Modified PRDG Model for Caregiver Segmentation Using Zarit Burden Interview Instrument

[1*]**Nabillah Annisa Rahmayanti,** [1]**Retno Aulia Vinarti,** [1]**Arif Djunaidy,** [2]**Anna Tjin,** [3]**Jeng Liu**

[1]Department of Information Systems, Faculty of Intelligent Electrical and Information Technology, Institut Teknologi Sepuluh Nopember, Indonesia.
[2]Trinity College Dublin, The University of Dublin, Trinity Centre for Global Health, 7-9 Leinster Street, South, Dublin 2, Ireland.
[3]Tunghai University Department of Sociology No.1727 Section 4, Taiwan Blvd, Xitun District, Taichung City, Taiwan.

email: [1*]bellasnabillah@gmail.com, [1]zahra_17@is.its.ac.id, [1]adjunaidy@its.ac.id, [2]annat@tcd.ie, [3]jliu@thu.edu.tw

Corresponding author

Abstract - *The increasing demand for Indonesian workers in Taiwan has an impact on caregiver problems which can be triggered by the burden of caring for the elderly. Therefore, the aim of this study is to identify the characteristics of caregivers who are resilient to burdens based on Indonesian female caregivers who work in Taiwan data to be a guide for selecting prospective caregivers. The process includes analyzing the personal characteristics that have the most influence on the burden using multiple regression and then clustering caregiver data using K-Means with the Elbow Method and Silhouette Index. Then, segmentation in each cluster based on a comparison of the average values. The results of clustering accuracy on dimensions (PRDG) and modified dimensions (S+PRDG) were compared and the smallest error cluster was in case 4 in the S+PRDG dimension with the Elbow Method of 3.6%. Based on segmentation on that dimension, cluster 2 is a resilient caregiver cluster. Then the results of the multiple regression analysis (Number of Children, Education and Work Location) were studied further for each caregiver in cluster 2 and the conclusions are, their average number of children is 1, final education is in junior high school and their work location is in the capital of Taiwan.*

Keywords: Caregivers, S+PRDG Model, ZBI Instruments, K-Means Algorithm, Elbow Method, Silhouette Index.

1   Introduction

Global migration has increased rapidly since 1960 to date. This increase is an important part of the globalization process. In addition, the global labor market has emerged, and laborers can now be transferred across national borders based on capital demands. In the Southeast Asia region, Indonesia and Taiwan are a pair of countries that has established a relationship between sender and recipient in terms of labor (Kennedy, 2012). Therefore, families in Taiwan have had the option of employing foreign caregivers since 1991; the Taiwan government established a procedure and quota system for importing workers into the country (Cheng, 2003). The increasing demand for female workers, especially those caring for the elderly in developed countries such as Taiwan, is proportional to the increase in the education level of women in importer countries. As their education level is generally at the university level and most of them are career women, taking care of their elderly is burdensome to some extent. Therefore, to care for their parents, they employ female workers from other countries (e.g., Indonesia) (Yeoh & Huang, 2010).

Due to the large demand from families who care for the elderly, the Taiwanese government has given the option of employing foreign caregivers. However, this does not mean that it is an easy thing for foreign workers to work in Taiwan. They have to adapt to varying job demands, which affect their stress levels (Loveband, 2004). Some of these workers are able to adapt to the demands of their work as caregivers, but most of them struggle with the

difficulties (Law et al., 2021). Workers who take care of the elderly have a higher level of burden because some of the elderly have comorbidities, one of which is memory problems (e.g., dementia) (Tam et al., 2018).

Basnyat and Chang (2017) stated that the level of burden experienced by caregivers was not only caused by the varying demands of their work but also due to the individual differences of each caregiver themselves. The different characteristics of each individual caregiver greatly affect their resilience in adapting to their workload. Adelman et al. (2014) stated that caregivers who care for patients for a long period of time have a considerable burden. Furthermore, something that is quite serious and is becoming a concern is when the caregiver is not paid and has a long period of time caregiving, it all causes financial difficulties, and sometimes the caregiver will feel unable to adjust to the work environment, and to deal with social factors such as undue pressure and failure to perform tasks, difficulty in maintaining relationships, harassment, and neglect. All of them can be several possibilities for the caregiver to close her own life history (Thapa et al., 2021). Additionally, some of the caregivers who are migrant workers would try to escape and end up becoming illegal workers (Loveband, 2004). Caregivers spend about 20.5 hours per week and 20% of those caregivers work >40 hours per week (Adelman et al., 2014). Therefore, the burden of caregivers is of further concern because it has a very serious impact on mental and physical health (Tsai et al., 2021) which affects the quality of the care provided. Recruiter agencies and government should be aware of the characteristics of female foreign workers who wish to work in Taiwan. For example, they should know about the workers' work experience, foreign language skills, and family background. The number of Indonesian Migrant Workers or better known as Tenaga Kerja Indonesia (TKI) in Taiwan, according to data from BNP2TKI (National Agency for the Placement and Protection of Indonesian Workers) (BNP2TKI, 2020) in 2019, is 79,574 legal workers from more than 500 TKI companies, which is an increase of 10% from the previous year (Lidwina, 2020). It does not include the number of TKI who migrated to Taiwan illegally. Utami (2020) said that there are six problems commonly faced by Indonesian migrant workers in Taiwan, namely, unpaid salaries, work accidents, repatriation of Indonesian migrant workers, sexual harassment, abuse, and the act of running away from the employer. For example, in the case of the problem where migrant workers run away from their employers' houses, it is suspected that the possible causes are unclear understanding of the employment contract and violation of rights committed by the employers during the implementation of the employment contract (Rahman et al., 2021). Therefore, caregivers who work overtime and have no days off because of the dependence of the elderly in their care are triggered by these causes. As a result, the caregivers feel stressed and run away from their employers' houses. Apart from the dependence of the elderly on caregivers, this problem can also be caused by other burdens related to personal strain, role strain, social life, and feelings of guilt felt by caregivers while caring for the elderly. Therefore, to reduce the problems faced by caregivers in Taiwan, we need to find out information about caregivers who are resilient to the burden.

