USING THE CHARACTERISTICS OF SERVICE TIME FOR ACCIDENTS IN POLICE PERSONNEL ALLOCATION

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Abstract：To analyze the characteristics of service time for police dealing with accidents is useful in determining personnel allocation for traffic police. This paper surveys accident records from ALIUI (Automatic Location Identification using ISDN), which is used by the Police Bureau of Taoyuan County Government in Taiwan and recorded all calls to 110 for police help or service. From statistical analysis of 894 accident records, it shows that the average service time for an accident is 159.8 minutes, including response time of 28.7 minutes and handling time of 131.1 minutes. Using the chi-square test, the statistical distribution of accidents happened in daytime and nighttime is determined to have exponential distribution with 1.62 and 0.99 events per hour, respectively. Based on workload analysis, this paper calculates that the police personnel required to respond to traffic accidents is 19 police on-duty per day.

Key Words：handle time, personnel allocation, response time, service time for accident

1. INTRODUCTION

Dealing with traffic accidents is one of basic duties of police, and the service time required is directly related to the quality of processing. The service time of traffic accidents usually includes response time to an announcement, handling time on the scene and administrative operation time. The response time indicates the time from when the case reported after the accident happened to the time that police arrived on the scene, and it can be divided into dispatching time of the service center and police driving time. Handling time on the scene indicates the time from the police arrival until the completion of accident handling on the scene. Administrative operation time indicates the time required by a policeman to report the data concerning the accident or the negotiation achieved between the civilians related to the event until the whole case is closed. In Taiwan, complete and detailed data on the service time for traffic accidents has not yet been compiled. Not only it is impossible to assess the efficiency of the service policeman in charge of the accidents, but also it is impossible to determine the required manpower to serve for traffic accidents. The major purpose of this paper is to analyze the response time, handling time and administrative operation time on the basis of complete accident events to control the characteristics of service time for accidents of different types, different time spans, and different days of a week. The results will be provided to police units to establish the standard service time and to assess the efficiency of policemen on handling traffic accidents, and as well as serving as a reference to calculate the required manpower for the service of traffic accidents.

The data analyzed in this paper was selected 894 cases about traffic accident among the all 110 calls to Taoyuan County Police Department in June 2000, and a statistical package "SPSS

for Windows" was used to perform basic statistic analysis. The Taoyuan Police Department has used ALIUI (Automatic Location Identification Using ISDN) since March 2000 to automatically demonstrate all calls to 110 for police help or service. This system can record data including type, time, location, contents, time span of announcement for service and time to close the case, etc. In order to determine the characteristics of the service time of police on traffic accidents, this paper selects the major variables related to cases and composes definitions as shown in Table 1. Because the data cannot separate the time required for the handling on the scene and administrative operation, this paper has combined them as "policeman handling time".

Table 1. Definitions of the variables about traffic accidents

Variables	Definitions
accident type	A1: Fatality accidents A2: Injury accidents A3: Property loss only accidents Others: None loss at all (Including the accident makers had left when the police arrived)
time of accident happened (T1)	the time when police service center received 110 call
dispatching time (T2)	the time when police service center dispatched police to deal with accident
time of arriving at scene (T3)	the time when policemen arrived at accident scene
end time (T4)	the time when policemen finished the accident case
response time (RT)	the time interval from 110 call to policemen arrived at accident scene RT = T3 - T1.
police handling time (HT)	the time interval of policemen deals with the accident on the scene HT = T4 - T3
total service time (TST)	the time interval from 110 call to policemen finished the accident case TST = T4 - T1

