สำนักงานวิทยทรัพยากร จุฬาลงกรณ์มหาวิทยาลัย

CHAPTER 4

RESULTS

During data collection, there were many problems faced since most of the required sources of data were not available. Financial documents (DIP and PO) of the Communicable Diseases Control Project only available for 1988 - 1994, as well as malaria reports. While time-series data on malaria vectors were very limited, that is only for 1976 - 1986, i.e. the studies at Nambo village (coastal area) from 1976 - 1979, Woncho hamlet (inland area of island) from 1977 - 1984 and Wawotobi subdistrict (inland area of mainland) from 1980 - 1986. Cross-sectional entomological data and monthly survey data less than three years are not included in this study.

Therefore, most data collected are incomplete and inconsistent. The incompleteness and inconsistency of data will affect the result of this study such as the inference might be biased. Statistical tools have been applied to minimize bias.

The results of this study will be presented in five parts, i.e. the costs, effectiveness, efficiency, the factors affecting and the alternative model of vector control measures in malaria control programme.

4.1 The Costs of Vector Control Measures

Vector Control Measures is a sub-programme of the malaria control programme in the Communicable Diseases Control Project, beside surveillance (case finding and treatment) sub-programme. There are several activities in the vector control sub-programme, i.e. indoor residual spraying, insecticide impregnated bed-nets, larviciding (by *B. thuringiniesis*), source reduction and biological control by larvivorous fish.

The data on costs of vector control measures were only available from 1988 - 1994. These costs excluding vehicles, spraycans and insecticides, as well as the cost of microscopes in the malaria surveillance sub-programme. Those things were supplied from the Malaria Headquaters Jakarta in physical terms.

4.1.1 Component of Cost

The cost components of Vector Control Measures of Malaria Control Programme are presented in Table 4.1. This table shows that the average cost for VCM each year is 74.77% of the total budget of malaria control programme. The cost for VCM are varied depending on the availability of budget from the Government and foreign aid. At least 95.85% of total costs of VCM are for recurrent or operational costs, while the capital costs accounted for only 4.15%.

Table 4.1. The Cost Components of VCM in South-east Sulawesi Province, Indonesia from 1988 - 1994 (in thousands rupiahs)

Cost Components	1988	1989	1990	1991	1992	1993	1994	Total
1	2	3	4	5	6	7	8	9
Capital Cost								
- Equipment's *	1,560	1,210	240	1.190	1.325	1,375	1750	8.650
- Vehicles	0	0	0	0	0	0	0	0
- Buildings	5.292	0	4,500	5,000	400	0	0	15.192
Sub Total	***6,852***	***1,210***	***4,740***	***6,190***	***1.725***	***1,375***	***1.750***	***23,842***
Recurrent Cost								
- Personnel's **	31.728	14,516	27,138	41,231	20.950	25,768	25.525	186.856
- Travels	35.354	8,871	15,089	26,444	21.048	19.710	5.150	131.666
- Insecticides	0	0	0	0	0	0	0	0
- Other Supp.'s	2.400	1.375	4,740	19,305	21,465	21.625	23,175	94.085
- Training	6.185	3,630	6,468	11,784	5.070	4,750	3,150	41.037
- Maintenan. & Other Operat.	16.847	11.515	6.798	19.221	21.962	14.525	5.025	95.893
Sub Total	***92,514***	***39,907***	***60,233***	***117,985***	***90.495***	***86.378***	***62,025***	**549,577**
TOTAL	**99,366**	**41,117**	**64,973**	**124,175**	**92.220**	**87,753**	**63,775**	**573.379**
MCP Budget	117.096	73,433	78,606	156,571	126.582	115,494	99.054	766.836
% VCM Budget	84.86	55.99	82.66	79.31	72.85	75.98	64.38	74.77

Note : Vehicles, spraycans, fontans, and insecticides are supplied from National Malaria, Jakarta

* Excluding the costs for spraycans and fontans

** Excluding salary (this cost only the wages for nonpermanent sprayman).

Source : Financial documents (DIP and PO) of the CDC Project of Southeast Sulawesi

The capital costs are excluded the costs of vehicles, spraycans and fontans which is supplied form the National Malaria, Jakarta in physical terms, as well as insecticides for recurrent costs. There is no cost for long term training in malaria control programme in South-east Sulawesi.

In the recurrent costs, the higher cost proportion is the cost for personnel (32.59%) while the lowest proportion is the cost for training (7.16%). The cost for personnel is excluded salary that it is only the wages for nonpermanent workers such as spraymen. The salaries for permanent workers of malaria personnel are derived from the Routine Budget of national and local governments, which are not covered in this study.

4.1.2 Cost by Activities

VCM's activities consist of IRS, insecticide impregnated bed-nets, larviciding, source reduction and biological control by larvivorous fish. The cost of each activity is shown in Table 4.2. The costs for other VCM activities were available since 1987, i.e. biological control by larvivorous fish (1987), source reduction (1988), larviciding by *B. thuringiniensis* (1990), IIBN (1991) and Environmental Sanitation (1992). The cost some activities are not available every year.

During 1988 - 1994, IRS was still responsible for the major proportion of VCM costs (81.61%). Proportion of the rest activities are : 7.54% for source reduction, 3.53% for biological control, 3.34% for IIBN, 2.41% for larviciding and 1.58% for environmental sanitation (Table 4.2).