Such information is useful for Indonesian female foreign worker recruiters and the government in determining what kind of actions should be implemented to reduce the burden of the caregivers before sending them abroad. Therefore, information about caregivers who can withstand the burden needs to be investigated further. A study on identifying personal characteristics to predict the burden experienced by Indonesian female foreign workers in Taiwan has been carried out by Troy et al. (2020) who investigated the relationship between burden and personal characteristics of Indonesian caregivers living in Taiwan using the data of 299 caregivers who care for the elderly. The burden and severity of the caregiver's burden were measured using Zarit Burden Interview (ZBI), and the results of the Exploratory Factor Analysis (EFA) test showed that the burden of the caregivers was multidimensional in nature and related to Personal strain, Role strain, Dependency, and Guilt (PRDG), which were in line with previous studies (Springate & Tremont, 2014; Lau et al., 2019). However, the study did not show any results in the form of information about caregivers who were able to withstand the burden based on available data.

Information on caregivers who are able to withstand the burden can be seen based on their load score. A high load score indicates that the caregiver is depressed or has a high burden, while a low load score indicates otherwise. To be able to calculate the load score of the caregiver, the ZBI instrument is used. The ZBI itself is a common instrument in studies conducted to assess the workload of caregivers. The ZBI was originally developed to assess the burden of caregivers caring for the elderly with dementia. In the ZBI instrument, there are dimensions determined by several researchers using the EFA test. The dimensions are not limited to caregivers who treat elderly people with dementia, but they also include caregivers who treat patients with a particular disease. Therefore, the dimensions of the ZBI instrument can be adjusted to the case study but cannot be separated from the basic dimensions of personal strain, role strain, dependency, and guilt, which can be abbreviated as PRDG in this study. The personal strain dimension has ten instruments based on the rotated factor matrix of the EFA test results. These instruments are related to the personal burden of the caregivers. After further research on nine items (6, 12, 9, 11, 3, 5, 4, 13, 17) of the personal strain instruments, it was found that three items (6, 12, 13) are more related to problems around the social life of the caregivers. Therefore, this study proposes adding the dimension

of Social life, so that the dimensions become S+PRDG, with the hope that caregivers who are able to withstand the burden can be examined in more detail.

The purpose of this study is to experiment and estimate caregiver segmentation using the clustering method of K-Means algorithm. Since the K-Means algorithm has difficulties in determining the number of initial clusters, then two methods are used: Elbow Method and Silhouette Index. To evaluate which model is better (PRDG or S+PRDG), cluster accuracy is used. After finding out which cluster is better, an analysis of caregiver characteristics is carried out to explain the cluster results. The results of this study can be used as guidelines by the government and recruiter agencies that recruit Indonesian female foreign workers in selecting prospective caregivers, so that they can make appropriate strategies and decisions before sending them to work abroad.

2 Literature Review

2.1 Caregiver

A caregiver is a family member or a helper who intends to care for children or older adults, some of whom may have certain diseases or physical or mental disabilities (e.g., recipient) (Windham, 2015). The caregivers discussed in this paper are specific to Indonesian female caregivers who work in Taiwan (e.g., TKI). These caregivers care for the elderly for approximately 20 hours per week with 20% of them working overtime, meaning that their total working time exceeds the average total working time per week, but is less than 40 hours per week. Somehow, this condition puts a burden on the caregivers. In addition to the working loads, the burden can also be determined from the caregiver's personal characteristics. For example, caregivers with lower education levels (e.g., primary schools) feel more pressure on the balance of work and family than those who graduate from junior or senior high school. Furthermore, unmarried caregivers tend to have difficulties in controlling their emotions when caring for the elderly (Chang et al., 2021).

Hoenig and Hamilton (1966) proposed a concept regarding the meaning of the caregiver burden, which is divided into two aspects: subjective and objective. Subjective burden is a burden related to the feelings of caregivers when caring for patients. Objective burden is an activity related to the negative experience felt by the caregiver. Therefore, understanding the caregivers' attributes associated with burden is important. According to Zhu Liu et al. (2020), the attributes related to caregiver burden are self-perception, multifaceted determination, and overtime. Self-perception is how caregivers reflect their personal experiences while working with their patients. Multifaceted strain is a multidimensional caregiver burden such as emotional and psychological stress that is often experienced by caregivers.

Furthermore, the routine and social activities of caregivers in providing care for a long period or working overtime can be disrupted (Yoon et al., 2014; Arian et al., 2017). The higher the number of hours worked or overtime put in per day to provide care to elderly care recipients, the more impact it has on the high burden. The study by Juvang et al. (cited in Li et al., 2007) showed that there was a positive relationship between the number of hours caregiver worked to care for the elderly and the objective burden faced by them. The longer the time spent caring for the elderly, the more objective burden is felt by the caregiver (Rafiyah et al., 2011). When caregivers spend more time working on caring for the elderly, they may have less time to themselves. In fact, they also need time for their social life, such as chatting and visiting their friends and family. Finally, such condition has an impact on the caregivers' daily activities. Based on the attributes related to the caregiver burden, these attributes can be grouped into several dimensions similar to those in the proprietary instrument, namely, Personal strain, Role strain, Dependency, and Guilt (PRDG) dimensions (Troy et al., 2020). Another instrument added in this research is Social life related to overtime. Therefore, the dimensions become S+PRDG.