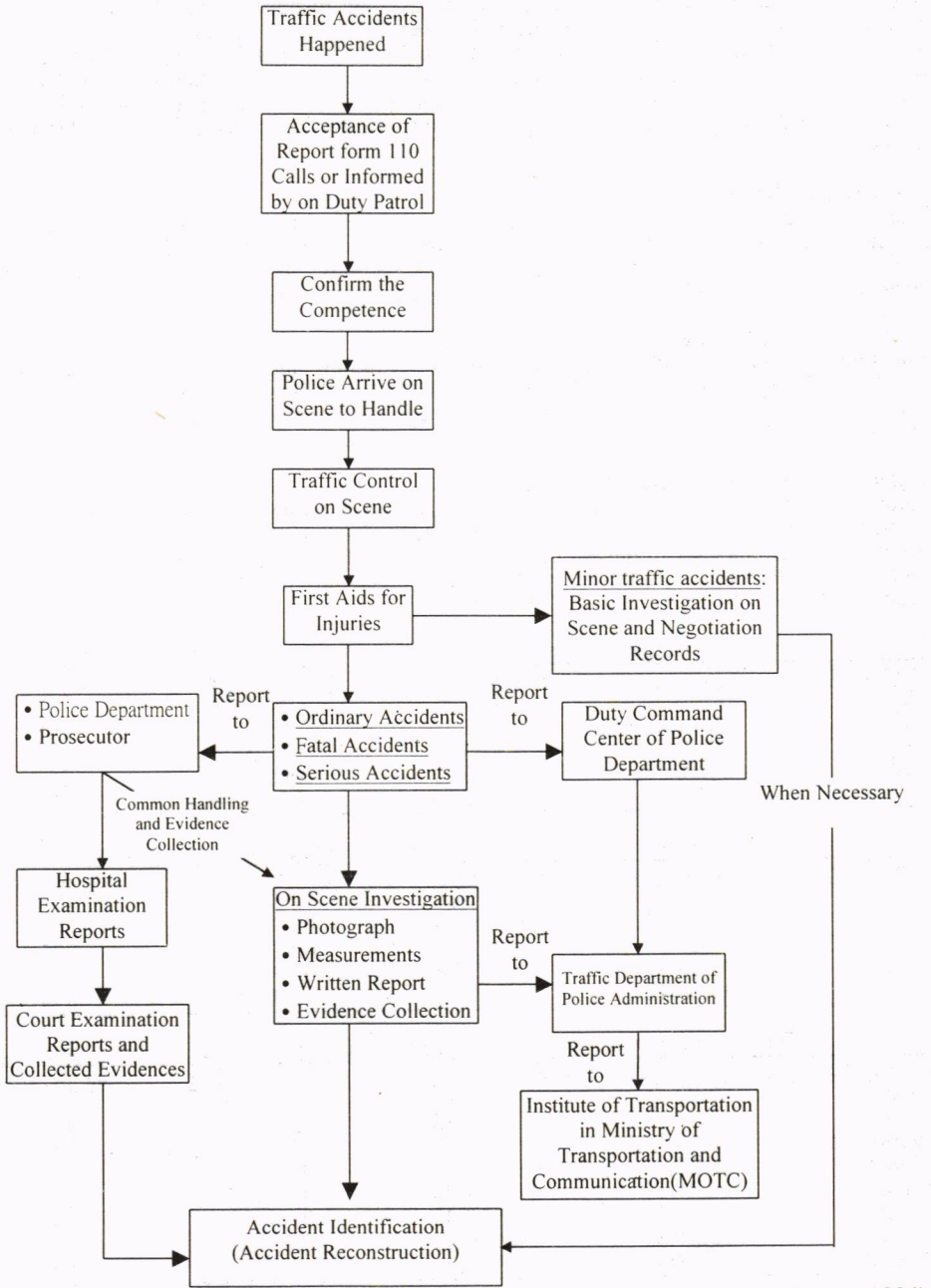
2. ACCIDENT HANDLING PROCEDURE AND PROCESS TIME

2.1 Accident Handling Procedure

The most significant aspects of handling traffic accidents include investigation on the scene and identification of responsibilities (Wang, 1994), of which investigation at the site of the traffic accident is one of the most important duties of policemen and is the basis to identify the responsibilities of accident. It is dangerous handle traffic accidents and often creates congestion on the roadways. The handling time and service quality greatly influence the rights of civilians, such acceptance the report of accident cases, arrival at the scene, aids to injuries, investigation of traces and records, so it must be completed within a minimum amount of time. Therefore, the service time for accidents can be regarded as an index of a traffic policeman's efficiency in executing his duties (Tsai, 1997). However, both the police unit and the traffic management unit emphasize the procedures of traffic accident handling to avoid jeopardizing peripheral traffic during the handling of accidents (Lin et al., 1999). Complete accident handling procedures include the acceptance of case reports, dispatching policemen to perform investigation on the scene, completing of accident investigation reports, and study of the reasons for the accident in accordance with the investigation reports (Su et al., 1999). But regarding the practical tasks, if all cases regardless of the scale of the accidents follow such procedures, there will be difficulties and obstacles in execution. The flowchart of practical handling procedures in Taiwan is shown in Figure 1.

2.2 Accident Dealing With Time Analysis

Using the statistical package "SPSS for Windows", this paper has listed average handling time for road accidents in Tables 2 to 4 in accordance with accident types, investigation time span and days of week, for announcement response time, policemen handling time on scene, and total time.



Sources：(Wang, 1994)

Figure1. Flowchart of practical handling procedures of traffic accidents in Taiwan

According to the analysis from the tables, the average response time of police units is 28 minutes and 42 seconds (in which the police department announcement response takes an average of 5 minutes and 34 seconds, and the local branch dispatch response takes an average of 23 minutes and 8 seconds), the average handling time by the police posts is 2 hours 11 minutes and 6 seconds, the average handling time for individual cases is 2 hours 39 minutes and 48 seconds. In general, the average handling time for an individual case is described as follow:

(1)Accidents types
The longest time, which is for fatal accidents (A1) is an average of 4 hours 22 minutes and 18 seconds, property loss only accidents (A3) take 3 hours 15 minutes and 25 seconds, injury accidents (A2) take 3 hours 4 minutes and 13 seconds, and the shortest is non-damage accidents (others) which take 1 hour 14 minutes and 51 seconds.

(2)Time of accident occurrence
The longest average handling time is 3 hours 3 minutes and 8 seconds, for the morning (06:00 – 12:00), then late night (00:00 – 06:00) with 2 hours 50 minutes and 13 seconds, evening (18:00 –24:00) with 2 hours 36 minutes and 9 seconds, while the shortest is the afternoon (12:00 – 18:00) with 2 hours 19 minutes and 42 seconds.

(3)Different days in a week of accidents:
Saturday has the longest average handling time of 3 hours 8 minutes and 53 seconds, followed by Sunday with 2 hours 51 minutes and seconds, then 2 hours 46 minutes and 4 seconds for Wednesday, 2 hours 45 minutes and 51 seconds for Tuesday, 2 hours 34 minutes and 32 seconds on Thursday, 2 hours 30 minutes and 7 seconds on Friday, and the shortest on Monday of 1 hour 55 minutes and 22 seconds.

Table 2. Average service time of different accident types (hr : min : sec)

accident type	response time	police handling time	total service time	sample size
A1	00:24:55	03:57:22	04:22:18	3
A2	00:42:56	02:21:16	03:04:13	148
A3	00:29:35	02:45:50	03:15:25	491
Others	00:18:38	00:56:12	01:14:51	252
Average	00:28:42	02:11:06	02:39:48	894

Table 3. Average service time of accidents in time of day (hr : min : sec)

time of day	response time	police handling time	total service time	sample size
00-06	00:33:06	02:17:06	02:50:13	105
06-12	00:34:52	02:28:15	03:03:08	251
12-18	00:26:50	01:52:52	02:19:42	303
18-24	00:22:31	02:13:38	02:36:09	235
Average	00:28:42	02:11:06	02:39:48	894

Table 4. Average service time of accidents in day of week (hr : min : sec)

day of week	response time	police handling time	total service time	sample size
Monday	00:22:55	01:32:27	01:55:22	97
Tuesday	00:34:15	02:11:35	02:45:51	145
Wednesday	00:28:20	02:17:43	02:46:04	110
Thursday	00:27:41	02:06:50	02:34:32	149
Friday	00:21:11	02:08:54	02:30:07	161
Saturday	00:41:52	02:27:00	03:08:53	138
Sunday	00:21:33	02:29:43	02:51:16	94
Average	00:28:42	02:11:06	02:39:48	894