Table 4.2. The Costs of VCM Activities in South-east Sulawesi Province. 1988 - 1994 (in thousands rupiahs)

Activities	1988	1989	1990	1991	1992	1993	1994	Total
1	2	3	4	5	6	7	8	9
VCM :								
1. IRS	70,501	38,779	49,289	75,319	78,021	75,763	55,888	443,560
2. IIBN	-	-	-	17,414	250	495	0	18,159
3. Larviciding	-	-	1,782	2,273	3,000	2,875	3,150	13,080
4. Source Reduc	14,268	0	10,902	9,044	0	6,750	0	40,964
5. Biol.Control	7,127	2,338	0	3,625	2,345	1,770	1,962	19,167
6. Envir.Sanit.	-	-	-	-	8,604	0	0	8,604
Sub Total								**543,534**
Other MCP :								
1. Ento Survey	14,377	0	0	2,440	4,208	5,620	6,225	32,870
2. Treatment	2,950	10,186	407	6,189	7,290	3,995	6,940	37,957
3. Surveillance	14,780	22,132	12,572	25,957	27,072	23,740	28,339	154,592
Sub Total								**225,419**
TOTAL								**768,953**

Notes : IRS = Indoor Residual Spraying; IIBN = Insecticide Impregnated Bed-Net; Source Reduc. = Source Reduction; Biol. Control = Biological Control; Envir.Sanit. = Environmental Sanitation; Ento.Survey = Entomological Survey.
Source : Financial documents (DIP and PO) of the CDC Project of Southeast Sulawesi

4.1.3 Sources of Financing

There were several sources of financing which used in the VCM in South-east Sulawesi, such as Ministry of Health, Ministry of Transmigration, Foreign Aid (World Bank, WHO, OECF, etc.) and NGO (Table 4.3). Unfortunately, because the most of data were not available then only a few of them could be identified especially those which were derived from the financial documents of the CDC Project of South-east Sulawesi.

In the period 1988 - 1994, the Foreign Aid contributed 29.55% for VCM and 25.64% for MCP of their total costs. Since 1992, there was no more foreign aid budget for VCM/MCP in South-east Sulawesi.

Table 4.3. The Cost of Malaria Vector Control Measures in South-east Sulawesi by the Sources of Financing, 1988 - 1994 (in thousands rupiahs)

Year	Vector Control Measures			Malaria Control Programme		
	MOH	IBRD	OECF	MOH	IBRD	OECF
1	2	3	4	5	6	7
1988	25,002	74,364	0	34,712	82,384	0
1989	41,117	0	0	73,433	0	0
1990	37,658	0	24,315	50,714	0	27.891
1991	54,319	0	69,856	71,930	0	84.391
1992	92,220	0	0	119,292	0	0
1993	87.753	0	0	115,394	0	0
1994	63,775	0	0	99,054	0	0
TOTAL	401,844	74,364	94,171	564,529	82,384	112.282

Notes : MOH = Ministry of Health of Indonesia. IBRD = Fund from World Bank; OECF= Fund from Japan
Sources : DIP and PO of CDC Project. and Provincial Integrated Health Development Project of South-east Sulawesi

4.1.4 Unit Cost of VCM

The unit cost of VCM and other MCP's at a certain year activities are presented in Table 4.4.

Table 4.4. The Unit Cost of VCM and Other MCP's Activities in S.E. Sulawesi for Certain Year (in rupiahs)

ACTIVITIES	Year	Units	Quantities	Total Costs	Unit Cost
1	2	3	4	5	6
1. VCM* :					
1.1. IRS :					
- DDT	1991	houses	100,000	75,319,000	753.19
- FICAM	1993	houses	50,000	75.763.000	1.515.26
- ICON	1994	houses	50 000	55,887,500	1,117.75
1.2. IIBN	1991	units	1,500	17,414,000	11.609.33
1.3. Larviciding	1991	h.a.	300	2.273.000	7.576.67
1.4. Source Reduc	1991	units	2	9,044,000	4,522.000.00
1.5. Biological Control	1991	locations	19	3,625,000	190.789.47
1.6. Environ. Sanitation	1992	man-days	244	8,604,000	35,262.30
2. Treatments	1991	cases	30,700	6,189,000	201.60
3. Surveillance **	1991	blood films	19,500	25,957,000	1.331.13
4. Entomological Survey	1991	locations	8	2.440.000	305.000.00

Notes : * Excluding the costs of vehicles, spraycans, fontans and insecticides.
** Excluding the costs of microscopes.

The unit cost for indoor residual spraying per-house by using Ficam[R] (Bendiocarb) is relatively 2.01 times higher than the unit cost DDT. While Icon[R] (Lambdacyhalotrine) is relatively 1.48 times higher than DDT. If the average number of persons for each house is 5, then the unit cost per-person for indoor residual spraying by using DDT, Ficam[R] and Icon[R] are 151, 303 and 224 rupiahs respectively.

4.2 Effectiveness of VCM

4.2.1 Baseline Data of Vector Behaviors

There are two species of anopheles mosquitoes which have been confirmed as malaria vectors in South-east Sulawesi, i.e. *An. subpictus* and *An. barbirostris*. Other species which are strongly suspected as malaria vector are *An. flavirostris* and *An. nigerrimus*. *An. subpictus* plays a role as malaria vector at the coastal areas, while *An. barbirostris* operates in the inland areas. *An. flavirostris* has suspected play s role as malaria vector in the inland of the island while *An. nigerrimus* occurs in the inland areas of the mainland.

Baseline data for the application of indoor residual spraying has been derived from 3 entomological studies (1976-1986), i.e. at Nambo village for *An. subpictus* (1976-1979), Kampeonahu village (at Woncho and Wanajati hamlets) for *An. barbirostris* and *An. flavirostris* from 1977-1984, and Wawotobi subdistrict (at Lalohao, Wawolemo, Pondidaha and Teteona villages) for *An. barbirostris* and *An. nigerrimus* from 1980-1986. After several years of study, the study areas were sprayed with insecticide, i.e. Nambo in September 1978 with 1 year follow-up, Woncho was sprayed in November 1983 with 1 year follow-up (Wanajati was the spraying area), and Lalohao and Wawolemo were sprayed in February 1983 with 4 years follow-up (Pondidaha and Teteona were left unsprayed as the control areas).

The data on feeding and resting behaviors of vectors from those studies are illustrated in the Table 4.5 and 4.6.

