and also on families and social support systems. Thus, early detection mechanisms and intervene at the right moment are necessary to prevent spread of hikikomori, which require understanding of loneliness dynamics, correlates and measurement of hikikomori behavior through scales and questionnaires including pathophysiology and biological traits of hikikomori (Teo et al. 2018). Empirical investigations of hikikomori have predominantly used questionnaires or scales containing *K*-point items with different sub-scales or dimensions, different cut-off scores, and are not comparable. Scales with increased length (number of items) and width (number of levels or response-categories) tend to show greater values of mean, variance, reliability and validity (Chakrabartty, 2023). Moreover, analysis of ordinal data emerging from such scales ignore distributions of scores of item, scale and thus, fail to ensure meaningful aggregation of scores of items, dimensions and normality assumption, a pre-requisite for various parametric statistical analysis (Šimkovic and Träuble, 2019). Self–reported scales generating ordinal data are often skewed, requiring verification of normality (Clason and Dormody, 1994). Studies combining hikikomori-related biomarkers and social/psychological factors of social isolation to find overall hikikomori status are rare. The paper suggests transforming raw item scores to normally distributed hikikomori scores (*H*-scores) for meaningful aggregation reflecting hikikomori status satisfying desired properties along with better estimation of reliability, validity. Proposed method can include indicators in ratio or ordinal scale irrespective of scale formats, quantifies progress of hikikomori across time, and evaluates association with Quality-of-life (QoL) for hikikomori sufferers with meaningful application including statistical analysis and inferences.

Literature review:

The term social isolation is associated with claustration, social withdrawal, homebound syndrome, internet addiction, etc. (Maaïa et al. 2014). Factors influencing hikikomori syndrome include among others modern-type depression (MTD) (Kato & Shigenobu, 2017), extreme loneliness (Dasgupta, 2021), internet addiction (Miriam et al. 2024), overprotective parenting (Höschl, 2022), lack of involvement of parent (Kato et al. 2019), presence of other psychopathology of the parent (Höschl, 2022). Gender effect in hikikomori gave contrasting results. Higher manifestation of hikikomori syndrome were found among males (Kondo et al. 2007) and reverse among girls (Miriam et al. 2024). Hikikomori patients showed more anxiety with reduced QoL in comparison to other patients in community psychiatry clinics in Japan (Imai et al., 2021). Yong (2024) found relationship of hikikomori with factors relating to demographic, mental health, outgoing behaviors, internet addiction and concluded inadequacy of hikikomori classification to capture loneliness in Japanese society. However, association of loneliness with major depressive disorder (MDD) and generalized anxiety disorder (GAD) is not clear (Steen et al. 2022). Hikikomori was associated with ASD (including undiagnosed autism spectrum conditions (ASC)) and depressive symptoms, especially MTD (Katsuki et al. 2020) who observed that hikikomori patients have lower self-esteem and difficulty in social communications and social interactions. Biomarkers of hikikomori in terms of blood tests and other pathological tests have been undertaken. Hayakawa et al., (2018) observed hikikomori patients had lower levels of serum uric acid (UA) for men and lower high-density lipoprotein cholesterol (HDL-C) levels for women. Higher long-chain acylcarnitine levels is common among hikikomori patients irrespective of gender and different levels of bilirubin, arginine, ornithine (Setoyama et al. 2022). The authors used blood metabolic signatures of hikikomori for diagnosis and found that area under the ROC curve of 0.854 indicating high prediction accuracy. Several scales are being used for diagnosis and evaluation of hikikomori syndromes. The popular one is the *Hikikomori questionnaire (HQ25)*, containing 25 number of 5-point items (0: Strongly Disagree to 4: Strongly Agree) in three subscales viz. socialisation (11 items), isolation (8 items), and emotional support (6 items). ROC analysis of summative *HQ25* scores gave cut-off score of 42 (out of maximum 100) for hikikomori (Teo et al. 2018). *Multidimensional Scale of Perceived Social Support (MSPSS)* (Zimet et al. 1988) aims at measuring perceived social support from Family (4 items), Friends (4 items), and a Significant Other (4 items). *MSPSS* contains 12 number of 7-point items (1: very strongly disagree to 7: strongly agree). Here, higher score indicates higher social support. *UCLA Loneliness Scale* (*UCLA-LS*) is a 20-item, 4-point scale developed to measure feelings of loneliness of the subjects (Russel et al. 1980) where higher the score, higher is the loneliness feeling. Different versions of *UCLA-LS* have been developed. Among them, *ULS-6*, with 6 items had unidimensional structure (Neto, 2014). Subjects select that best describes them for each of 12 pairs of statements in *Preference for Solitude Scale (PSS*), despite solitude preference being uncorrelated with social anxiety (Burger, 1995). 14-item questionnaire *Compulsive Internet Use Scale (CIUS*) assess frequency of occurrence with 5-point items ("never", "rarely", "sometimes", "often", and "very often") where the cut-off score is 20 (Meerkerk et al. 2009). Consensus gold standard test for hikikomori does not exist yet (Teo et al. 2018)While Cronbach alpha reliability of the above scales is popular, content validities were computed by relationship of MSPSS, UCLA-LS and PSS (Gundogmus et al. 2021). However, such relationships are influenced by method of sample selections. Sample selected by Gundogmus et al. (2021) ignored those who could qualify as Hikikomori by clinical examination. Sample used by Teo et al. (2018) consisted of clinical population and also normal (healthy) persons selected from one region and is not representative of Japanese population. Moreover, social isolation is likely to be high in societies where individualization is high. The convergent validity of HQ-25 computed as $r_{HQ25,R-UCLA}$ and $r_{HQ25,PSS}$ were 0.88 and 0.73 respectively but, $r_{HQ25,MSPSS}$ was (-) 0.81 (Teo et al. 2018). However, value of correlation depends heavily on group heterogeneity and may not confirm high comparability.