2.2 Zarit Burden Interview (ZBI)

Zarit Burden Interview (ZBI) is an instrument developed by Professor Steven H. Zarit of the University of Pennsylvania (Zarit et al., 1980), which is often used to assess the burden of care. This instrument has been translated into several languages and used in various countries such as America and Europe. In addition, the validity and reliability of this instrument have also been tested by researchers in China, Korea, and Japan. Caregivers were asked 22 questions about the impact of caring for the elderly on their lives. Then, they will be assessed to find out how burdened they are. In each question, caregivers were asked to mark how often they felt a certain way. Each item is given a score of 0 to 4 (0 = never, 1 = rarely, 2 = sometimes, 3 = quite often and 4 = almost always). The total score is calculated by adding the score of each item, with a value varying from 0 to 88. There is no cutoff score, but the higher score means the higher caregiver burden. There are several dimensions to the ZBI instrument, and these dimensions can be adjusted based on the studies of each researcher.

Table 1: ZBI Instrument Question Indicators

ZBI Items	Indicators
Item 1	The elderly patient asking for more help than needed
Item 2	Caregiver doesn't have enough time for herself because of the elderly patient
Item 3	Caregiver feels stressed between caring care recipient and her family
Item 4	Caregiver feels embarrassed over the elderly's behavior
Item 5	Caregiver feels angry when she's around her elderly patient
Item 6	Caregiver feels that the current elderly affects relationship with family or friends in a negative way
Item 7	Caregiver feels afraid of the future of elderly care patient
Item 8	Caregiver feels the elderly is too dependent on her
Item 9	Caregiver feels strained when she is around the elderly patient
Item 10	Caregiver feels her health has suffered because of involvement with the elderly patient
Item 11	Caregiver feels that she doesn't have much privacy as she want, because of the elderly patient
Item 12	Caregiver feels that social life has suffered because of the elderly patient
Item 13	Caregiver feels uncomfortable about having friends over, because of the elderly patient
Item 14	Caregiver feels that the elderly expect her to be the only one who can be depend on
Item 15	Caregiver doesn't have enough money to support the elderly patient other than the rest of the expenses
Item 16	Caregiver feels unable to take care of the elderly much longer
Item 17	Caregiver feels lost control of her life
Item 18	Caregiver want to leave the care of the elderly patient to someone else
Item 19	Caregiver is confused about what to do for elderly patients
Item 20	Caregiver feels she has to do more for the elderly patient
Item 21	Caregiver feels she can do a better job for caring the elderly patient
Item 22	Caregiver feels that caring for the elderly is a burden

Table 2: Comparison of Caregiver Burden Dimensions

ZBI Items	Previous Study				Current Study
	(Parpa et al., 2017)	(Unson et al., 2016)	(Ankri et al., 2005)	(Troy et al., 2020)	
Item 1	Personal Strain	Anger	-	Dependency	Dependency
Item 2	Personal Strain	Personal Strain	-	Personal Strain	Dependency
Item 3	Personal Strain	Personal Strain	-	Personal Strain	Personal Strain
Item 4	Social Strain	Social Strain	Emotional	Personal Strain	Personal Strain
Item 5	Social Strain	Anger	Emotional	Personal Strain	Personal Strain
Item 6	Social Strain	Social Strain	Social Strain	Personal Strain	Social Strain
Item 7	-	Inadequacy	-	Role Strain	Role Strain
Item 8	Personal Strain	Dependency	-	Dependency	Dependency
Item 9	-	Anger	Emotional	Personal Strain	Personal Strain

Item 10	Personal Strain	Personal Strain	Social Strain	Role Strain	Role Strain
Item 11	Social Strain	Social Strain	Social Strain	Personal Strain	Personal Strain
Item 12	Social Strain	Social Strain	Social Strain	Personal Strain	Social Strain
Item 13	Social Strain	Social Strain	Social Strain	Personal Strain	Social Strain
Item 14	Personal Strain	Dependency	-	Dependency	Dependency
Item 15	Personal Strain	Personal Strain	Guilt	Role Strain	Role Strain
Item 16	Uncertainty	Inadequacy	Guilt	Role Strain	Role Strain
Item 17	Personal Strain	Personal Strain	Social Strain	Personal Strain	Personal Strain
Item 18	Uncertainty	Inadequacy	Guilt	Role Strain	Role Strain
Item 19	Uncertainty	Inadequacy	Guilt	Role Strain	Role Strain
Item 20	Guilt	Inadequacy	Guilt	Guilt	Guilt
Item 21	Guilt	Inadequacy	Guilt	Guilt	Guilt
Item 22	-	-	Emotional	Role Strain	Role Strain

3   Methodology

The data used for this current study is based on Indonesian female caregivers working in Taiwan. This data is the same as the one used by Troy et al. (2020). Data was obtained using the questionnaire instrument. The questionnaire contains 22 ZBI (Zarit Burden Interview) questions. There were 299 respondents spread across the territory of Taiwan.

After the data had been obtained, the next step was to preprocess the data by eliminating missing values, converting data types, and recoding some variables (Section A in Figure 1). Next, Confirmatory Factor Analysis (CFA) was conducted to see whether the number of factors and the grouping of ZBI items was in accordance with the theory in previous studies which produced 4 factors (Section B in Figure 1).

Based on the literature review, one dimension of S (Social life) was added to PRDG, turning it into S+PRDG. This addition would be validated using the clustering technique to see whether the number error was lower after the modification had been made or not. In the next step, multiple regression analysis was carried out on several factors such as education, number of children, marital status, work location in Taiwan, Chinese proficiency, and others. The purpose of using multiple regression analysis was to see the significance of the relationship between these factors on the 5 dimensions (S+PRDG). The most significant factors were called the key indicator (Section C in Figure 1).