Table 4.5. The Proportion of In/Out-door Human Bite and Indoor Resting of Malaria Vectors in South-east Sulawesi, 1976 - 1986

Year	An.subpictus (Nambo)			An flavirostris (Woncho)			An.barbirostris (Wawotobi)		
	IMB	OMB	NIR	IMB	OMB	NIR	IMB	OMB	NIR
1	2	3	4	5	6	7	8	9	10
1976	16.23	50.25	33.52	-	-	-	-	-	-
1977	24.47	36.04	39.49	19.13	54.92	25.95	-	-	-
1978	27.65	48.06	24.34	34.97	46.05	18.95	-	-	-
1979	16.96	83.04	0.00	25.82	51.42	22.76	-	-	-
1980	-	-	-	21.05	57.89	21.05	6.35	70.38	23.27
1981	-	-	-	42.51	50.24	7.25	15.35	20.63	64.02
1982	-	-	-	29.17	49.66	21.17	13.86	16.00	70.15
1983	-	-	-	27.52	70.12	2.36	11.14	35.56	53.30
1984	-	-	-	39.62	60.38	0.00	15.75	48.66	35.59
1985	-	-	-	-	-	-	15.74	43.05	41.21
1986	-	-	-	-	-	-	20.28	48.95	30.77

Note : In Wawotobi subdistrict, only Lalohao and Wawolemo are presented — Spraying period
IMB=Indoor Man Bite; OMB=Outdoor Man Bite; NIR=Night Indoor Resting;
IMB, OMB and NIR are measured in proportion (%) e.g. proportion of NIR = (NIR / (NIR+IMB+OMB)*100)
Source : Provincial Health Office, South-east Sulawesi Province

Table 4.5 shows that the proportions of *An.subpictus, An.flavirostris* and *An. barbirostris* on night indoor resting were decreasing while outdoor man-bait was increasing. The pair t-test shows that there is significant correlation proportion of *An.subpictus* between indoor resting and outdoor man-biting ($r = -0.966$ and $p < 0.05$), as well as *An. barbirostris* ($r = -0.988$ and $p < 0.01$), while *An.flavirostris* only has a weak correlation ($r = -0.590$ and $p < 0.10$). The proportions of indoor and outdoor man-biting for *An.flavirostris* were significantly different ($p < 0.01$), but no significant difference could be shown for *An.subpictus* and *An. barbirostris.* This means that the vectors performed to avoid resting inside on the house wall, especially after the areas were sprayed.

The proportion of unfed - female mosquitoes without blood in their abdomen - for *An. subpictus* and *An. barbirostris* seem to decline after spraying (Table 4.6). Formerly, the density of these vectors which rest on the wall before biting were high. But after spraying application most of the mosquito vectors enter the house directly biting man, and escape from the house with or without resting on the wall after feeding. This behavior will reduce the probability contact between insecticide and the vector, then indoor residual spraying becomes ineffective. One indicator which could be used as a measurement is parity index or percent of parous (number of female mosquitoes that have oviposited at least once) . If parity index is still high it means that indoor residual spraying is ineffective as shown for *An. barbirostris* in Table 4.6.

Table 4.6. The Indoor Resting Density, Abdominal Conditions and Parity Index of Malaria Vectors in South-east Sulawesi, 1976 - 1986

Year	*An.subpictus* (Nambo)			*An.flavirostris* (Woncho)			*An.barbirostris* (Wawotobi)		
	Density	% Unfed	% Parous	Density	% Unfed	% Parous	Density	% Unfed	% Parous
1	2		4	5	6	7	8	9	10
1976	3.32	53.17	-	-	-	-	-	-	-
1977	1.57	56.19	-	1.83	25.95	-	-	-	-
1978	0.51	27.81	-	0.33	18.95	-	-	-	-
1979	0.00	0.00	-	0.43	22.76	-	-	-	-
1980	-	-	-	0.17	21.05	-	0.61	100.00	41.27
1981	-	-	-	0.07	7.25	80.00	34.51	97.61	39.90
1982	-	-	-	0.24	21.17	82.00	13.61	97.13	33.87
1983	-	-	-	0.09	2.36	25.00	5.84	NA	25.03
1984	-	-	-	0.00	0.00	0.00	2.05	NA	53.05
1985	-	-	-	-	-	-	0.83	100.00	42.42
1986	-	-	-	-	-	-	1.33	54.16	54.24

Note : % Unfed = (# Unfed / (# Unfed + # Blood fed + # Halfgravid + # Gravid)* 100) Spraying period
% Parous = (# Parous / (# Parous + # Nully Parous)*100); Density = # of mosquitoes collected per man-hours;
Source : Provincial Health Office, South-east Sulawesi Province

There is not enough evidence to justify that the vector resting behavior has been changed. More observations after spraying with more frequencies of spraying are needed to support the decision. But, at least data above show that the proportion of vectors resting behavior have been reduced gradually after serial rounds of spraying.

4.2.2 Coverage of VCMs and Other MCP Activities

The coverage of IRS is one of the requirement in malaria eradication, but in malaria control programme, it is not necessary. If the coverage of IRS is high, it means that many people are protected from malaria transmission. The annual coverage of IRS in South-east Sulawesi are presented in Table 4.7 which shows that the coverage of indoor residual spraying have increased by the year and decreased gradually since 1986. The higher coverage of 74% was attained in 1985. The coverage of other MCP activities was low and seemed relatively stable.

Table 4.7. The Coverage of IRS and Other MCP Activities in South-east Sulawesi, 1973 - 1994

Year	IRS		TREATMENT		SURVEILLANCE		PCD	
	Houses	Cover.	Cases	Cover.	Blood Fl.	Cover.	Blood Fl.	Cover.
1	2	3	4	5	6	7	8	10
1973	5,670	3.81	9,958	1.34	8,605	1.16	1,485	0.20
1974	9,704	6.41	4,137	0.55	7,500	0.99	994	0.13
1975	16,950	11.03	11,388	1.48	8,400	1.09	367	0.05
1976	21,835	13.23	21,976	2.66	8,896	1.08	1,800	0.22
1977	18,587	11.18	8,849	1.06	10,126	1.22	2,095	0.25
1978	39,268	23.25	33,872	4.01	13,159	1.56	1,573	0.19
1979	37,980	21.85	26,689	3.07	11,911	1.37	NA	NA
1980	42,711	22.66	34,235	3.63	16,471	1.75	NA	NA
1981	53,205	26.96	24,716	2.51	22,473	2.28	NA	NA
1982	65,834	32.61	27,350	2.71	26,140	2.59	NA	NA
1983	65,197	31.74	24,709	2.33	24,709	2.33	NA	NA
1984	58,036	26.68	31,125	2.86	31,125	2.86	13,244	0.22
1985	165,991	74.12	32,495	2.90	37,035	3.31	NA	NA
1986	165,092	69.31	31,503	2.65	17,142	1.44	8,233	0.36
1987	33,949	14.01	22,229	1.83	15,623	1.29	1,496	0.12
1988	42,132	17.02	23,739	1.92	13,190	1.07	2,907	0.23
1989	123,798	49.07	68,021	5.39	51,733	4.10	3,673	0.29
1990	80,324	29.76	24,030	1.78	23,054	1.71	3,170	0.23
1991	99,960	36.45	26,758	1.95	23,707	1.73	5,162	0.38
1992	50,166	18.09	31,260	1.25	17,653	1.27	4,727	0.34
1993	50,436	17.83	28,388	2.01	12,755	0.90	5,804	0.41
1994	52,203	18.09	30,132	2.09	18,058	1.25	3,304	0.23

