CHAPTER 3

METHODOLOGY

The purpose of this chapter is to present the methodology used in this research. This research intends to provide an overall conceptual framework of research, together with a summary and sequence of steps involved.

Research Design and Data Collection

This study is a descriptive and cross-sectional study that uses questionnaires as a survey instrument for the collection of data and information. The information and survey data are collected in various ways, including a literature review, a survey by a questionnaire designed for self-completion. Quantitative analysis is mainly used; however, qualitative techniques are also utilized to provide an interpretation of the research results. The use of both techniques will provide more reliable and valid information for data analysis according to the hypotheses on which the study is based.

This study focuses upon the level of the police station as the unit of analysis in that that is closely attached to people living in the vicinity. The study areas are representative of each part of the country, such as the Bangkok Metropolitan area, as well as the Northern, Western, and Eastern regions. The sub-sections in each police station were also observed and subjected to analysis.

Design of the Survey

Population

For the purposes of this study, police officers, both commissioned and non-commissioned, working in each part of the country, including the Bangkok Metropolitan area, as well as the Northern, Western, and Eastern regions, were observed. The size of the population of police officers was 221, 839 (Royal Thai Police, Metropolitan Police Bureau, 2001).

Sampling Strategies and Sample Size

Firstly, the random sampling technique was used to select a representative sample of police stations as the focus of the study. The second stage involved the calculation of the sample size of police officers from the total number of police officers in the police stations selected for the purposes of this study, using Yamane's formula, with a deviation value at 0.05: (Yamane, 1973)

$$n = \frac{N}{1 + Ne^2}$$

when n = Sample size

N = Population size

e = Deviation Value of sampling of 0.05

Calculation of sample size of police officers

$$n = \frac{221{,}839}{1 + 221{,}839 \times (0.05)^2}$$

When the population of police officers is 221,839, the sample size of police officers is 399.

The third stage involved the use of proportionally stratified random sampling to select a sample of 399. The sample size in each police station varies according to the number of officers, both commissioned and non-commissioned, working in the various police stations in each part of Thailand, as illustrated in Table 7 below.

Table 7

Sample Size of Police Officers

Police Station	Sample Size
Metropolitan area	100
Northern region	100
Western region	100
Eastern region	100
Total	400

Analysis Tool

SPSS is a statistical software package capable of effectively analyzing data, the results of which are displayed in the form of graphs and tables. These are as follows: (1) data editor (2) viewer or output navigator (3) multidimensional pivot tables (4) high-resolution graphics (5) database access (6) data transformation (7) electronic distribution SPSS (8) outline help.

Norusis (1983) states that the SPSS batch system is a comprehensive tool for managing, analyzing, and displaying data. A broad range of statistical analyses and data modification tasks are accomplished with a simple, English-like language. Results can be easily obtained with minimal understanding of computer intricacies.

SPSS is a comprehensive statistical software system designed to handle all steps in an analysis ranging from data listings, tabulations, and descriptive statistics to complex statistical analyses. Meaningful results are seldom found by simply passing numbers through a statistical procedure. After decades of developing software and receiving feedback from a broad group of users, SPSS has incorporated an abundance of options and features to help researchers better understand their data and communicate the results to others. Graphics integrated with the statistical procedures are helpful in both understanding and communicating results. (SPSS Base 8.0 Application)

Variables of the Study

The study areas are representative of each part of the country, including the, Northern, Western, and Eastern regions, as well as the Bangkok Metropolitan area. The sub-sections in the police stations under study were observed for further analysis. A behavioral analysis will be conducted to provide estimates of the factors related to job performance and job satisfaction. Each factor will be investigated using statistical analysis and Multivariate Analysis, namely the logistic regression model (Agresti, 1996;

Berry & Lindgren, 1990). The different administrative areas and sub-sections will be compared using non-parametric statistic analysis (Siegel, 1956).

The factors affecting work motivation are then, examined as independent variables, namely factors relating to socioeconomic background, the administration, and benefits, while the dependent variable is the level of satisfaction. The aim of this process is to collect information regarding the specific background characteristics, behavior and opinions of the sample, as shown in Table 8 below.