The next step was performing Elbow Method and Silhouette Index to find the optimum initial cluster, followed by clustering using the K-Means algorithm (Section D in Figure 1). The clustering was performed using 6 scenarios on two dimensional models: PRDG and S+PRDG. After that, an evaluation of the clustering results was carried out to see the number of clustered errors from each scenario and determine which case was the best. The best case was the one with the smallest clustered error value (Section E in Figure 1). Next was the process of segmenting the results of the clustering based on the average value of each dimension in each cluster and comparing it with the total average value in each dimension.

The process was done to obtain the PRDG and S+PRDG segmentation results. After that, the clustering results were given a rating from the case scenario to indicate which cluster had the lowest burden and which one had the highest burden based on the results of the previous segmentation (Section F in Figure 1). Lastly, after going through all of those processes, the results of the cluster that had the lowest burden were obtained. Based on the results, it can be seen which respondents or caregivers are included in the cluster.

Then the background of each respondent related to the key indicators that had been obtained from the results of the multiple regression analysis in the previous stage was reviewed. Therefore, information about the background

of respondents who were in the cluster with the lowest burden was obtained (Section G in Figure 1). Recruiter agencies and the government can use the conclusions from the results obtained in making strategies and decisions for the next wave of prospective Indonesian migrant workers. For the details, each stage of the process in this study can be seen in Figure 1, along with the marking of each process from A to G, which will be described in more detail according to the marking given in the following explanation.
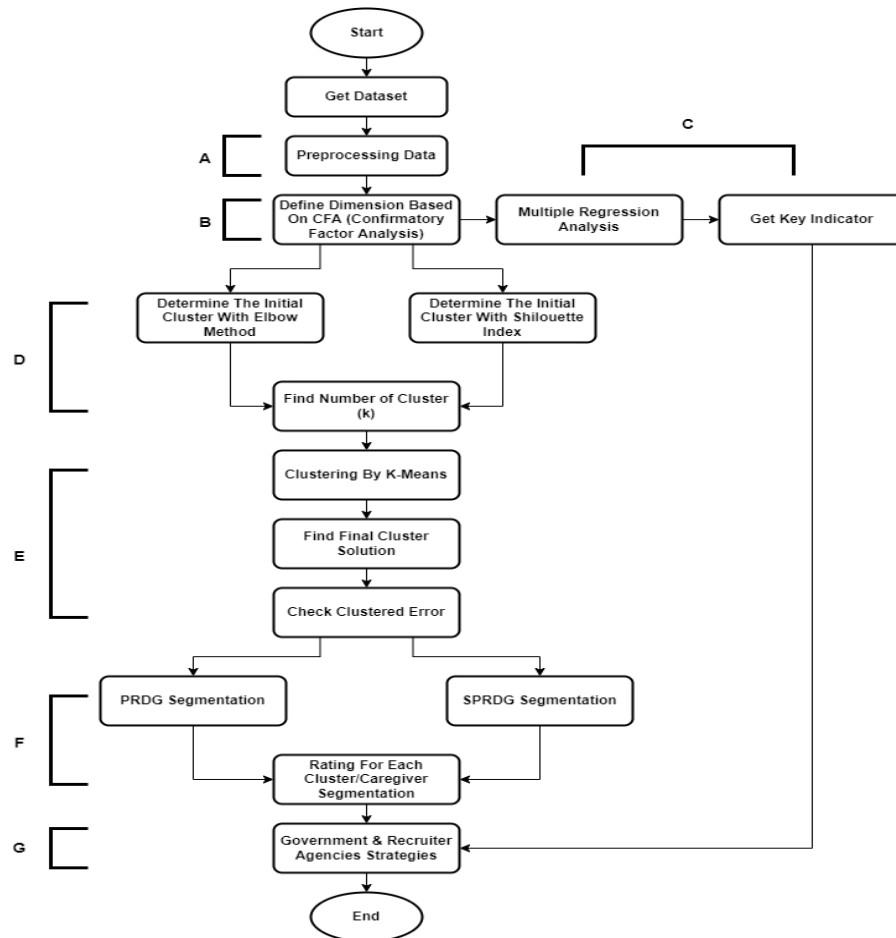

Figure 1: Stages of caregiver segmentation based on PRDG, S+PRDG
model and clustering techniques.

3.1 Preprocessing Data (A)

After getting the dataset, the next step was the preprocessing stage. At this stage, the data was cleaned because there was a missing value in the existing data. In addition, some data were converted from string to numeric so that the analysis process can be carried out later. The recoding ranged from 0-4 to 1-5. All stages, from preprocessing to multiple regression analysis, were carried out using the SPSS 25.

3.2 Defining the Dimensions Based On CFA (Confirmatory Factor Analysis) & Literature Review (B)

The S+PRDG dimension was proposed after the Confirmatory Factor Analysis (CFA) test was carried out to see whether the number of factors and the grouping of the variables were in accordance with the theory in the previous study (Troy et al., 2020) which resulted in 4 dimensions (PRDG). The results from the CFA show that the Kaiser Meyer Oikin Measure of Sampling Adequacy (KMO MSA) value is 0.887 > 0.50, then factor analysis can be carried out and the Anti-Image Correlation value is > 0.50, thus the MSA assumption is fulfilled and the results of the Rotated Component Matrix show the distribution of items in the four factors (see Table 3). However, after careful consideration of the literature, it turns out that the personal strain dimension can be further developed into a new dimension by separating items that lead to caregiver social relationships into dimensions of Social life.

Thus, the dimensions become S+PRDG. This is reinforced by the statement of Ong et al., (2018) that the social support felt by the caregiver, such as relationships with family and friends, is able to mediate the relationship between resilience and the burden of the caregiver, and this is very important because it functions as a protective factor to protect the caregiver from the perceived burden while caring for the elderly. In addition, the Social life dimension was added based on a literature review of previous studies that also used the ZBI Instrument and the existence of a Social life dimension in that study (see Table 2).