Note : Cover. = % population coverage PCD-1984 = cumulative 1979-1984 PCD-1986= cumulative 1985-1986
Source : Malaria Unit. Provincial Health Services. South-east Sulawesi
Malaria Subdirectorate, CDC & EH Directorate General, MOH Indonesia

Table 4.8. The Coverage of Other VCM Activities in MCP, South-east Sulawesi, 1987 - 1994

Year	IIBN (units / m.d.)	Larviciding (h.a.)	Source Reduc. (Units)	Biological Control		Env. Sanitation (man-days)
				Locations	# Fishes	
1	2	3	4	5	6	7
1987	-	-	-	NA	1,989	-
1988	-	-	4	NA	NA	-
1989	-	-	0	7	28,000	-
1990	-	75	3	3	12,000	-
1991	1,500 units	300	2	19	15,000	-
1992	100 m.d.	300	0	15	NA	244
1993	134 m.d.	300	9	10	NA	0
1994	0	300	0	10	NA	0

Note : IIBN = Insecticide Impregnated Bed-Net, that is bednets have impregnated with synthetic pyrethroids.
Larviciding = method of larva control by using substance such as *B.thuringiensis*
Source Reduction = a method of environmental management to control larva of mosquitoes.
Source : Malaria Unit, Provincial Health Services, South-east Sulawesi

Table 4.9. The Outcome of Malaria Control Programme in South-east Sulawesi, 1973 - 1994

Year	PARASITE RATE (%)			Clinical Malaria Cases *)		% SPR of PCD *)
	PR(t)	ΔPR(t)	% Changes	Number	% Prevalence	
1	2	3	4	5	6	7
1973	28.33	-	-	7,270	0.98	84.31
1974	25.22	3.11	10.98	6,822	0.90	61.77
1975	10.96	14.26	56.54	9,195	1.20	42.51
1976	10.01	0.95	8.67	7,248	0.88	19.11
1977	6.14	3.87	38.66	13,382	1.61	9.55
1978	12.06	- 5.92	-96.42	4,808	0.57	6.29
1979	16.09	- 4.03	-33.42	13,597	1.56	NA
1980	11.30	4.79	29.77	24,978	2.65	NA
1981	4.82	6.48	57.35	19,082	1.93	NA
1982	2.97	1.85	38.38	21,810	2.16	NA
1983	7.36	- 4.39	-147.81	34,743	3.28	NA
1984	4.37	2.99	40.63	33,179	3.05	8.15
1985	4.22	0.15	3.43	31,486	2.81	NA
1986	1.28	2.94	69.59	31,503	2.65	15.91
1987	1.48	- 0.20	-15.23	22,229	1.83	15.37
1988	1.60	- 0.12	7.92	23,739	1.92	10.32
1989	1.88	- 0.29	-17.97	19,033	1.51	56.03
1990	1.04	0.85	44.98	19,220	1.42	29.54
1991	1.18	- 0.14	-13.99	23,071	1.68	80.60
1992	1.59	- 0.41	-34.88	24,653	1.78	24.75
1993	1.16	0.43	26.94	28,388	2.01	40.35
1994	1.08	0.09	7.48	30,132	2.09	12.85
1995	0.64	0.44	40.55	31,745	2.19	NA

Note : % prevalence = number of cases (new and old) per 100 population per year
SPR (Slide Positivity Rate) = number of slide with malaria positive divided by number of slide examined from PCD.
Source : Malaria Unit, Provincial Health Services, South-east Sulawesi
*) Malaria Subdirectorate, CDC & EH Directorate General, MOH Indonesia

Since 1987, other VCM activities were introduced such as biological control by using larvivorous fish (1987), source reduction (1988), larviciding by using bacterium *B. thuringiensis* (1990), insecticide impregnated bed-nets (1991) and environmental sanitation (1992). The aim of these activities is to assess alternative methods of vector control measures, as the supplement to indoor residual spraying. The coverage of other VCM activities are still limited at a selective areas (Table 4.8).

4.2.3 Outcome of Programme (VCM)

VCM by indoor residual spraying in South-east Sulawesi commenced in 1973 with 28.33% of PR. After 5 years operation, at 1977 declined to be 6.14%, but in 1978 increased to 12.06 and 1979 PR increased to 16.09%. Since that time, the reduction of PR became inconsistent, i.e. decreased or increased (Table 4.9).

The data on the number of clinical malaria cases which is gathered from the reporting and recording system do not seem to significantly change while the figure of slide positivity rate (SPR) could not used to depict the real malaria situation, because of its coverage < 10% of the population (Table 4.9 and Table 4.7).

4.2.4 Effectiveness of VCM by IRS

The effect of indoor residual spraying in reducing of PR can be depicted by the equation below :

$$PR_t = \beta_0 + \beta_1 PR_{(t-1)} + \beta_2 IRS_t + \beta_3 Treat_t + \varepsilon_t \quad \ldots \ldots \ldots \ldots \quad (4.2.1)$$

where : β_0 = constant
β_i = coefficient (slope)s, $i = 1, 2, 3$.
ε_t = error term

Results of regression analysis for IRS from 1973 - 1994 (N = 22; k = 4) are :

$$PR_t = -0.1655 + 0.6807\, PR_{(t-1)} - 0.0447\, IRS_t + 0.9942\, Treat_t$$

$$t\text{-stat.} = (-0.0683) \quad (8.3118)^{***} \quad (-0.8914) \quad (1.1990)$$