2.3 Distribution of Accident Dealing With Time

In order to establish the standard operation time for dealing with traffic accidents, this paper calculates the central tendency and dispersion of service time of different accident types in Table 5 and discusses as follows:

(1)Because there are so few accident of type A1, the mean data may be used for the reference standard.
(2)The third quartiles of service time can be used as the standard operation time for dealing with road accidents A2, A3, and others. Accident type A2 requires 195.75 minutes, 181.00 minutes are requires for accident type A3, and 84.37 minutes are requires for other accidents.
(3)On average, 157.05 min for every accident could be the reference of decision for standard operation time.

Table 5. Central tendency and dispersion of service time of different accident types(hr : min : sec)

accident type	statistics	response time	police handling time	total service time	sample size
A1	first quartiles	00:08:12	01:48:24	02:31:30	3
	median	00:23:29	03:00:11	03:23:11	
	mean	00:24:55	03:57:22	04:22:18	
	third quartiles	00:43:06	07:03:32	07:12:13	
A2	first quartiles	00:05:52	00:48:54	01:15:27	148
	median	00:10:38	01:37:59	02:00:26	
	mean	00:42:56	02:21:16	03:04:13	
	third quartiles	00:48:27	02:35:46	03:15:45	
A3	first quartiles	00:05:27	00:50:08	01:07:53	491
	median	00:09:52	01:24:47	01:48:51	
	mean	00:29:35	02:45:50	03:15:25	
	third quartiles	00:16:53	02:32:20	03:01:00	
Others	first quartiles	00:05:35	00:13:05	00:29:32	252
	median	00:09:03	00:32:58	00:51:21	
	mean	00:18:38	00:56:12	01:14:51	
	third quartiles	00:17:39	01:00:49	01:24:22	
Average	first quartiles	00:05:34	00:39:41	00:58:36	894
	median	00:09:49	01:12:41	01:34:53	
	mean	00:28:42	02:11:06	02:39:48	
	third quartiles	00:17:27	02:08:01	02:37:03	

3. ANALYSIS ON TIME INTERVAL OF ACCIDENTS

According to Table 3, the average interval between cases at different times of day are: late night (00:00 – 06:00) 102.86 minutes, evening (18:00 – 24:00) 45.96 minutes, morning (06:00 – 12:00) 43.03 minutes, and afternoon (12:00 – 18:00) of 35.64 minutes. Accidents happening in late night (00:00 – 06:00) are clearly different from other times. In order to realize the practical interval and frequencies, we divide the time span into two parts, late night (00:00 – 06:00) and daytime/evening time (06:00 – 24:00) for analysis. The latter is including morning (06:00 – 12:00), afternoon (12:00 – 18:00) and evening (18:00 – 24:00).

The interval between accidents indicates the time span between two consecutive accidents. As it is difficult to determine the real time of the accident occurrence, the accident interval in this paper is based on the time span as the received 110 calls at the police duty center.

After the time interval of accidents is rearranged, and sorted in a sequence of length of time, it can now be calculated in order to sketch the time distribution. As indicated from the daytime/evening data, the average time interval between accident occurrences is 36.6 minutes, with a standard deviation of 37.79 minutes. After division into 15 groups, the diagram of accident occurrences every 10 minutes interval is shown in Figure 2, and it looks alike to the exponential distribution. According to the late night data, the average accident occurrence interval is 60.44 minutes, with a standard deviation of 65.55 minutes. After division into 15 groups, the diagram of accident occurrences every 10 minutes interval is shown in Figure 3, and it also looks alike to the exponential distribution.
In order to confirm the statistical distribution of the accident occurrence interval, we apply chi-square statistic to perform test of goodness of fit, as follows:

$$\chi^2 = \sum_{i=1}^{k} \frac{(Oi - Ei)^2}{Ei} \tag{1}$$

where χ^2 = calculated chi-square value
O_i = observed frequency of observations in interval of occurred time
E_i = theoretical frequency of expected observations in interval of occurred time
i = the interval of sequence i accident occurrence
k = the groups of intervals of accident occurrence