Limitations:

Common limitations of scales for evaluation of hikikomori syndromes are:

- They differ with respect to length, width and anchor values of the response-categories (like 0 -3; 1 – 4, 1 – 7, 1 – 5 and 0 – 4) giving non-uniform score ranges and unknown distributions of scale scores. Mean and variance of MSPSS using 7-point scale will be higher than the same for other scales considered.
- Use of anchor value "Zero" can distort mean, variance, between group variance. Large frequency of zero responses reduces item-total correlation, expected value of an item.
- Distance between strongly disagree to slightly disagree ≠ distance between slightly disagree and somewhat disagree ≠ distance between somewhat disagree and neither agree nor disagree. Thus, response-categories are not equidistant and average of item scores is not meaningful for ordinal items (Lewin et al. 2002).
- Despite different values of inter-item correlations, item-total correlations and factor loadings, assigning equal importance to items and dimensions is not justified. Factor loadings of items

found through Factor Analysis (FA), Principal Component Analysis (PCA) are different.

- Different responses to different items can generate tied score reducing discriminating power of scale.
- Meaningful addition of scores of items X and Y as $Z = X + Y$ demands similar distribution of X and Y facilitating knowledge of distribution of Z to find $P(Z = z) = P(X = x, Y = z - x)$ or $P(Z \leq z) = P(X + Y \leq z) = \int_{-\infty}^{\infty}(\int_{-\infty}^{z} f_{X,Y}(x, t - x)dt)\, dx$ for discrete and continuous cases respectively. Clearly, knowledge of probability density function (pdf) of X, Y and Z are needed.
- Comparison of two scales with different formats goes beyond finding $\mu_{Scale-1}$> or < $\mu_{Scale-2}$ or to find $r_{Scale1,Scale2}$. Concept of comparability is different from correlation and may demand that for any given score x_0 of Scale-1, finding equivalent score y_0 of Scale-2 and vice versa, similar rank orderings by the scales, etc. For example, X and $1/X$ are quite comparable despite $r_{X,1/X}$ = -0.65 ∀ X: 1, 2, 3, .….30.
- Traditional ROC-AUC approach assumes normal distribution, violation of which may give improper ROC curve if within-group variations are dissimilar (Chakrabartty, 2021). Small sample size usually results in jagged ROC curve (Obuchowski, 2003). ROC curves for Scale-1 and Scale-2 may differ even if $AUC_{Scale-1} = AUC_{Scale-2}$.
- Reliability of multidimensional hikikomori has been measured by KR–20 (applicable only for dichotomous items: yes/no or true/false) (De Vellis & Thorpe, 2021), Cronbach alpha, test- retest, etc. Test-retest reliability ($r_{test-retest}$) may be high if there is no effect of treatments/interventions during the time-interval between two administrations or scores of each subject is improved or deteriorated uniformly. $r_{test-retest}$ may not reflect true stability of the construct(s). Jelenchick et al. (2012) used correlation to compute $r_{test-retest}$ of Internet Addiction Test developed by Young (1998). Clearly, $r_{test-retest}$ is not a sufficient condition to demonstrate agreements.
- Cronbach's alpha increases as number of response-categories increases. Despite finding three-factor structure of *HQ25*, (eigenvalues > 1) Teo et al. (2018) computed Cronbach's alpha violating assumptions of unidimensionality and tau-equivalent property (or true score equivalence) of alpha. Limitations and misuses of alpha have been addressed (Sijtsma, 2009). For multidimensional constructs, alpha may not make sense.