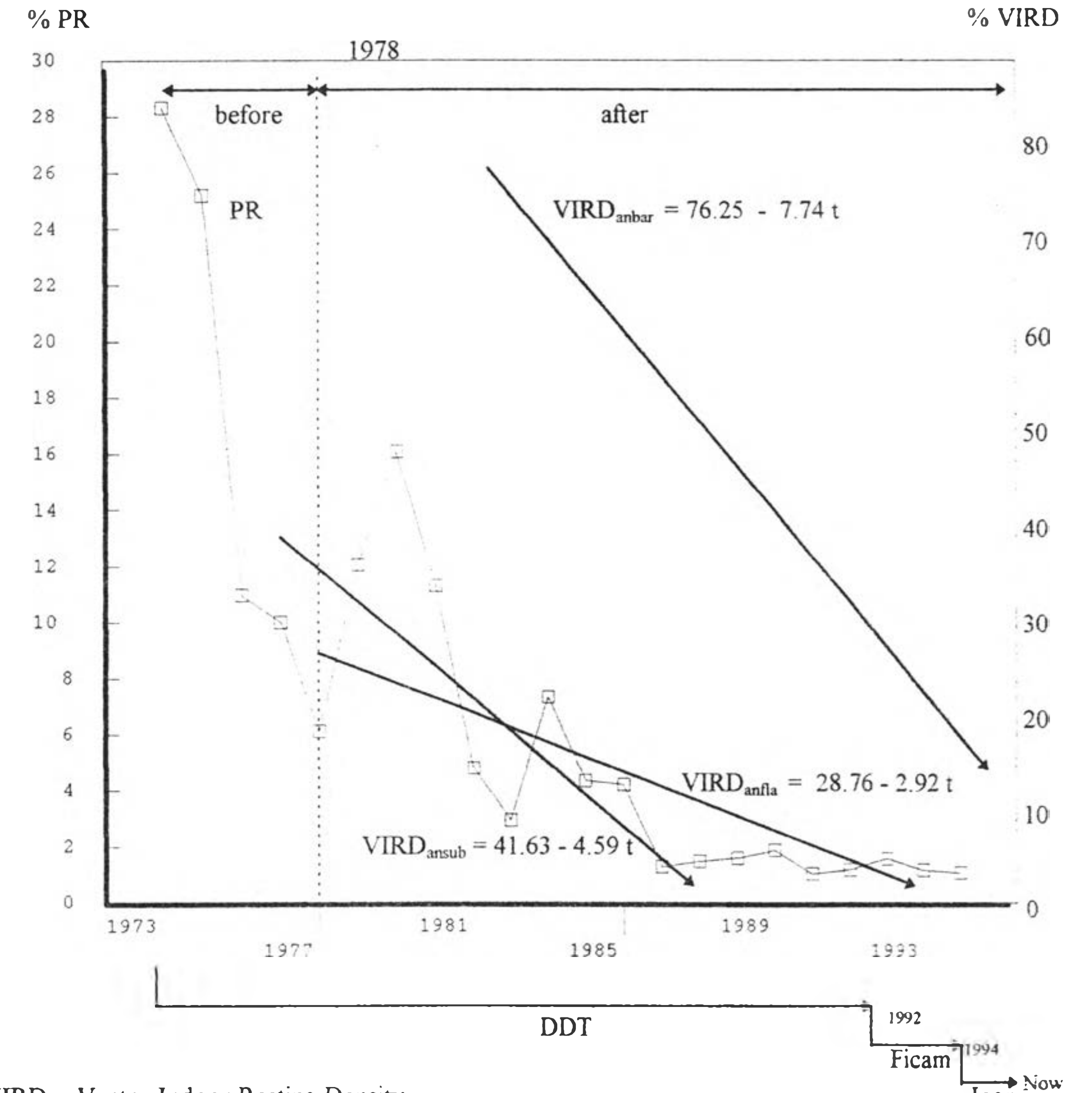
$$R^2 = 0.8364 \quad \text{F - statistic} = 30.6812 \quad \text{Durbin Watson} = 2.3631$$
$$\textit{Adjusted} - R^2 = 0.8092 \quad \text{Prob.(F-stat.)} = 0.0000$$

(4.2.2)

Note : *** significant at $p < 0.01$

Regression analysis shows that every 1% increase in the population protected by indoor residual spraying, the PR will decrease by 0.04%. Application of t-test showed that there is no linear relationship between the coverage of IRS with decreasing of PR ($p < 0.1$). Analysis of variance approach shows that it is a good fit of the regression model ($p < 0.01$). If only IRS is put in the equation, the effect of increasing 1% of population protected by IRS could reduced PR by 0.20% ($p<0.05$), but this model only can explain 21% of variation of PR.

Figure 4.1 The Outcome (% PR) of Vector Control Measures in S.E.Sualwesi Indonesia, 1973 - 1994



VIRD = Vector Indoor Resting Density
ansub = *An. subpitus*, anfla = *An. flavirostris* and anbar = *An. barbirostris*

The Figure 4.1 shows that the outcome of vector control measures by IRS in the malaria control programme became inconsistent since 1978, compared to the previous five years operation. If all requirements of IRS method have been met, e.g. coverage (in spraying area), completeness, sufficiency and regularity, then the problem might come from the vector(s). There are two main problems of vectors, i.e. resistance to insecticides (physiological resistance) and changed behavior (behavioral resistance). When the proportion of vectors indoor resting increased and the parasite rate also increased, it means that the vector becomes resistant to insecticide. But when the proportion indoor resting of vector decreased, while the PR increased, it means that there is a changed resting behavior of vector or at least the vectors have avoided to contact with insecticide (irritation effect).