Table 8

The Independent Variables to be Analyzed

Socioeconomic Background factors	Job Satisfaction	Job Performance
Gender of the respondent	Work group	Quality of work
Age of the respondent	The work itself	Quantity of work
General level of education	Working conditions	Timeliness
Police rank of the respondent	Supervision	Efficiency
Type of work	Payment	Job knowledge (Competence) and skills
Length of service in police station	Opportunities for promotion	Judgment ability
Overall length of service		Adaptability
Marital status of the respondent		
Household type		
Children in household		
Household income		
Household members (size)		
Ownership of residence		
Motorcycle ownership		
Car ownership		

Single questions were used for collecting uncomplicated data, for example information relating to personal background and demographics. For the more complicated data questions, a categories selection was used. Furthermore, two variables, such job satisfaction and job performance will be investigated in order to understand the situation of each section of police organization. Indicators of police officers' job satisfaction and job performance will also be accessed through a self-reporting mechanism measure using Likert's five-point rating scale. The two variables are as follows:

Variable 1: Job satisfaction: This is assessed through a self-report regarding police officers' opinion as to whether they experience a pleasurable or positive emotional state resulting from a positive appraisal of their job or job experience. This is measured using the following six categories:

1. Payment: This refers to the amount of financial remuneration that police officers receive and the degree to which this is viewed as equitable compared with that received by others in the Royal Thai Police. Pay includes salary, welfare, and fringe benefits.

2. The work itself (Nature of work assignment): This refers to the extent to which the job provides the police officers with interesting tasks, opportunities for learning, and the chance to accept responsibility.

3. Opportunities for promotion (promotion and policy procedures): This refers to the chance for advancement in the hierarchy of the Royal Thai Police.

4. Supervision: This refers to the abilities of the police superiors to provide technical assistance and behavioral support. Supervision also covers control, examination, monitoring, the relationship between superior and subordinate, providing advice, solving problems, giving subordinate a chance for participation, and treating subordinates fairly.

5. Work group (Working relationship with colleagues): This refers to the degree to which police colleagues are technically proficient and socially supportive.

6. Working conditions: This refers to the degree to which the physical environment contributes toward police work.

Variable 2: Job performance: This is assessed through a self-report measure of police officers' opinion as to how often they successfully perform several job-related behaviors and outcomes. These are measured in terms of the following seven factors:

1. Quality of work: This refers to the characteristics of output that enhance the usefulness to people as the recipients.

2. Quantity of work: This refers to the volume of useful output associated with police officers' job assignments.

3. Timeliness: This refers to the use of appropriate time on production of output that is speedy, fast, finishing on time, etc.

4. Efficiency: This refers to the ability of police officers to minimize input and to maximize output, which means that they use the least administrative resources of input-men, money, and materials-for purposes of best production.

5. Job knowledge (Competence and skills): This refers to efficiently solve problems, technical, conceptual, and structurally oriented.

6. Judgement: This refers to the ability of police officers to exercise discretionary behavior.

7. Adaptability: This refers to the ability of police officers to adjust properly and expeditiously to changing and unstructured situations, as well as to problems encountered within the working environment.

Furthermore, the Pairwise-Comparison Technique (AHP) will be applied in terms of the Analytical Hierarchy Process in order to determine important strategies for operational police officers. This is a technique for decision-making which can assist in identifying and weighting selection criteria, analyzing the data collected for the criteria, and expediting the decision-making process (Webber et al. 1996). Critical factors will be identified by comparing each variable in order to better understand police officers' needs with regard to their benefits. The variables to be compared are as follows:

1. Improve police payment standard
    1.1 Improve salary standard
    1.2 Improve salary/promotion steps
    1.3 Improve basic additional allowance
    1.4 Improve additional allowance for extra-responsibilities
    1.5 Allowance for food and other expenses
2. Improve system regarding right to take leave
    2.1 Leave of absence

2.2 Annual vacation leave

2.3 Sick leave

3. Improve government reserve fund and cooperative police society fund

3.1 Retirement allowance/pension paid

3.2 Superannuation and gratuities

3.3 Tuition fees for children's education

4. Improve criteria and standards relating to career and position

4.1 Appropriate training and seminars to improve skills and techniques regarding service delivery

4.2 Encourage further academic study

4.3 Improve opportunity for career advancement and promotion

4.4 Equity, justice and potential in the job environment

5. Improve standard of living

5.1 Existing police residence

5.2 Provide new residence

5.3 Medical service and medical fees for police officers' families

6. Improve job environment for delivering services to the public

6.1 Facilities

6.2 Weapons, vehicles and equipment

6.3 Out-of-date materials

Indicators of police officers' job satisfaction and job performance were also assessed through a self-reporting mechanism using Likert's five-point rating scale, as illustrated in Table 9, and Table 10.