Table 3: Confirmatory Factor Analysis Results

ZBI Items	Rotated Component Matrix			
	Factor 1 Personal Strain	Factor 2 Role Strain	Factor 3 Dependency	Factor 4 Guilt
Item 3	0.626			
Item 4	0.674			
Item 5	0.671			
Item 6	0.767			
Item 9	0.635			
Item 11	0.618			
Item 12	0.668			
Item 13	0.590			
Item 17	0.534			
Item 7		0.541		
Item 10		0.575		
Item 15		0.766		
Item 16		0.709		
Item 18		0.748		
Item 19		0.557		
Item 22		0.404		
Item 1			0.688	
Item 2			0.436	
Item 8			0.803	
Item 14			0.772	
Item 20				0.835
Item 21				0.832

3.3 Multiple Regression Analysis to Get the Key Indicators (C)

After finding the dimensions based on the CFA results, the next step was to determine what key indicators can be used to measure the relationship between several predictor variables (representing the caregiver's family structure, job qualifications, and job characteristics) and each response variable (S, P, R, D, G). The results of multiple regression analysis in previous studies concluded that there was a positive or negative relationship between each of the existing factors (e.g., education, Mandarin proficiency, work location, etc.) and the dimensions of the PRDG and also severity of the burden of each factor based on the results of multinomial analysis. Meanwhile, in the current study, multiple regression analysis was used to see the significance of the relationship between the response variable and two or more predictor variables. The difference between the current study and previous studies (Troy et al., 2020) is that this study does not discuss the unidirectional relationship of each variable with the dimensions of the load and the severity of the load. However, this paper discusses more about how the addition of a new dimension (S) can affect the caregiver clustering model. The cluster model is then used to better understand the personal characteristics, which consitute the background of caregivers who are tough against the burden. Thus, the pattern is obtained.

Each personal caregiver's characteristic represents several categories (see Table 4) such as family structure, work qualifications, and employee characteristics, where each category consists of several personal characteristics

which are independent variables, while load dimensions such as Personal Strain and so on are dependent variables. Thus, this study uses multiple regression to analyzetheir relationship. The effect sizes, which are R Square from the multiple regression results, show how much variation in the predictor variables can be explained by the dependent variable. In the family structure category (see Table 4), the largest effect size is in the Guilt dimension which shows 0.027 or 2.7% of the variation of the Guilt dimension can be explained by the number of children and the marital status of the caregiver. The large effect sizes have an effect on the p-value (significance influence of the independent variable individually on the dependent variable) which in the family structure category, the significance of the number of children variable on the Guilt dimension has the smallest p-value among others with $p = 0.005$ or $p < 0.05$ or it can be said that the number of children variable has a significant influence on the Guilt dimension. Likewise, in the category of work qualifications, 0.089 or 8.9% of the variation in the Personal Strain dimension can be explained by the education, Chinese proficiency and elderly work experience of the caregiver. Education has a significant influence on the dimensions of Personal Strain, with $p = 0.000$ or $p < 0.05$. Furthermore, in the employment characteristic category, the effect size of 0.111 or 11.1% variation from the Role Strain dimension can be explained by recipient age and location of work. The location of work variable has a significant effect on the Role Strain dimension, with $p = 0.000$ or $p < 0.05$. Based on the results of multiple regression analysis (see Table 4), it can be concluded that there are three key indicators that represent each category of caregiver personal characteristics, namely the number of children, education, and location of work.

Table 4: Multiple Regression Test Results

Variables	Personal Strain	Role Strain	Dependency	Guilt	Social Life
Family Structures					
Number of Children	0.168	0.019	0.028	*0.005*	0.725
Marital Status	0.338	0.829	0.422	0.379	0.225
R Square	0.018	0.026	0.016	0.027	0.009
Work Qualifications					
Education	*0.000*	0.203	0.024	0.076	0.007
Chinese Proficiency	0.209	0.009	0.215	0.028	0.216
Elderly Care experience	0.020	0.269	0.142	0.281	0.119
R Square	0.089	0.031	0.026	0.029	0.034
Employment Characteristics					
Recipient Age	0.067	0.967	0.012	0.363	0.242
Location of Work	0.333	*0.000*	0.542	0.003	0.574
R Square	0.015	0.111	0.022	0.034	0.005

3.4 Determining the Initial Cluster (D)

A common problem when using K-Means algorithm is that it is very sensitive to initial partitioning (Khan & Ahmad, 2004). Thus, it becomes a weakness of the algorithm as we must determine the number of the clusters ourselves. As this algorithm cannot define the appropriate number of clusters by itself, it relies on the user to guess the number of clusters in advance. Therefore, to determine the optimal number of initial clusters, several approaches using other algorithms are needed. A couple of algorithms that are commonly used to determine the optimum initial cluster are the Elbow Method and the Silhouette Index. The Elbow Method is used to determine the best number of clusters that can be used to produce the best cluster results and maximize the quality of cluster results (Dewi & Pramita, 2019) and the Elbow Method determines the best number of clusters from the percentage of comparison between the number of clusters that will form an elbow at a point (Madhulatha, 2007).