Although from the existing entomological data it is very difficult to justify the changed resting behavior of vectors, however, those assumptions lead the author to estimate that a change in behavior of vectors has occurred since 1978 after five years of DDT application. Then, hypothesis testing could be applied for the equation below :

$$PR_t = \beta_0 + \beta_1 PR_{(t-1)} + \beta_2 IRS_{before} + \beta_3 IRS_{after} + \varepsilon_t \qquad (4.2.3)$$

Regression result (N=22, k = 4) are :

$$PR_t = 2.2559 + 0.6958 PR_{(t-1)} - 0.2435 IRS_{before} - 0.0342 IRS_{after}$$

$$\textit{t-stat.} = (1.190) \quad (7.916)^{***} \quad (-1.065) \quad (0.706)$$

$$R^2 = 0.9124 \quad \text{F - statistic} = 29.8330 \quad \text{Durbin Watson} = 2.2454$$
$$\textit{Adjusted} - R^2 = 0.8326 \quad \text{Prob.(F-stat.)} = 0.0000 \qquad (4.2.4)$$

Note : *** significant at $p < 0.01$

T-test for partial coefficient regression shows that the effectiveness of IRS after changed of vector behavior (β_3 = - 0.034211 with p = 0.4892) is lower than the effectiveness before change of vector resting behavior (β_2 = - 0.243513 with p = 0.3010). But, t-test for the equality between coefficients β_2 and β_3 for the equation above shows that the value of t = - 0.99438 which does not exceed the critical t-value (2.101) with df = 18 for two-tails significance. There is not enough evidence to reject the null-hypothesis at the level of confidence $\alpha = 5\%$ ($p<0.05$). The author concludes that statistically the effectiveness of IRS before (1973-1977) and after changed behavior of vectors (1978-1994) are not significantly different.

The figure above may be caused by the inconsistency effect of IRS in reducing PR. Result of regression analysis (4.2.2) above shows that IRS only have a little effect (slope = - 0.0447) but there is no significant effect ($p <0.10$). Other reason that the beginning of first spraying for the whole areas are not the same. In the Table 4.7 shows that the number of houses spraying increased by the year. Its mean that the first contact between vectors and insecticide were different point in time. Hence, the occurrence of change in behavior of vectors were not in the same time, which affect the accuracy of estimation for the period of change in behavior vectors.

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4.3 Efficiency of VCM

4.3.1 Marginal Cost of VCM

The cost of VCM and other MCP activities are presented in Table 4.10 while the cost VCM activities are shown in Table 4.11. Those costs are measured in the cost per population instead of total costs.

Table 4.10. The Costs Per Population of Malaria Control Programme, Per Capita Income and Literacy Rate in South-east Sulawesi, 1973 - 1994

Year	MCP (Rp. /Pop.)	VCM (Rp. /Pop.)	Treatment (Rp. /Pop.)	Surveillance (Rp. /Pop.)	Per Capita Income(Rp)	Literacy (%)
1	2	3	4	5	6	7
1973	8.24	NA	NA	NA	NA	NA
1974	5.14	NA	NA	NA	NA	NA
1975	7.70	NA	NA	NA	NA	NA
1976	7.87	NA	NA	NA	NA	NA
1977	7.87	NA	NA	NA	NA	NA
1978	10.14	NA	NA	NA	63,691.38	NA
1979	12.67	NA	NA	NA	66,578.32	NA
1980	39.42	NA	NA	NA	84,160.12	68.53
1981	18.36	NA	NA	NA	92,053.06	NA
1982	18.14	NA	NA	NA	105,555.35	NA
1983	32.53	NA	NA	NA	112,463.07	NA
1984	47.63	NA	NA	NA	121,920.19	NA
1985	62.62	NA	NA	NA	110,852.63	74.82
1986	23.65	NA	NA	NA	110,402.43	NA
1987	9.40	NA	NA	NA	112,806.39	NA
1988	25.38	21.54	0.64	3.20	130,726.25	NA
1989	14.30	8.01	1.98	4.31	132,861.35	NA
1990	13.11	10.94	0.07	2.10	130,357.26	84.17
1991	23.50	18.67	0.93	3.90	135,315.25	NA
1992	16.24	11.56	0.99	3.69	132,275.32	NA
1993	14.11	10.72	0.49	2.90	139,468.45	NA
1994	10.88	7.01	0.76	3.11	144,929.26	NA

Notes : The costs of MCP and per capita income are measured in real -value by using formula : $C_n = C_o \times (1 - i)^n$,where C_0 = Cost at based year (1973), C_n = Cost at time t and I = inflation rate (8.4%).

Sources : Malaria Unit. Prov. Health Services, Health Planning Div. Prov. Health Office & Prov. Statistical Office, S.E Sulawesi

Data of costs for vector control measures activities were available only for the period 1988 - 1994, as well as the cost of IRS. Therefore, the cost of MCP will be used in the hypothesis testing instead of the cost of VCM. The cost of VCM accounted for about 75% (range 56% - 85%) of MCP.

The incompleteness of data and unavailability of unit cost of VCM cause the limitation in the cost-effectiveness analysis of this study. Therefore, marginal cost will be used to evaluate the efficiency of VCM.

Table 4.11. The Costs Per Population of Vector Control Measures, in South-east Sulawesi, 1988 - 1994

Year	IRS (Rp. /pop.)	IIBN (Rp. /pop.)	Larviciding (Rp. /pop.)	Source Red (Rp. /pop.)	Biologic. Ctr (Rp. /pop.)	Envir.San. (Rp. /pop.)
1	2	3	4	5	6	7
1988	15.28	-	-	3.09	1.54	-
1989	7.55	-	-	0.00	0.46	-
1990	8.22	-	0.30	1.82	0.00	-
1991	11.32	2.62	0.34	1.36	0.54	-
1992	10.62	0.03	0.41	0.00	0.32	1.17
1993	9.26	0.06	0.35	0.83	0.22	0.00
1994	6.14	0.00	0.35	0.00	0.22	0.00

Notes : IRS = Indoor Residual Spraying. IIBN = Insecticide Impregnated Bed-Net. Source Red = Source Reduction.
Biologic.Ctr. = Biological Control. Envir.San. = Environmental Sanitation.
The costs of VCM are measured in the real-value by using formula : $C_n = C_o \times (1 - i)^n$.