Table 9

Measurement of Variables Regarding Police Officers' Job Satisfaction

Variables	Description	Indicators	Question No.
Job Satisfaction	The pleasure or displeasure resulting from appraisal of the police officers' job or their job experience	Job satisfaction is assessed through a self-reported measurement by police officers on six influences. For this purpose, Likert's five-point rating scale is used. The results will show: 1) the average value (mean) and standard deviation 2) the correlation coefficient	Part III: 1-20
Work Group	The amount of financial remuneration that police officers receive and the degree to with others in the Royal Thai Police. Pay includes salary, welfare, and fringe benefits.		1-3
The Work Itself	The extent to which the job provides the police officers with interesting tasks, opportunities for learning, and the chance to accept responsibility.		4-7
Working Conditions	The chances for advancement within the hierarchy of the Royal Thai Police.		8-10
Supervision	The abilities of police superiors to provide technical assistance and behavioral support. Supervision also covers control, examination, monitoring, the relationship between superiors and subordinates, providing advice, solving problems, and treating subordinates fairly.		11-14
Remuneration	The degree to which police colleague are technically proficient and socially supportive.		15-17
Opportunities for Promotion	The degree to which the physical environment contributes toward police work and enhances the workplace.		18-19

Table 10

Measure of Variables on Police Officers' Job Performance

Variables	Descriptions	Indicators	Question No.
Job Performance	The level of police officers' practices on several job related-behaviors and outcomes.	Job performance is assessed through a	Part IV: 1-7
Quality of work	The characteristics of useful output that enhance the usefulness to the public as the recipients of police services.	self-reported measure of police officers on seven	1
Quantity of Work	The volume of useful output associated with police officers' job assignments.	factors influences. Likert's five-point	2
Timeliness	The appropriate time spent on production of output, which is speedy, fast, finishing assignments on time, etc.	rating scale is used. The results will show:	3
Efficiency	The ability of police officers to minimize input and to maximize output.	1) the average value (mean) and	4
Job knowledge (Competence) and skills	The ability of police officers to sufficiently solve problems, technical, conceptual, and structurally oriented.	standard deviation 2) the correlation coefficient	5
Judgment Ability	The ability of police officers to exercise discretionary behavior.		6
Adaptability	The ability of police officers to adjust properly and expeditiously to changing and unstructured situations.		7

Questionnaire Design

The questionnaires (see Appendix A) were designed by using the guidelines recommended by Warwick and Lininger (1975).

Each type of questionnaire was accompanied by a cover letter asking for cooperation in completing it. The objectives of the research are explained

on the front page. The second page describes suggestions and the methods to be used in completing the questionnaire. It is arranged into five parts, with the items in each part numbered consecutively. The first part deals with general background information on the respondents. The second part deals with the satisfaction of the respondents regarding the transformation into the Royal Thai Police, decentralization, and public participation. The third part deals with the level of job satisfaction of the respondents, wherein questions are asked about pay, the work itself, opportunities for promotion, supervision, work group, and working conditions. The fourth part concerns a pairwise comparison of factors related to police officers' benefit. The second, the third, and the fourth parts all use a five-point scale response format to measure respondents' level of satisfaction with regard to various characteristics. The fifth part uses open-ended questions to elicit suggestions from the respondents.

Validity of the Questionnaire

Validity refers to the extent to which any measuring instrument measures what it is intended to measure (Carmines & Zeller, 1979).

The validity of the questionnaire is established by using the method of content validity, whereby the researcher must fulfill the following conditions:

1. Review the relevant literature and related research in a clear and concise manner, including underlying contents concerning measurement of those incidents,

2. Select representative data from each part of the contents in an efficient manner, and

3. Compile the representative data or items and arrange them in a testable format.

The questionnaire will be constructed by following the above three steps. Additionally, three scholars will be requested to examine and make comments on the items in the questionnaire to ensure content validity during the development stage of the questionnaire. After revising each item's content according to the comments and suggestions, the questionnaire will be ready to be distributed in order to determine its reliability.

Pilot Test

A pilot survey of the samples was designed and a preliminary test conducted before the actual survey took place. A survey questionnaire was designed in order to facilitate the procedure relating to data collection and to keep it straightforward and clear enough for ease of understanding by the respondents. The questionnaire was pilot-tested on respondents similar to those sampled in the main study. The main objective of the pilot test, which was tried out at Chonburi Police Station, was to check its wording and format, as well as to measure the reliability of the questionnaire itself.

As a result of both the pilot test and consultation with members of the research committee, revisions were made to the questionnaire. Some modifications were made to the format and content, especially some of the wording that was not clearly understood, in order to improve the overall

validation of questionnaire. The data was entered into the Statistical Package for the Social Science (SPSS for Windows) for both quantitative and qualitative analyses.