The equation (1) below is used to calculate the SSE (Sum of Squared Error) mathematically. Also, the percentage of the calculation result becomes a comparison between the number of clusters (Kodinariya & Makwana, 2013). Elbow shape in this method is formed by comparing one's SSE value with another SSE value. If the SSE value of the first cluster is higher than the second cluster's SSE value, then it forms an elbow-like shape. The best initial cluster is the one with the sharpest decline of the SSE value (Purnima & Arvind, 2014). K is the number of clusters used in the K-Means algorithm, Xi is the number of data, and Ck is the number of clusters in the k cluster. The larger the number of K clusters, the smaller the SSE value (Irwanto et al., 2012). The smaller the SSE value, the better the cluster is.

$$SSE = \sum_{k=1}^{k} \sum_{x_i \in S_k} \|X_i - C_k\|^2 \qquad (1)$$

Similar to the Elbow Method, Silhouette validity index is a statistical measure used to solve the problem of determining the optimal number of K clusters that can provide a brief graphical representation of how well each object is located in the cluster (Rousseeuw, 1987). This method is a combination of the method of separation and cohesion (Kodinariya & Makwana, 2013). The equation (2) below is used to calculate the Silhouette Index mathematically by calculating the average distance of each j object to all objects in cluster p, the same cluster as object j, denoted by ap,j. Then, calculate the average distance of each j object to all objects in cluster q, where p is not equal to q, called dq,j. Then, find ap,j from the minimum dq,j, which shows the objects' mean difference x(j) for the cluster closest to its neighbors. The higher the S$_{x(j)}$ value, the more precise the placement of x$_{(j)}$ to cluster p. Silhouette Index values are usually in the range of -1 to 1. The optimum number of clusters is obtained when the index value is close to 1.

$$S_{x(j)} = \frac{b_{p,j} - a_{p,j}}{max\{a_{p,j}, b_{p,j}\}} \qquad (2)$$

In this stage, we determine the optimum number of the initial cluster (k) using the Elbow Method and Silhouette Index. WEKA software was used in this process. Table 5 contains a description of the results of k clusters for each different dimension after clustering using samples, namely the total value of each dimension (P, R, D, G and S, P, R, D, G).

Table 5: Initial Cluster Result

Initial Cluster Differences			
PRDG Dimension		S+PRDG Dimension	
Elbow	Silhouette	Elbow	Silhouette
k=3	k=5	k=3	k=4

3.5 Clustering Using K-Means (E)

To find caregivers who can withstand the burden, clustering is carried out according to the dimensions of caregiver burden that have been described previously (see Table 2). According to Yedla, Madhu, and Srinivasa Rao Pathakota (2010), clustering is the process of grouping data objects into the same group called a cluster. Clustering is an example of unsupervised classification. Unsupervised is a grouping that does not depend on class and training standards. The grouping can be done using various methods, one of which is K-Means. The K-Means algorithm was first proposed by Stuart Lloyd in 1957 (Lloyd, 1982), even though it was not published until 1982. K-means is a partition clustering method that is widely used in industries. K-means is considered a clustering algorithm since it is easy to implement and the most efficient in terms of execution time.

In this stage, we do clustering using the K-Means algorithm, which was conducted by trying out different scenarios. For example, in the first case scenario, one variable is chosen at random in each dimension of Personal strain, Role strain, Dependency, Guilt (PRDG) and also Social life when clustering is done in the S+PRDG dimension. Clustering was done by trying out 6 scenarios in each dimension. This clustering process adjusts the initial k from the results of both the Elbow Method and Silhouette Index.

The 6 case scenarios referred to in this study were selected randomly. One item from each dimension was then used 6 times with no repetitions, except for the Dependency, Guilt, and Social life dimensions which have a limited variety of variable items, meaning that it is possible to use the same item in the next case. For example, case 1 contained item 9 from the Personal strain dimension, item 16 from the Role strain dimension, item 8 from the Dependency dimension, item 20 from the Guilt dimension, and item 6 from the Social life dimension. Then, case 1 went through a clustering process using the K-Means algorithm and the optimum initial cluster that had been determined previously. The purposes of these scenarios were (1) to test the K-Means clustering algorithm and (2) to find the lowest error rate in one cluster.

In addition to the clustering process using K-Means, the thing that needed to be considered was how much clustering that had been done can group caregivers correctly according to the clusters. This can be seen from the number of clustered errors. The case selected for further analysis regarding which respondents or caregivers were grouped into the cluster as well as each respondent's educational background and work location in Taiwan was the case that had the least number of clustered errors.

3.6 Caregiver Segmentation (F)

After going through the clustering process with K-Means, the average results for each dimension (P, R, D, G and S, P, R, D, G) in each resulting cluster were obtained. As the average value of each dimension was known, the next step was to segment the results of the average value of each dimension in each cluster by comparing it with the average total value of each dimension (P, R, D, G and S, P, R, D, G). The total average value was obtained by adding up the overall average value of the dimensions in each cluster and dividing it by the number of clusters produced. After that, segmentation was done by comparing the results of the average value of each dimension (P, R, D, G and S, P, R, D, G) in each cluster with the average total value. If the average value of each dimension in each cluster (P, R, D, G and S, P, R, D, G) is higher than the average total value, then an over bar appears (e.g., $\overline{D}$: Higher dependency value). However, if the result of the average value of each dimension (P, R, D, G and S, P, R, D, G) in each cluster is lower than the average total value, then an under bar appears. Caregiver feels a dependency burden from care recipient (e.g., $\underline{D}$: Lower dependency value; caregiver does not feel a dependency burden from care recipient) (Ait et al., 2015).

3.7 Government & Recruiter Agencies' Strategies (G)

After rating each cluster based on its segmentation, information about which cluster had the lowest rating value in all aspects of the S+PRDG dimension was obtained. The lowest rating was chosen because the dimension in this research study is the burden of the caregiver, which is negative. Thus, if the rating is low, the caregivers in the cluster are resistant to the burden. Based on the cluster that had the lowest segmentation rating value for each aspect of the dimension, it was also known which caregivers or respondents were included in the cluster. Next, additional information about what factors affected caregiver burden based on key indicators that had been obtained from the multiple regression analysis process as well as each caregiver or respondent's education and work location in Taiwan were examined. Therefore, the information obtained from the results of a series of analysis processes and clustering can help recruiter agencies and the government in selecting, formulating strategies and decisions for prospective Indonesian Migrant Workers or TKI before they get hired abroad by looking at their educational background and work placement locations.