The null hypothesis for test of goodness of fit is:

H_0: accident occurrence interval is distributed as exponential; (2)

The data for accident intervals during the daytime/evening are shown in Table 6. The chi-square statistic is 15.77, less than the critical value 22.63, so we do not reject the null hypothesis. Therefore the daytime/evening accident occurrence interval is distributed as exponential distribution.

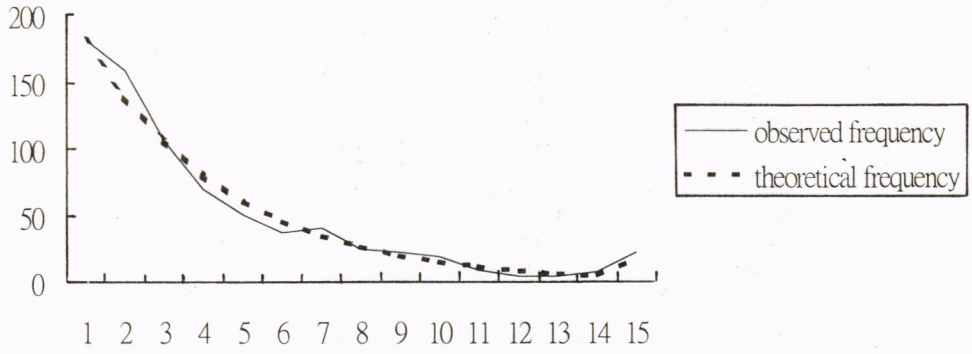


Figure 2. Comparison on frequency of accident interval in daytime

Table 6. Test on statistical distribution of accident interval in daytime

time interval of accident happened (Min)	observed frequency O_i	theoretical probability	theoretical frequency E_i	$(O_i - E_i)^2 / E_i^2$
0-10	181	0.2390	181.45	0.0011
10-20	158	0.1819	138.07	2.8758
20-30	106	0.1384	105.06	0.0083
30-40	70	0.1053	79.95	1.2375
40-50	51	0.0802	60.83	1.5897
50-60	37	0.0610	46.29	1.8646
60-70	41	0.0464	35.22	0.9472
70-80	25	0.0353	26.80	0.1213
80-90	22	0.0268	20.40	0.1263
90-100	19	0.0204	15.52	0.7806
100-110	9	0.0156	11.81	0.6683
110-120	5	0.0118	8.99	1.7681
120-130	5	0.0090	6.84	0.4939
130-140	8	0.0069	5.20	1.5035
140-	22	0.0218	16.56	1.7864
Total	759	1.0000	759	15.7727

Note: $\lambda = (1/36.6) \times 10 \times 6 = 1.64$ (events/hr), $\chi^2_{13,0.05} = 22.36$.

The data for accident intervals in the late night are shown in Table 7. The chi-square statistic is 13.58, less than the critical value 22.36, so we do not reject the null hypothesis. Therefore, the late night accident occurrence interval is also distributed as exponential distribution.