Sources : Malaria Unit. Provincial Health Services. South-east Sulawesi
Health Planning Division. Provincial Health Office. South-east Sulawesi

The regression model of MCP costs is illustrated by the equation below :

$$PR_t = \beta_0 + \beta_1 PR_{(t-1)} + \beta_2 MCPCost_t + \beta_3 VCMCost_t + \beta_4 SURCost_t + \beta_5 TRECost_t + \beta_6 INCOME_t + \beta_7 DUMMY_t + \varepsilon_t \quad \ldots \ldots \ldots (4.3.1)$$

where : β_0 = constant
β_i = coefficient (slope)s, i = 1, 2, 3, ..., 7
ε_t = error term

Results of regression analysis for VCM from 1978 - 1994 with (N=17, k=8) are :

$$PR_t = \underset{(2.338)^{**}}{27.375} + \underset{(0.475)}{0.109PR_{(t-1)}} + \underset{(1.232)}{0.069MCPCost_t} - \underset{(-0.677)}{0.171VCMCost_t} + \underset{(0.491)}{2.232SURCost_t}$$

$$- \underset{(-0.436)}{2.502TRECost_t} - \underset{(-3.701)^{***}}{2^{-4}INCOMEt} - \underset{(-0.238)}{2.172DUMMY_t}$$

R^2 = 0.8538 F - statistic = 7.5092 Durbin Watson = 1.7910
Adjusted - R^2 = 0.7401 Prob.(F-stat.) = 0.0037

... ... (4.3.2)

Note : ** significant at $p<0.05$; *** significant at $p<0.01$. Value in the bracket = t-value

Regression analysis above shows that for every one percent increase in VCM, the PR will be reduced by 0.17%, but there is no significant effect of VCM costs in the reduction of PR ($p < 0.10$) as well as treatment could reduced 2.50% of PR (p <

0.10). Analysis of variance approach shows that is the fit of regression model is good ($p < 0.01$).

By the same assumptions for the period of before and after changes in vector behavior as mentioned above, then hypothesis testing for the efficiency MCP could be applied for the equation below :

$$PR_t = \beta_0 + \beta_1 PR_{(t-1)} + \beta_2 \text{ MCP Cost}_{before} + \beta_3 \text{MCP Cost}_{after} + \varepsilon_t \quad \ldots \ldots (4.3.3)$$

$$PR_t = 1.9258 + 0.7617 PR_{(t-1)} - 0.4761 \text{ MCP Cost}_{before} - 0.0441 \text{ MCP Cost}_{after}$$

t-statistic =	(1.2117)	$(7.1988)^{***}$	(-1.2077)	(-0.7687)
variance =		(0.01120)	(0.15539)	(0.0033)
covariance (β_2, β_3) =			(0.01156)	

R^2 = 0.8351 F - statistic = 30.3915 Durbin Watson = 2.1689

Adjusted - R^2 = 0.8076 Prob.(F-stat.) = 0.0000

... ... (4.3.4)

Note : *** siginificant at $p < 0.01$; N = 22; and k = 4.

T-test for partial coefficient regression shows that the efficiency of MCP after changed of vector behavior (β_3 = - 0.044102 with p = 0.4521) is lower than the efficiency before change of vector resting behavior (β_2 = - 0.476066 with p = 0.2428). But, t-test for the equality between coefficients β_2 and β_3 shows that the value of t = - 1.173160 which does not exceed the critical t-value (2.101) with df = 18 for two-tails significance. There is not enough evidence to reject the null-hypothesis at level of confidence α = 5% ($p<0.05$). The author concludes that statistically the efficiency of MCP before (1973-1977) and after (1978-1994) changed behavior of vectors are not different. Because most of the MCP cost consists of VCM cost, analogically it could be said that there is no different between the efficiency of VCM before (1973-1977) and after (1978-1994) changed in resting behavior of vectors.

There are some possible reasons why the efficiency of VCM before and after changed in resting behavior of vectors are not different, i.e. a little effect of IRS in reducing PR, the first spraying were not the same time and incompleteness data of costs. The costs of VCM only available from 1988-1994 and for the overall MCP only covered the costs from CDC Project, while the other sources of financing such as Malaria Headquaters, other Ministry, etc. are not available. Those condition could affect the result of regression analysis in this study.

4.3.2 Contribution of IRS

As mentioned above that if the vectors have avoided contacting with insecticide due to changed in resting behavior of vectors as well as if vector(s) become resistant to insecticide, then the indoor residual spraying by insecticide becomes wasteful. The regression model of IRS in 1978-1994 below is used to measure the contribution of IRS in the reduction of PR :

$$PR_t = \beta_0 + \beta_1 PR_{(t-1)} + \beta_2 IRS_t + \beta_3 Treat_t + \beta_3 Income_t + \varepsilon_t \quad \dots \quad \dots \quad \dots \quad (4.3.5)$$

$$= 5.3404 + 0.3779\ PR_{(t-1)} - 0.0681\ IRS_t + 1.0022\ Treat_t - 7.831^{-06}\ Income_t$$

$$t\text{-}statistic = (\ 1.3581)\quad (1.5905)\quad (-1.5421)\qquad (1.1663)\qquad (-1.8026)^{*}$$

$$R^2 = 0.7186 \qquad F\text{ - statistic} = 7.6594 \quad \text{Durbin Watson} = 1.6118$$
$$Adjusted\ \text{-}\ R^2 = 0.6247 \qquad \text{Prob.(F-stat.)} = 0.0026$$

... ... (4.3.6)

Note : * significant at $p < 0.10$; $N = 17$ and $k = 5$.

By using the formula (3.6.8), results is found that the contribution of the lagged PR, IRS, treatment, and per capita income effect are 39.64%, 5.64%, 11.88% and 42.85% respectively. This figure tells us that the contribution of IRS is very small in the reduction of PR due to changed behavior of vector resting. Despite the fact that the houses have been sprayed by insecticide involving the expenditure of more money for it application, when most of the vectors already avoided contact with insecticide on the wall surfaces, then IRS only has a little effect. Therefore, if the IRS was not effective, it means there is a waste of resources.

4.4 Factors Affecting VCM

4.4.1 Factor Affecting Cost

There are two factors which possibly affect the cost of VCM. They are sources of financing and government policy. Because this study was only limited to costs which are derived from the Financial Documents (DIP and PO) of CDC Project of South-east Sulawesi, then the sources of financing were only incurred from the government and a limited foreign aid. Thus the cost of VCM in malaria control programme depends on the financial ability of government budget and the availability of foreign aid. This leads to the expenditure of VCM and other MCP activities being inconsistent by the year, sometimes increased and decreased (Table 4.10). The amount of funding each year will affect the coverage of VCM and other MCP activities. Information about other sources of financing for VCM such as from Malaria Headquaters, Other Ministries, private sectors and community participation are very important, unfortunately those are not covered in this study.