Reliability of the Questionnaire

Reliability concerns the extent to which an experiment, test, or any measuring procedure, yields the same results on repeated trials (Carmines & Zeller, 1979). The most well-liked test for examining the reliability of the questionnaire is Alpha Cronbach's coefficient (Cronbach, 1951) which is used to determine the internal consistency of a measure. George and Mallery (2003) provide the following criteria:

1. >0.9 : Excellent,
2. >0.8 : Good,
3. >0.7 : Acceptable,
4. >0.6 : Questionable,
5. >0.5 : Poor, and
6. < .5 : Unacceptable

Data Collection and Coding

Data collection is planning for and obtaining useful information on key quality characteristics produced by developed design process (Yamane, 1973). Therefore, questionnaires are needed to collect the opinions of operational officers. Due to time and budgetary constraints, the method of data collection

is conducted by means of questionnaire surveys of provincial police organizations. Pilot tests were carried out during March 2008, whereas the data collection process itself was conducted during May to July 2008, with an objective the gathering useful information from police officers nationwide. With regard to the sample size calculated in Section 3.2.2 (400 samples), 495 questionnaires were surveyed in order to correct any errors they contained, of which only 400 questionnaires contained complete information capable of being used for research analysis. The instructions for answering the questionnaire were formulated before the questionnaires were distributed in order to ensure the quality of the information they contained. This questionnaire was divided into five parts as follows:

Part I: Personal background,

Part II: Questions regarding police officer's opinions regarding their feelings of satisfaction or dissatisfaction with certain characteristics and activities of the police,

Part III: Questions pertaining to the on-the-job performance police officers,

Part IV: A pairwise comparison of factors related to police benefits, and

Part V: Suggestions for the future development of the Royal Thai Police.

In addition, a coding process was been formulated both for organizing the data and providing a means to introduce the interpretations of it into

certain quantitative methods. Each segment is labeled with a "code" suggesting how the associated data segments inform the research objectives.

A frequent criticism of the coding method is that it seeks to transform qualitative data into quantitative data, which can be seen in the open-ended questions in Part V, thereby draining the data of its variety, richness, and individual character.

Data Analysis

Data collected from samples were analyzed statistically using SPSS for Windows. The data analysis of this study was categorized into two parts, as follows:

Quantitative Data Analysis

Statistical techniques were used for the quantitative data analysis, the results of which were presented in the form of percentages, means scores, standard deviation, and Pearson's product moment correlation coefficient. A behavioral analysis was conducted to provide estimates of factors related to work incentives using the Multivariate Analysis technique. The different administrative areas and sub-sections were compared using non-parametric statistical analysis. Furthermore, the Analytical Hierarchy Process (AHP) was applied as a pair-wise comparison analysis in order to determine the important strategies to be adopted by operational police.

1. Testing of Hypotheses

This section describes the means of hypothesis testing using proven statistical methods. The body of data set examined and tested for normality distribution and homogeneity of variance in order to determine the suitable statistical type. In a special case involving testing for normality of distribution, samples are standardized and compared with a standard normal distribution. The Kolmogorov-Smirnov test was used to determine goodness of fit, while Levene's test was applied to determine homogeneity of variance.

2. Multivariate Analysis using the Logistic Regression Model

Logistic regression is a statistical technique that has been developed specifically for analyzing relationships between dichotomous dependent variables (events-whether they occur or not) and categorical/interval/ continuous independent variables (Agresti, 1996; Horowitz, Koppelman, & Lerman, 2000; Menard, 2001; Tabachnick & Fidell, 1996). The binary logistic regression model for job satisfaction and job performance, estimates the probability of a respondent being involved in each group as a function of predictor variables (independent variables), including the socioeconomic characteristics of the respondents. This model is used in this research since the dependent variable Y (group classification) can only take on two values, i.e. a respondent with job satisfaction and a respondent lacking in job satisfaction. The probability that a respondent would exhibit job satisfaction is given in equation 2.1, and the logistic regression model (Z_i) is given in equation 2.2.

$$\pi_i = \frac{e^{Z_i}}{1+e^{Z_i}} \tag{2.1}$$

$$Z_i = \ln\left(\frac{\pi_i}{1-\pi_i}\right) = B_0 + B_1X_1 + B_2X_2 + \ldots + B_NX_N \tag{2.2}$$

Where π_i is the likelihood that a respondent would exhibit job satisfaction; X's are independent predictor variables, while both main effects and interactions can generally be accommodated; B's are model coefficients and are estimated by using the maximum likelihood method.

A maximum likelihood estimate is a parameter value whereby the data actually obtained have the highest probability of being observed (Berry & Lindgren, 1990). The likelihood of the entire observed sample is given as a product of the likelihood of the individual observations, which is shown in equation 2.3

$$L = \prod_{n \in N} \prod_{n \in J} P_n(j)^{\delta jn} \qquad (2.3)$$

Where;

L = Likelihood of the entire observed sample

N = All observations

J = Choice containing all the alternatives

$Pn(j)$ = Probability of individual n choosing alternative j

δjn = 1 if individual n chooses alternative j, and 0 otherwise.