4 Results and Discussion

Two methods were used to determine the initial cluster, namely the Elbow Method and the Silhouette Index, which were followed by clustering using K-Means (see Figure 1). The difference in initial clusters affected the number of clustered errors that were significantly different in both the PRDG and S+PRDG dimensional models. Table 6 and Table 7 describe the trial results of 6 cases and also the total value of each dimension (P, R, D, G and S, P, R, D, G). It can be seen that the initial cluster generated from the Elbow method produced smaller clustered error values in both dimensional models. In addition, the S+PRDG dimensional model had smaller clustered error values using both the initial cluster from the Elbow Method and Silhouette Index when compared to the PRDG dimensional model. By comparing the two models, it was determined that cluster 2 had the lowest burden. The caregiver segmentation is described in Table 9 by taking one case scenario, namely case 4 in the S+PRDG dimensional model. Case 4 consists of 5 ZBI instruments.

Table 6: PRDG Model Clustering Results

| Case | PRDG | | | |
| | Elbow Method K=3 | | Silhouette Index K=5 | |
	Lowest Cluster	Clustered Error	Lowest Cluster	Clustered Error
Total	Cluster 2	38.1 %	Cluster 2	53.17%
Case 1	Cluster 2	40.1%	Cluster 2	30.1%
Case 2	Cluster 2	21.4%	Cluster 2	45.4%
Case 3	Cluster 2	24.7%	Cluster 2	46.8%
Case 4	Cluster 2	11.3%	Cluster 2	33.1%
Case 5	Cluster 2	34.1%	Cluster 2	52.8%
Case 6	Cluster 2	27.7%	Cluster 2	40.8%

Table 7: S+PRDG Model Clustering Results

Case	S+PRDG			
	Elbow Method K=3		Silhouette Index K=5	
	Lowest Cluster	Clustered Error	Lowest Cluster	Clustered Error
Total	Cluster 2	5.3%	Cluster 2	10%
Case 1	Cluster 2	30.1%	Cluster 2	38.4%
Case 2	Cluster 2	8.6%	Cluster 2	19.3%
Case 3	Cluster 2	14%	Cluster 2	22.7%
Case 4	Cluster 2	*3.6%*	Cluster 2	19%
Case 5	Cluster 2	5%	Cluster 2	15.7%
Case 6	Cluster 2	11.3%	Cluster 2	36.7%

Item 3 represents the P dimension, item 7 represents the R dimension, item 8 represents the D dimension, item 21 represents the G dimension, and lastly, item 12 represents the S dimension. Case 4 was chosen because it is in the S+PRDG dimensional model which has a lower clustered error than the PRDG dimension model. In addition, it also has the lowest clustered error value. In Table 8, it can be seen that the average value of cluster 2 in each dimension (S, P, R, D, G) is smaller than the average total value (last row).

Table 8: Comparison of Clusters Based on The K-Means Method

Cluster	Size	P	R	D	G	S	Pattern
1	104	2.56	4.04	3.98	3.70	2.41	$\overline{P}\,\overline{R}\,\overline{D}\,\overline{G}\,\overline{S}$
2	125	1.56	2.12	1.99	2.30	1.47	$\underline{\mathbf{P}\,\mathbf{R}\,\mathbf{D}\,\mathbf{G}\,\mathbf{S}}$
3	70	2.21	1.15	4.4	3.45	2.17	$\overline{P}\,\underline{R}\,\overline{D}\,\overline{G}\,\overline{S}$
Total	299	2.11	2.44	3.45	2.94	2.01	

Thus, the under bar appears in each dimension of cluster 2. Cluster 1 has the highest rating on burden. The average value of each dimension in cluster 1 is higher than the average total value, resulting in the appearance of the upper bar. Based on the results from cluster 1, it is indicated that the caregiver group within the cluster experiences a burden on all dimensions. However, in cluster 3, only the average value of the role strain dimension is lower than the average total value. In cluster 3, the caregivers feel pressured because they have to take care of elderly people and fulfill other obligations for their families. The burden experienced by caregivers is related to personal strain.

In addition, caregivers also feel other burdens such as the dependence of the elderly who rely too much on their caregivers, feeling guilty about not taking care of the elderly optimally, and feeling stressed because they have to take care of the elderly continuously, resulting in them not having the time to socialize with friends and relatives. The next process was finding out which caregivers or respondents were included in cluster 2 and finding out the educational background and work location in Taiwan of each caregiver included in cluster 2. The purpose of the process is to provide information for recruiter agencies and also the government regarding key indicators that have an influence in determining the next prospective workers who will be sent to Taiwan, who are certainly more able to withstand the burden. Table 9 describes which respondents or caregivers are included in cluster 2 along with information about their number of children, education and work locations in Taiwan. Table 9 shows the caregivers (121 respondents) in cluster 2 grouped by their number of children, education and work location. Even though the number of caregivers in this cluster is high, it has a minimum cluster error (3.6%); approximately 4 caregivers (green in the red cluster) were misplaced (see Figure 2).