Suggested method:

Chakrabartty (2023) suggested transforming ordinal item scores to equidistant scores where anchor values are taken as 1, 2, 3, 4, 5,……, and ensuring each item is positively related to the traits being measured, say hikikomori. The method is based on matrix of raw scores $((\boldsymbol{X_{ij}}))_{n\times m}$ where n individuals answer the scale containing m number of items. The general element X_{ij} denotes raw score in the j-th item by the i-th individual. Clearly $1 \leq X_{ij} \leq 5$ for 5-point items. Monotonic equidistant scores are obtained by giving different weights $W_{ij} > 0$ to

j-th level of i-th item following either of the following two approaches:

Approach-1:

For an item, find frequency of each level. Let the maximum frequency be f_{max} and the minimum frequency be f_{min}.

Assign initial positive weights W_1, W_2, W_3, W_4 and W_5 to the levels so that $W_1, 2W_2, 3W_3$,

$4W_4$, $5W_5$ form an arithmetic progression, ensuring $pW_p - (p-1)W_{(p-1)} = \beta$ for p = 2, 3, 4, 5. $W_1 + 4\beta = 5W_5 \Longrightarrow \beta = \frac{5W_5 - W_1}{4} = \frac{5.\frac{f_{max}}{mn} - \frac{f_{min}}{mn}}{4} = \frac{5f_{max} - f_{min}}{4mn}$ where $W_1 = \frac{f_{min}}{mn}$,

$2W_2 = W_1 + \beta \Longrightarrow W_2 = \frac{W_1 + \beta}{2}$, $W_3 = \frac{W_1 + 2\beta}{3}$; $W_4 = \frac{W_1 + 3\beta}{4}$; and $W_5 = \frac{W_1 + 4\beta}{5}$

Convert the initial weights to final weights $W_{ij(Final)} = \frac{W_{ij}}{\sum_{j=1}^{5} W_j}$ so that $\sum W_{ij(Final)} = 1$ and $kW_{ik(Final)} - (k-1)W_{i(k-1)(Final)}$= Constant.

Approach – 2:

Weights based on area under $N(0,1)$. Steps to obtain $W_j's$ are illustrated in Table 1.

Levels	Proportion (p_i)	Cumulative Proportions(C_i)	Area under the standard Normal curve	Initial Weights
1	$p_1 = \frac{f_1}{mn}$	p_1	$A_1 = Upto\ p_1$	$w_1 = \frac{A_1}{\sum A_i}$
2	$p_2 = \frac{f_2}{mn}$	$p_1 + p_2$	A_2= Up to $p_1 + p_2$	$w_2 = \frac{A_2}{\sum A_i}$
3	$p_3 = \frac{f_3}{mn}$	$p_1 + p_2 + p_3$	$A_3 = Upto\ p_1 + p_2 + p_3$	$w_3 = \frac{A_3}{\sum A_i}$
4	$p_4 = \frac{f_4}{mn}$	$p_1 + p_2 + p_3 + p_4$	$A_4 = Upto\ p_1 + p_2 + p_3 + p_4$	$w_4 = \frac{A_4}{\sum A_i}$
5	$p_5 = \frac{f_5}{mn}$	$p_1 + p_2 + p_3 + p_4 + p_5$=1.00	$A_5 = Upto\ p_1 + p_2 + p_3 + p_4 + p_5$	$w_5 = \frac{A_5}{\sum A_i}$
Total	1.00		$\sum_{i=1}^{5} A_i > 1$	1.00