Regarding to the above likelihood function, equation, is in exponential form. Because the exponential function is monotonic, maximizing the log of the likelihood function is the same as maximizing the likelihood function. The log likelihood function, denoted as L^*, is given by equation 2.4

$$ln\, L = {}^*L = ln \prod_{n \in N} \prod_{n \in J} P_n(j)^{\delta jn} \qquad (2.4)$$

$$^* L = \sum_n \sum_j \left(\delta_{jn} . ln\, P_{jn}\right) \qquad (2.5)$$

This non-linear function has been shown to have the property of global concavity (McFadden, 1973) and can be maximized using any of the non-linear optimization algorithms. Since it is more convenient to work with the log likelihood function than with the likelihood function, it is common practice to maximize the function in equation 2.5.

It is generally acknowledged that the goal of logistic regression is to correctly predict the category of outcome for individual cases using the most parsimonious model. To accomplish this goal, a model is created that includes all predictor variables that are useful in predicting the response variable. Several different options are available during model creation. Variables can be entered into the model in the order specified by the researcher or logistic regression can test the fit of the model after each coefficient is added or deleted, called stepwise regression.

Stepwise regression is used in the exploratory phase of research but it is not recommended for theory testing (Menard, 2001). Theory testing is the testing of a-priori theories or hypotheses of the relationships between variables. Exploratory testing makes no a-priori assumptions regarding the relationships between the variables; thus the goal is to discover relationships.

There are two main uses of logistic regression. The first is the prediction of group membership. Since logistic regression calculates the probability or success over the probability of failure, the results of the analysis are in the form of an odds ratio. Logistic regression also provides knowledge of the relationships and strengths among the variables. The process by which

coefficients are tested for significance for inclusion or elimination from the model involves several different techniques.

The null hypothesis is that all coefficients in the equation take the value zero. The null hypothesis can be statistically rejected if any relevant model parameter is different from zero at a 0.05 significance level. An individual predictor variable is assessed for inclusion using the Wald statistical test and test of change with a -2-log-likelihood (-2-LL). A Wald test is used to test the statistical significance of each coefficient (β) in the model. A Wald test calculates a Z statistic, which is shown in equation 2.6

$$Z = \frac{\hat{\beta}}{SE} \qquad (2.6)$$

This z value is then squared, yielding a Wald statistic with a chi-square distribution. However, several authors have identified problems with the use of the Wald statistic. Menard (2001) warns that for large coefficients, standard error is inflated, lowering the Wald statistic's (chi-square) value. Agresti (1996) states that the likelihood-ratio test is more reliable for a small sample sizes than the Wald test.

The likelihood-ratio test uses the ratio of the maximized value of the likelihood function for the full model (L_1) over the maximized value of the likelihood function for the simpler model (L_0). The likelihood-ratio test statistic is shown in equation 2.7

$$-2\log\left(\frac{L_0}{L_1}\right) = -2[\log(L_0) - \log(L_1)] = -2(L_0 - L_1) \qquad (2.7)$$

This log transformation of the likelihood functions yields a chi-squared statistic. This is the recommended test statistic to use when building a model through stepwise elimination in the SPSS (Norusis, 1983).

The Hosmer-Lemshow statistic evaluates the goodness-of-fit by creating 10 ordered groups of subjects and then compares the actual number in each group (observed) to the number predicted by the logistic regression model (predicted). Thus, the test statistic is a chi-square statistic with a desirable outcome of non-significance, indicating that the model prediction does not significantly differ from the observed. The 10 ordered groups are created based on their estimated probability; those with an estimated probability of below 0.1 form one group, and so on, up to those with a probability of 0.9 to 1.0. Each of these categories is further divided into two groups based on the actual observed outcome variable (success, failure). The expected frequencies for each of the cells are obtained from the model. If the model is good, then most of the subjects with success are classified in the higher deciles of risk and those with failure in the lower deciles of risk (Hosmer & Lemeshow, 2000).

The advantage of the model derived from binary logistic regression, besides the ability to predict the probabilities of respondents being involved in each group for job satisfaction and job performance, is that with all other predictor variables held constant, the probability of being involved in a satisfying job which may increase/decrease for every unit increment in each predictor variable, can be estimated. This increase/decrease is equal to the model coefficients (B_i) and is recognized as log odds. On the other hand, the odds of an event, which can be called "odds ratios", are more useful than the log odds. The odds ratios can be estimated using equation 2.8

$$\text{The odds ratios (O.R.)} = e^{B_i} \; ; i = 1, 2, \ldots, N \qquad (2.8)$$

The odds ratios are defined as the probability of the event occurring divided by the probability of the event not occurring. It is an exponential term raised to the power of the coefficient of the predictor variable.