Table 9: Number of Children, Education, and Location of Work in Cluster 2

Respondent	Total Respondent	The Average of Personal Characteristics		
		Number of Children	Education	Work Location
2,8,10,11,16,17,20,21,23,24,99,100,104,105,107,108,109,110,111,113,30,32,35,36,38,40,41,42,44,45,268,269,273,275,279,281,283,287,288,290,293,49,53,54,57,61,63,66,67,70,71,72,74,76,77,78,80,85,86,93,94,145,146,148,153,155,156,159,161,165,167,120,122,130,134,135,136,137,138,141,143,170,174,175,178,179,181,183,184,186,193,196,198,200,203,210,211,213,214,215,221,222,225,229,235,236,237,240,244,245,247,248,249,254,255,256,257,258,262,263,266	121	2	Junior High School	Capital

Based on the results of the clustering analysis it can be said that cluster 2 in each case of the experimental scenario always has low segmentation results in each dimension based on both PRDG and S+PRDG comparisons. However, based on the results of the cluster error, where the cluster error itself indicates how well the cluster results are formed, we look for clustering results which have the smallest cluster error, and that is in case 4 in the S+PRDG dimension with a cluster error of 3.6%, which means that the cluster formed in case scenario 4 has a validity of 96.4%. The results of the selected clustering, which have been declared valid at 96.4%, are then re-analyzed regarding caregivers who are members of the cluster. The analysis carried out is related to the results of multiple regression, that is personal caregiver characteristics which have the most influence on the burden (number of children, education, and location of work). The results presented (see Table 9) are the average results of the overall personal characteristics of the cluster members.
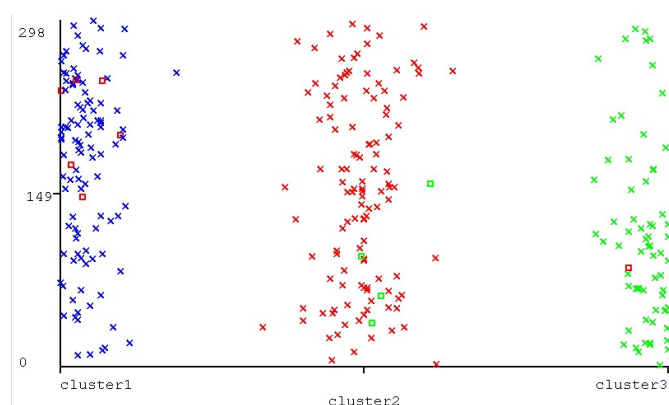

Figure 2: Result of Case 4 Clustering

The number of children, education, and work location of the caregivers in cluster 2 are dominated by those who on average, have 1 child and have a minimum education level of junior high school. Furthermore, most of them work in the capital city of Taiwan (see Table 9). Taipei (capital of Taiwan) is a base location for Indonesian female workers in Taiwan (Representative Office of Indonesia in Taipei, 2020). Taipei's position is in the northern region of Taiwan. The North and Central areas of Taiwan are the areas where the majority of the Indonesian population is located (Taichung City Government, 2010). The large population of Indonesians in both regions (North and Central) may affect the Social life of caregivers in those areas, as socializing can reduce their stress level. This could be one of the reasons why the caregivers in cluster 2 have a low burden. Another information gathered from cluster 2 is the education level of the caregivers. It can be seen that the majority of the caregivers in cluster 2 graduated from junior high school, followed by high school. A higher level of education has more impact on knowledge, maturity, and problem-solving ability in coping with their work as a caregiver (Dambi et al., 2016). Table 9 becomes a pattern that will serve as a guideline for female labor recruitment agencies and also

the government in selecting prospective female workers who will work as caregivers for the elderly before working abroad, especially in Taiwan.

5 Conclusion

The main objective of this study was to find out which caregivers could withstand the burden they face. It revealed that cluster 2 is the most important cluster as it is the cluster that has the lowest load in all dimensions based on the segmentation results. In addition, the caregivers who are included in cluster 2 have been identified based on the results of the clustering. Furthermore, information regarding each caregiver's number of children, educational background, and location of work in Taiwan have been obtained as those are the main indicators affecting caregiver burden.

In addition, this study adds Social life as a dimension based on the literature review of several previous studies that also used the Social life dimension. Other than that, there is a separation of items from the Personal strain dimension into dimensions related to social problems of the caregivers, which is called Social strain or Personal and Social strains in some studies. This study also found that the novel dimension (social life) other than PRDG, that is S+PRDG, has better cluster accuracy than the existing PRDG dimensions. This is a strong reason why Social life is added to the dimensions that already exist. Better cluster accuracy is obtained based on the results of clustering, where the dimensions of S+PRDG in all cases with the initial cluster using the Elbow Method k=3 or using the initial cluster Silhouette Index k=5 resulted in a lower percentage of clustered error than the PRDG dimension, both when using the initial cluster with the Elbow Method k=3 or with the Silhouette Index k=4. Besides, it is also known that in both the PRDG dimensions and the modified S+PRDG dimensions, the use of a smaller initial cluster k=3 results in a low cluster error. Based on Table 6 and Table 7, the lowest clustered error with a percentage of 3.6% is in case 4, which is in the S + PRDG dimension and the initial cluster using the Elbow Method k=3.

The findings of this study are expected to be used by recruiting agents and the Indonesian government as a guide for them in selecting prospective female workers, especially those who work as caregivers in Taiwan. This is explained specifically for selecting prospective female caregivers who will work in Taiwan because it relates to the data used in this study, which is collected from Indonesian female caregivers for the elderly who have worked in Taiwan. However, caregivers who work in Taiwan are not only female caregivers and from Indonesia, but there are also male caregivers and from other countries as migrant workers, and they do not only work specifically to care for the elderly, but also to care for patients who are chronically ill and patients who need special care. Therefore, we recommend that future research be done by collecting different datasets such as datasets for male caregivers or random (both male and female caregivers), based on their country of origin as in this study, and it would be better if, the case studies that are examined are also different, such as caregivers who treat patients with cancer, etc. Furthermore, the use of other analytical techniques is also required, such as the use of other clustering analysis techniques, namely Fuzzy Logic, K-Medoid, DBSCAN, etc., which of course will result in the number of clusters and different levels of accuracy, and will affect the cluster segmentation. In addition, future analysis can also combine optimization algorithms such as genetic algorithms, PSO (particle swarm optimization) algorithms, etc., for more optimal clustering results.

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