Some information about the government policy on VCM was found from interviews and discussion. The government policy on MCP including VCM is based on the global strategy of malaria control by WHO, which it is integrated MCP at the general health services. By this policy, the priority for MCP in the allocation of government budget became moderate since 1994 (Table 4.10), despite the fact that MCP is still given high priority in the CDC programme by the Ministry of Health. In control was the main activity in the MCP. Therefore, the cost of VCM is being reduced gradually since 1994.

4.4.2 Factors Affecting Implementation of IRS

In the implementation of IRS, there are some factors which could be affected such as vector resistance, resting behavior of vectors and behavior of the people (e.g. migrant workers, sleeping pattern, rejecting IRS, etc.).

The recent susceptibility status of the vectors in South-east Sulawesi is still unknown. Since 1985, *An. barbirostris* is becoming tolerance to DDT, while *An. subpictus* and *An. flavirostris* have not yet been tested.

The effect of resting behavior of vectors on the implementation on IRS in the reduction of PR, could be analyzed by the regression equation below :

$$PR_t = \beta_0 + \beta_1 PR_{(t-1)} + \beta_2 IRS_t + \beta_3 PIRD_{ansub} + \beta_4 PIRD_{anfla} + \beta_5 PIRD_{anbar} + \beta_6 TREAT_t + \beta_7 INCO_t + \varepsilon_t \qquad (4.4.1)$$

where :

β_0 = constant

β_i = coefficient (slope)s, i = 1, 2, 3, ..., 7

ε_t = error term

Results of regression analysis for IRS from 1976 - 1986 (N = 11, k = 8) are :

$$PR_t = \underset{(3.536)^*}{26.018} - \underset{(-1.826)}{0.454\, PR_{(t-1)}} - \underset{(-1.135)}{0.056\, IRS_t} - \underset{(-3.430)^*}{0.385\, PIRD_{ansub\,t}} - \underset{(-0.685)}{0.049\, PIRD_{anfla\,t}}$$

$$- \underset{(-3.363)^*}{0.126\, PIRD_{anbar.t}} + \underset{(1.322)}{1.251\, TREAT_t} - \underset{(-2.842)}{4.88^{-05}\, INCO_t}$$

R^2 = 0.9503   F - statistic = 8.1905   Durbin Watson = 2.8209

Adjusted - R^2 = 0.8342   Prob.(F-stat.) = 0.0559

(4.4.2)

Note : ** significant at $p < 0.05$

The results above show that there is a significant reverse effect of the proportions of indoor resting behavior of *An. subpictus* and *An. barbirostris* to the reduction of PR ($p < 0.05$). Each percent of proportion reduction, the PR will increase to 0.39% and 0.13 % respectively. While *An. flavirostris* seems only a little reverse effect to reduction of PR ($p < 0.10$).

4.4.3 Factors Affecting Outcome

The outcome of IRS could be affected by malaria treatment, per capita income and literacy rate. There is no doubt that changes in the environment due to socio-economic development have reduced receptivity and in many places transmission has been interrupted completely.

From the result of regression analysis (4.3.2) above shows that For every rupiahs per population of the cost for treatment increased the PR decreased by 2.50% ($p = 0.6730$), but there is no significant effects on the reduction of PR ($p<0.10$). While per capita income, for every rupiahs increased the PR decreased by 2.17^{-4} % ($p = 0.0049$) and there is a significant effect on the reduction of PR ($p < 0.01$).

The effect of literacy on the reduction PR can be tested by the regression equation below :

$$\mathbf{PR_t} = \beta_0 + \beta_1\,\mathbf{Literacy_t} + \varepsilon_t \quad \dots\dots\dots\dots\dots\dots\dots \quad (4.4.3)$$

Results of regression analysis ($N = 3$, $k = 2$) are :

$$PR_t = 53.42716 - 0.631687\ Literacy_t$$

$$\textit{t-statistic} = (3.260008) \quad (0.215324) \quad \dots\dots\dots\dots\dots\dots \quad (4.4.4)$$

$R^2 = 0.895903$ F - statistic $= 8.6064$ Durbin Watson $= 2.9748$
Adjusted - $R^2 = 0.791805$ Prob.(F-stat.) $= 0.2091$

Regression analysis above shows that there is no significant effect of literacy rate to the reduction of PR ($p < 0.10$). This result may be inaccurate, because the number of observations very small (N=3). More observations are needed to fully justify the effect of literacy rate in reducing the PR of malaria.

4.5 Alternative Model of VCM

When the behavior of vectors have been changed, and IRS only contributed a little effect to the reduction of PR, then an alternative method of VCM should be identified. From the various combination methods of VCM in the period of 1988-1994, results of regression analysis show that there is a model with the smallest *p-value* of F-ratio, as the following :

$$PR_t = 1.1342 - 0.2772\ LVC_{btl,t} + 0.0292\ Surveillance_t + \varepsilon_t \quad \dots\dots \quad (4.5.1)$$

$$\text{t - statistic} = (3.8662)^{**} \quad (-3.0089)^{**} \quad (2.0544)$$

R^2	= 0.7311	F-statistic	= 4.4381
Adjusted-R^2	= 0.5967	Prob. (F-stat)	= 0.0723

Notes : ** significant at $p < 0.05$, with N = 7 and k = 3

The result of regression analysis above shows that there is a significant effect of larviciding by using *B. thuringiensis* in the reduction of PR ($p<0.05$). Analysis of variance approach seems that the fit of this model is good enough ($p<0.10$).

Regression equation above can be transformed into the model of VCM below:

$$\mathbf{PR_t = \mathit{f}\,(COSTLVC_{bti,t}\ COSTSurv_t)} \quad \ldots \ldots \ldots \ldots \ldots \qquad (4.5.2)$$

where : PR_t = parasite rate at time t

f = the function of vector control measures model

$COSTLVC_{bti}$ = cost per population (in rupiahs) for larviciding by *Bacillus thuringiensis*

COSTSurv = cost per population (in rupiahs) for surveillance (including case finding, prompt treatment and monitoring of vector)

The model above is expected could save the wasted of costs of IRS due to changes in resting behavior of malaria vectors. On the other hand, it is a possible model of VCM which can be applied in the MCP at South-east Sulawesi Province, Indonesia.