Selection of independent variables:

The traditional approach to statistical model building involves seeking the most parsimonious model that still explains the data. The rationale for minimizing the number of variables in the model is that the resultant model is more likely to be numerically stable and is more easily generalized.

With regard to variable selection, forward stepwise method is used in this study, as it builds models in a sequential fashion and allows for the examination of a collection of models as shown in Figure 11. The forward stepwise method works in the following way: It starts out with a model that contains only the constant. At each step, -2×log likelihood (-2*LL*) values of the model with and without a certain independent variable are calculated.

The independent variable in question is selected from among the variables not included in the model up to that point. Variables considered in this fashion are referred to as candidate variables and -2*LL* is called the likelihood ratio statistic. The significance of the candidate variable is assessed on the computed likelihood ratio statistic and the degree of freedom of the variable. After the significance level of each candidate variables has been assessed, the one with the smallest significance level is selected to enter the model, provided it is less than the chosen cutoff value (0.05 in this case).

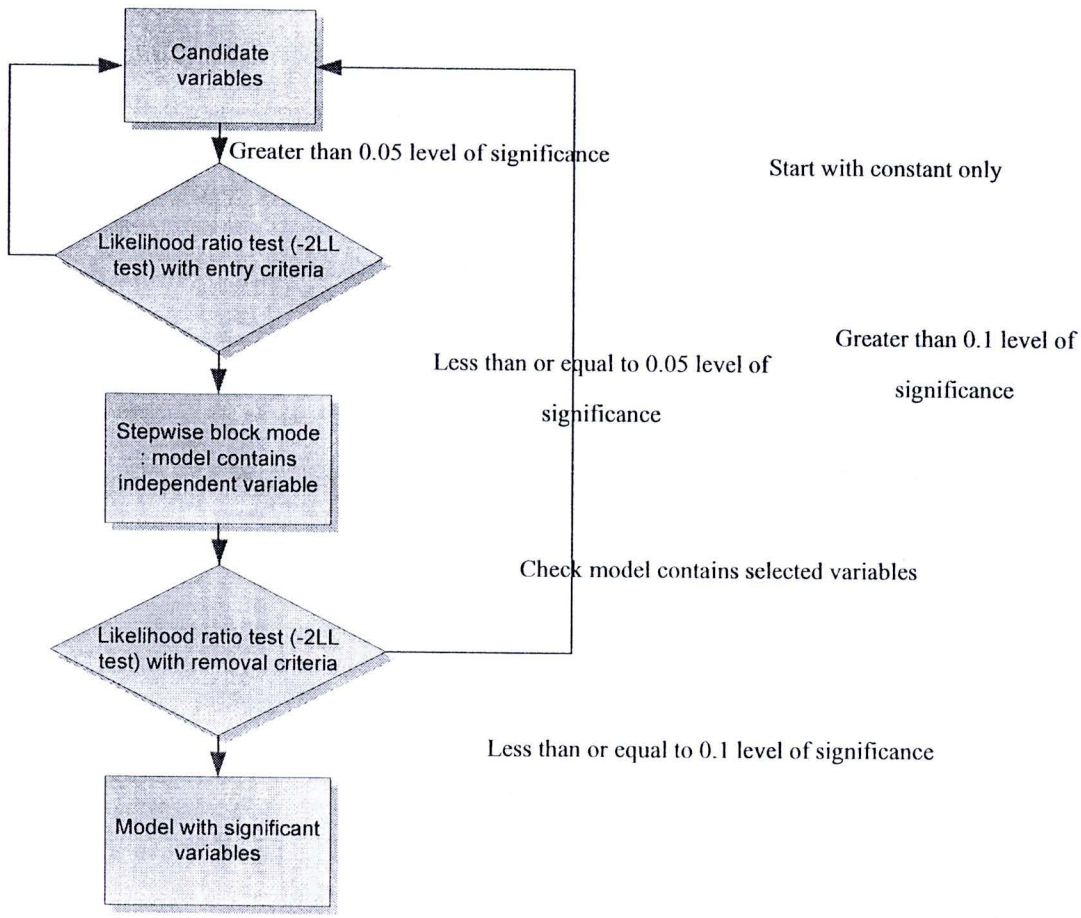

Figure 11 A forward stepwise method for logistic regression.

Since the entry of the new variable may change the significance of other variables, all other variables in the forward stepwise block that have been entered are then examined to see if they meet the removal criteria. The variable with the largest significance level for the likelihood-ratio statistic is removed from the model, provided it exceeds the chosen cutoff value (0.10 in this case). If no variables meet the removal criteria, the next eligible variable is entered into the model. If no variables meet the entry criteria, or if a variable is selected for removal, which results in a model that has already been considered, variable selection stops. The likelihood ratio test was used

for both the entry and removal of variables as research has shown it has the best statistical properties.