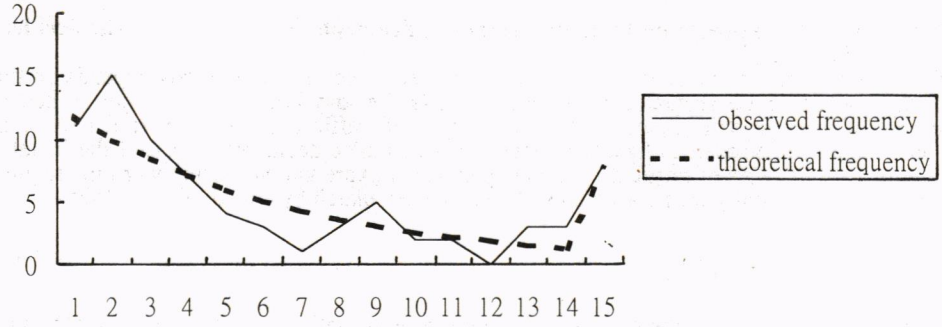


Fig. 3 Comparison on frequency of accident interval in late night

Table 7. Test on statistical distribution of accident interval in late night

time interval of accident happened (Min)	observed frequency O_i	theoretical probability	theoretical frequency E_i	$(O_i - E_i)^2 / E_i^2$
0-10	11	0.1525	11.74	0.0469
10-20	15	0.1292	9.95	2.5615
20-30	10	0.1095	8.43	0.2909
30-40	7	0.0928	7.15	0.0031
40-50	4	0.0787	6.06	0.6990
50-60	3	0.0667	5.13	0.8870
60-70	1	0.0565	4.35	2.5809
70-80	3	0.0479	3.69	0.1282
80-90	5	0.0406	3.13	1.1246
90-100	2	0.0344	2.65	0.1589
100-110	2	0.0292	2.24	0.0267
110-120	0	0.0247	1.90	1.9025
120-130	3	0.0209	1.61	1.1942
130-140	3	0.0177	1.37	1.9526
140 -	8	0.0986	7.59	0.0216
Total	77	1.0000	77	13.5785

Note: $\lambda = (1/60.44) \times 10 \times 6 = 0.99$(events/hr), $\chi^2_{13,0.05} = 22.36$.

4.POLICE MANPOWER REQUIRED TO HANDLE ACCIDENTS

4.1 Calculation Procedure

The determination of manpower required to handle traffic accidents requires complete working records to perform objective statistical analysis. Ideally, the analysis should be made in accordance with the data collected from a whole year to provide complete and reliable information, but that investigation would require greater budget. Although a police unit does not have a complete and detailed statistical data system, the required police manpower to handle daily traffic accidents can be estimated by means of sampling. To this is added considerations for duty shifts, rotated leaves, training, holidays, official leaves, sick or personal leaves, etc. In order to estimate the supervising manpower and the police manpower required to handle traffic accidents, the procedures of calculation are as follow:

(1) Collect the fundamental data and references
Fundamental data include the research objects, average daily traffic accidents occurrences by types, average manpower to handle daily traffic accidents, the hours for policemen to attend

training, competitions, etc. The basic references include the distribution characteristics of accident occurrence intervals, handling time for various traffic accidents, manpower adjustment factors, shift relief factor (*SRF*), etc.

(2) Calculate the average daily fundamental requirements for handling traffic accidents by policemen P_1

If there are confirmed that the distribution of accidents occurrence intervals depends on time of day and could be separated by several periods, i.e. daytime and late night. When the amount of average daily number of various types of traffic accident in period t (N^t_a), the police manpower needed to handle various types of traffic accidents (P_a), and the handling time for various types of traffic accidents in period t (T^t_a) are known, manpower/time required to handle average daily traffic accidents (T_1) can be calculated by equation (3) as follows:

$$T_1 = \sum_a \sum_t N^t_a P_a T^t_a \tag{3}$$

Furthermore, considering the daily service hours of each policeman (T_p), equation (4) can be used to calculate the fundamental police manpower required for handling daily traffic accidents P_1:

$$P_1 = T_1 / T_p \tag{4}$$

(3)Calculate the police manpower required to handle daily traffic accidents P_2

Policemen are obligated to attend official assignments including training, and competitions and workshop, as well as have sick and personal leaves, so the fundamental police manpower P_1 must be adjusted. The definition of shift relief factor (*SRF*) is:

$$SRF = H_t / H_p \tag{5}$$

Where H_t = Daily service hours of each policeman $T_p \times 365$
H_p = Daily service hours of each policeman $T_p \times$ reasonable working days in a year regulated by laws and codes

Currently, the daily service time of each policeman T_p is 8 hours, the preceding reasonable working days in a year according to the laws and codes indicating the working days deducting the holidays, national holidays, reasonable leaves of sick and personal reasons. Currently, government stagy in Taiwan work only 5 days a week, so there are about 110 days total holidays together with 15 days for sick and personal leave, there are 240 reasonable working days in a year. Thus, the manpower adjustment factor (*SRF*) will be 1.52, although this value may also be decided by policy.