Table 1: Calculation of weights, Alternate Method

Here, $w_j > w_{j-1}$ ∀ j= 2,3,4,5. To get equidistant scores, divide the difference between Maximum area and the Minimum area by 3 and call it the correction factor α. The modified areas $\Delta_1, \Delta_2, \Delta_3, \Delta_4$ and Δ_5 can be determined by taking $\Delta_1 = A_1$, $\Delta_2 = \Delta_1 + \alpha$; $\Delta_3 = \Delta_2 + \alpha$;

$\Delta_4 = \Delta_3 + \alpha$; $\Delta_5 = \Delta_4 + \alpha$ Define corrected weights $W_j = \frac{\Delta_j}{\sum_{j=1}^{5}\Delta_j}$ satisfying $\sum_{j=1}^{5} W_j = 1$. Correlation of E-scores by Approach-1 and 2 $\cong 1$.

Proposed hikikomori scores:

Standardize item-wise equidistant scores (E_i) by $Z = \frac{E-\bar{E}}{SD(E)} \sim N(0,1)$. Transform Z-scores to hikikomori score (H) by $H_i = \{(99)\left[\frac{Z_i - MinZ_i}{MaxZ_i - MinZ_i}\right] + 1\} \sim N(\mu_i, \sigma_i)$ and $1 \leq H_i \leq 100$. Dimension scores (D_i) is sum of relevant H_i's and hikikomori score $(H) = \sum D_i = \sum H_i \sim$ normal $(\sum_i \mu_i$, $[\sum \sigma_i^2 + 2\sum_{i\neq j} Cov(H_i, H_j)]$ and enables undertaking of parametric statistical analysis.

Results:

H-scores combines several scales in different formats, irrespective of their inter-correlations, satisfying the following desired properties:

- Monotonically increasing H-scores reflect total hikikomori status of an individual. Higher the H-score, higher is hikikomori status.
- f_{ij}=0 can be taken as zero value for scoring Likert items.
- H-scores avoid skew and outliers and give unique ranks to the individuals.
- The dimensions (chosen factors of hikikomori) can be ranked with respect to relative importance given by $\frac{D_i}{H} \times 100$.
- Elasticity of the i-th dimension is quantified by $\frac{\Delta H_i / H}{\Delta D_i / D_i}$
- Progress/deterioration of i-th patient or a group of patients in successive time-periods can be assessed by $\frac{H_{i(t-1)} - H_{it}}{H_{i(t-1)}} \times 100, \frac{\overline{H_t} - \overline{H_{(t-1)}}}{\overline{H_{(t-1)}}}$ respectively reflecting responsiveness of hikikomori-scale and also effectiveness of adopted treatment plans and interventions. Indicators showing deteriorations are critical requiring initiation of corrective actions.
- Path of progress/deterioration of one or a sample of hikikomori patients over time can be compared using longitudinal data. A decreasing graph of H_{i_t} and time (t) implies progress registered by the i-th patient and an increasing graph implies the reverse. Such plot is akin to hazard function of survival.
- Normality of H-scores facilitates estimation of population mean and population variance from a representative unbiased sample drawn by probability based sampling technique. Statistical tests of hikikomori-scores like $H_0: \mu_1 = \mu_2$ or $H_0: \sigma_1^2 = \sigma_2^2$ using cross-sectional or longitudinal data can be undertaken. Significance of progress of H can be tested by $H_0: \frac{H_{i(t-1)} - H_{it}}{H_{i(t-1)}} = 0$ by χ^2 test.
- Statistical hypothesis concerning hikikomori-score across gender, age, managerial positions, etc. can be tested by t-ratios or ANOVA.
- Question arises whether cut-off scores of 42 for *HQ-25* and 20 for *CIUS* are equivalent. If scores of *HQ-25* and *CIUS* are transformed to normally distributed H-scores, equivalent scores (x_0, y_0) of the two scales can be found by solving $\int_{-\infty}^{42} f(x)dx = \int_{-\infty}^{y_0} g(y)dy$ or $\int_{-\infty}^{x_0} f(x)dx = \int_{-\infty}^{20} g(y)dy$ so that area of the curve $f(x)$ for *HQ-25* up to x_0= area of the curve $g(y)$ for *CIUS* up to y_0. Chakrabartty, (2024) solved the equation using $N(0,1)$ table.
- A group of individuals can be classified into K-classes in terms of H-scores by Davies-Bouldin Index (DBI) (Davies and Bouldin, 1979) based on within-cluster and between-cluster distances by:
  $DBI_K = \frac{1}{K}\sum_{i=1}^{K}\sum_{j=1\ (i\neq j)}^{K} Max[\frac{DiamC_i - DiamC_j}{\|C_i - C_j\|}]$
  where $DiamC_i = \sqrt{\frac{\sum_{x_i \in C_i}\|x_i - C_i\|^2}{n_i}}$ is diameter of i-th class; C_i: Centroid (mean) of the i-th class; n_i: number of individuals in the i-th class.
  Lower *DBI* indicates higher classification efficiency. Fixing K=2 and obtaining data from normal and hikikomori sufferers, an optimal cut-off score of H-scale can be explored by lowest DBI value in the plot of DBI and number of clusters. However, the results need to be verified with clinical observations.
- Different methods of finding reliability deviating from theoretical definition of reliability $(\frac{True\ score\ variance}{Observed\ score\ variance})$ give different values of reliability (r_{tt}). Avoiding verification of assumptions of Cronbach's alpha, theoretical reliability $(r_{tt(Theoretical)})$was found by
  $$1 - \frac{2(variance\ of\ gth\ subtest)(1 - r_{gh})}{N.Sample\ variance}$$
  where N: sample size and r_{gh}: correlation between the two sub-tests (g-th and h-th) (Chakrabartty et al. 2024). A pre-requisite of the method is to dichotomize the test in g-th and h-th parallel sub-tests.
- Factorial validity of H-scores can be computed by $\frac{First\ eigenvalue}{\sum Eigenvalues}$ indicating validity of the main factor for which the test was developed (Parkerson et al. 2013) avoiding selection of criterion scale with similar factor structure and administration of two scales.

Discussion:

H-scores reflecting overall status of hikikomori may be found by combining scores of all causes of hikikomori and their intensities including Z-transformation of Biomarkers in ratio scales and further transformation to avoid negative scores for each biomarker. Normally distributed H-scores enable meaningful aggregation, satisfy desired properties and offer a number of benefits like ranking of the factors, statistical test of hypothesis and better measures of reliability and validity.

Association between H-scores and suitably designed QoLscale for hikikomori sufferers (QoL–H) (Nonaka and Sakai, 2022; Muris et al. 2023) can be found by simple correlation or by multiple correlation between H-scores as dependent variable and dimension scores of QoL–H as the independent variables or as canonical correlation between dimensions of H-scores and dimensions of QoL-H. Optimal cut-off score of H-scale can be explored by fixing K=2 (normal persons and hikikomori sufferers) in Davies-Bouldin Index. Empirical relationships may be established to see effect of hikikomori on socio-economic-demographic impact including ASD and with depressive symptoms, especially MTD, etc. Regression equation of QoL can be fitted on H-scores as predictors of QoL. However, checking normality of residual score is suggested for fitting of regression equations. Progress/deterioration path of two regions/countries can be compared from the beginning of the longitudinal study by selection of appropriate similarity measure.

Conclusions:

The paper is an improvement of assessment of hikikomori syndrome with benefits of parametric analysis for meaningful analysis. Planners and researchers can take advantages of the normally distributed *H*-scores to balance the supply and demand sides of hikikomori. Empirical investigation of properties of *H*-scores with emphasis on robustness and progress path may be undertaken. Future action required on evaluation of skills of hikikomori supporters including effective family interventions based on cognitive behavioral therapy (CBT) and implementation of robust support system at national level.

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