3. Pairwise comparisons in The Analytical Hierarchy Process (AHP)

Furthermore, the Analytical Hierarchy Process (AHP) was applied in order to determine the important strategies to be adopted by operational police officers. The Analytical Hierarchy Process (AHP) is an approach to decision-making that involves structuring multiple choice criteria into a hierarchy, assessing the relative importance of these criteria, comparing alternatives for each criterion, and determining an overall ranking of the alternatives. It is a structured technique for helping people deal with complex decisions. Based on mathematics and human psychology, the concept of AHP was developed by Saaty (1995) (Professor, University of Pittsburgh) in the 1970s and has been extensively studied and refined since then. It is used throughout the world in a wide variety of decision-making situations, in fields such as government, business, industry, healthcare, and education.

To incorporate their judgments about the various elements in the hierarchy, police officers compare the benefits two by two. The Criteria will be compared as to how important they are to the police officer, with respect to the Goal. The results can be used to set up the strategy for benefit of police, as know bottom-up approach.

The AHP carries out comparisons of the elements involved in a decision in an appropriate manner to derive their scales of priorities. Although paired comparisons are a simple concept (essential for the participation of non-technically trained experts), the way they are used in the AHP is novel

and unique. To make pairwise comparison judgments, the fundamental scale of the AHP of absolute values 1 to 9 and their reciprocals given in Table 11 below is used (Rabbani, 1996). Only homogeneous elements are compared. Clustering is needed to group and compare such elements including a common element from one cluster to an adjacent cluster. Because of the homogeneity requirement, one rarely compares more than seven elements in order to maintain good consistency. When there are more than seven elements, one can divide them into clusters with a common element from one cluster to another enabling one to combine the two clusters after deriving the relative scale for each (Saaty, 1995).

Table 11

Scale for Pairwise Comparisons

Scale	Meaning
1	Equal importance
3	Moderate importance of one over another
5	Strong or essential importance
7	Very strong or demonstrated importance
9	Extreme importance
2,4,6,8	Intermediate values

Note. From *Decisions in Transportation with the Analytic Hierarchy Process* (p. 165), by S. J., Rabbani and S. R. Rabbani, 1996, Paraiba, Brazil: Simon and Soheil Rabbani.

Saaty (1995) explains that the AHP process has several major uses, allowing the decision-maker to do the following:

1. Design a form that represents a complex problem
2. Measure priorities and choose among alternatives
3. Measure consistency
4. Predict
5. Formulate a benefit/cost analysis
6. Design forward/backward planning
7. Analyze conflict resolution
8. Develop allocation of resources from the benefit/cost analysis.

Priority as an Eigenvector: Relation to Consistency

In this study, the concept of AHP analysis, based on the principle expounded by Saaty (1990), the basic concept of this approach is demonstrated in the following section. Assume that n alternative are being considered with respect to the following goals:

1. To provide judgments on the relative importance of these activities
2. To ensure that the judgments are quantified to an extent which also permits a quantitative interpretation of the judgment among all activities.

Let us consider the element (criteria) $C_1, \ldots, C_n$ of some level in a hierarchy. We wish to find their weights of influence, $w_1, \ldots, w_n$, on some elements (alternatives) in the next level. Our basic tool is n-by-n matrix of numbers, representing our judgment of pairwise comparisons. We denote by

a_{ij} the number indicating the strength of C_i when compared with C_j. The matrix of these number a_{ij} is denoted A, or,

$$A = (ay), \qquad (i, j = 1, 2, \ldots, n) \tag{2.9}$$

The entires a_{ij} are defined by the following entry rules.

1. *Rule1*; If $a_{ij} = \alpha$, then $a_{ij} = 1/\alpha$, $\alpha \neq 0$.

2. *Rule2*; If C_i is judged to be of equal relative importance as C_j, then $a_{ij}=1$, $a_{ij} = 1$; in particular $a_{ij} = 1$, for all i.

Thus, the matrix A has the form

$$A = (a_{ij}) = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \tag{2.10}$$

Thus, our matrix A of judgements is reciprocal. If our judgment is perfect in all comparisons of can be exactly measured, then $a_{ik} = a_{ij}$ x a_{ik} for all i, j, k and we can call the matrix A consistent. An obvious case of a consistent matrix is one in which the comparisons are based on exact measurements; that is, the weights $w_1, \ldots, w_n$ are already known. Then:

$$a_{ij} = \frac{w_i}{w_j} \qquad i, j = 1, \ldots, n \tag{2.11}$$

and thus;

$$a_{ji} = \frac{w_j}{w_i} = \frac{1}{w_i / w_j} = \frac{1}{a_{ij}} \tag{2.12}$$

Also,

$$a_{ij} \cdot a_{jk} = \frac{w_i}{w_j} \cdot \frac{w_j}{w_k} = \frac{w_i}{w_k} = a_{ik} \tag{2.13}$$