The average police manpower for daily handling traffic accidents P_2 is obtained by multiplying the average fundamental requirement of police manpower handling daily traffic accidents P_1 by the manpower adjustment factor *SRF*.

$$P_2 = P_1 \times SRF \tag{6}$$

(4) Calculate average daily requirement of supervising police manpower P_3

The working policemen are the fundamental manpower to handle traffic accidents, however, supervising manpower is also necessary. Taiwan national highway policemen allocate one squad leader every 7 to 10 patrol policemen; which is similar to the United Sates inter-state highway and state high way system, where each supervisor supervises an average of 8.35 patrol policemen. Although supervisors may also assist in the handling of traffic accidents, their major duty is administrative support, so they are not included with the handling manpower. Therefore, P_3 the daily requirement of supervision police manpower after adjustment can be calculated by equation (7):

$$P_3 = (P_1 / k) \times SRF \tag{7}$$

(5)Calculate the police manpower required to handle traffic accidents P

$$P = P_2 + P_3 \tag{8}$$

4.2 Case Study

Taoyuan County Police Department has initiated the ALIUI (Automatic Location Identification Using ISDN) since March 2000 to automatically indicate and record all 110 calls for police help or service. This system has kept complete data, including the case types, time, location, contents, time of announcement for handling and case closed time. Using the traffic accident case reporting data of June 2000, this paper shall further analyze the handling time for various types of accidents, and estimate the average police manpower daily required for handling traffic accidents, as shown in Table 8. Due to the distributions of accidents occurrence intervals of daytime and late night are different, T_1 could be separated into two parts which are calculated by those accidents, manpower and service times.

According to Table 8, the total daily professional police manpower is 19 policemen which including 17 policemen required to handle traffic accidents and 2 supervisors. This analysis was limited to the data obtained from only the month of June 2000, the collection of more data in the future could provide more reliable results.

Table 8. The average police manpower daily required for handling traffic accidents

Time segment	Accident type	No. of accidents each month	No. of accidents each day $N^t a$	manpower Pa	service time per accident $T^t a$	Calculations
Day time	A1	2	0.07	2.0	5.30	
	A2	119	3.97	1.5	2.82	$T_1 = 87.36$ (Eq.3)
	A3	450	15.00	1.0	3.26	
	Others	218	7.26	1.0	1.23	$P_1 = 10.92$ (Eq.4)
	Subtotal	789	26.30	-	-	
Late night	A1	1	0.03	2.0	2.53	$P_2 = 17$ (Eq.5)
	A2	29	0.97	1.5	4.10	
	A3	41	1.37	1.0	3.19	$P_3 = 2$ (Eq.6)
	Others	34	1.13	1.0	1.34	
	Subtotal	105	3.50	-	-	$P = 19$ (Eq.7)

Note: k =8, SRF =1.52

5.SUMMARY

Based on the detailed and complete traffic accident data, this paper analyzes the response time and handling time. It also discusses the characteristics of different types of accidents, times of day, and days of the week. From the analysis of accident frequency and total service time per accident, the study also estimates the daily required police manpower for the entire county. The results of this paper could be used to establish practical standard handling time for road accidents and be a reference for the assessment of police efficiency in the handling of traffic accidents, for assigning police manpower on traffic accident services, as well as for calculating the required police manpower for handling traffic accidents.

Besides Taoyuan, there are many cities or counties in Taiwan have used the ALIUI system sequentially, to report all 110 cases and to record related data. How to use and who to manage the records are important issues in the future. If this system could be connected with the other new information techniques in police duty, it is helpful to supervise and control the handling of traffic accidents.

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