Consider the matrix equation

$$A \cdot x = y \tag{2.14}$$

Where, $x = (x_1, \ldots, x_n)$ and $y = (y_1, \ldots, y_n)$, is a shorthand notation for the set of equations.

$$\sum_{j=1}^{n} a_{ij} x_i = y_i \qquad i = 1, \ldots, n \tag{2.15}$$

Now, we observe that from Equation (3.11) we obtain

$$a_{ij} \cdot \frac{w_j}{w_i} = 1 \qquad i, j = 1, \ldots, n \tag{2.16}$$

and subsequently

$$\sum_{j=1}^{n} a_{ij} w_j \frac{1}{w_i} = n \qquad i = 1, \ldots, n \tag{2.17}$$

or

$$\sum_{j=1}^{n} a_{ij} w_j = n w_i \qquad i = 1, \ldots, n \tag{2.18}$$

which is equivalent to;

$$Aw = nw \tag{2.19}$$

In matrix theory, this formula expresses the fact that w is an eigenvector of A with eigenvalue n. When written out fully this equation looks as follows:

$$Aw = (a_{ij})w = \begin{array}{c|cccc} & A_1 & A_2 & \cdots & A_n \\ \hline A_1 & \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ A_2 & \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & & \vdots \\ A_n & \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{array} \times \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = n \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}$$

(2.20)

In practice, however, in which the a_{ij} are not based on exact measurements, but on subjective judgments, the Equation 2.18 no longer holds since a_{ij} will deviate from the "ideal" ratios w_i / w_j. Two facts of matrix theory are then considered. The first one is this. If $\lambda_1, \ldots, \lambda_n$ are the numbers satisfying the equation

$$Ax = \lambda x \tag{2.21}$$

i.e., are the eigenvalues of A, and if $a_{ij} = 1$ for all i, then

$$\sum_{i=1}^{n} \lambda_i = n \tag{2.22}$$

Therefore, if (2.19) holds, then all eigenvalues are zero, except one, which is *n*. Clearly, then, in the consistent case, *n* is the largest eigenvalue of A.

The second helpful fact is that if one changes the entries a_{ij} of a positive reciprocal matrix A by small amounts, then the eigenvalues change by small amounts.

Combining these two results, we find that if the diagonal of a matrix A consist of ones ($a_{ii} = 1$), and if A is consistent, then small variations of the a_{ij}

keep the largest eigenvalue, λ_{max}, close to n, and the remaining eigenvalues close to zero.

Therefore, if A is the matrix of pairwise comparison values, in order to find the priority vector, the vector w must be found to satisfy

$$Aw = \lambda_{max} w \tag{2.23}$$

Since it is desirable to have a normalized solution, w is slightly altered by setting

$$\alpha = \sum_{i=1}^{n} w_i \qquad w \text{ by } \left(\frac{1}{\alpha}\right)w. \qquad \sum_{i=1}^{n} w_i = 1.$$

and replacing This ensures uniqueness, and also that

Observe that since small changes in a_{ij} imply a small change in λ_{max}, the deviation of the latter from n is a measure of consistency. It enables us to evaluate the closeness of our derived scale from an underlying ratio scale, which we wish to estimate. Thus, the consistency index (C.I.) can be calculated as the following equation.

$$\frac{\lambda_{max} - n}{n-1} \tag{2.24}$$

For each size of matrix n, random matrices were generated and their mean C.I. value, called the random index (R.I.), was computed; these values are illustrated in Table 12. Using these values, the consistency ratio (C.R.) is defined as the ratio of the C.I. to the R.I. as shown in Equation (2.24)

$$C.R. = \frac{C.I.}{R.I.} \tag{2.25}$$

Table 12

Random Inconsistency Index (R.I.)

N	R.I
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51
12	1.48
13	1.56
14	1.57
15	1.59

Note. Form Applications of the Analytic Hierarchy Process: A Categorized, Annotated Bibliography (p. 39), by B. L. Golden, 1989, In B. L. Golden (Ed.) *The Analytic Hierarchy Process Applications and Studies.* Berlin: Springer Verlag.

Qualitative Data Analysis

Data analysis from in-depth interviews with senior police officers was used to compare bottom-up opinions and top-down opinions regarding their

needs. This can be an advantage both for the government and members of the public; even observations of police officers' behavior may support the quantitative results or may not. The results will be including explicitly explained factors, influences, or the relationship of variables. Suggestions and recommendations from both police officers and members of the public will prove valuable in the terms of the development of academic and practical applications.