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NUTRITION ANEMIA AND PHYSICAL ENDURANCE AMONG CIVIL CONSTRUCTION WORKERS

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Penyelidikan ini adalah untuk membuktikan suatu hypothesa bahwa ada pengaruh dari keadaan gizi dan kesehatan terhadap kemampuan bekerja para pekerja.

Sejumlah 571 pekerja laki-laki telah dipilih dari tiga daerah tempat bekerja yaitu : Rentang, Seladarma (pembuatan canal) Halim Perdanakusuma (pembuatan lapangan terbang).

Didapatkan bahwa seluruh pekerja mempunyai nilai gizi yang borderline dan tidak ada perbedaan didalam keadaan fisik mereka, namun masih terdapat rata-rata 30 per cent menderita anemia.

Anemia banyak disertai dengan rendahnya kadar Iron darah pada pekerja di Rentang dan Seladarma hal ini tidak terdapat pada pekerja di Halim. (Table 4).

Mengenai infeksi cacing terutama cacing tambang maka diseluruh pekerja menderita infeksi cacing tersebut tingkat pertama yaitu infeksi ringan yang tidak akan mempengaruhi keadaan fisik kecuali hanya kekurangan Iron didalam darah.

Untuk mengetahui kemampuan bekerja maka telah dipakai Harvard Step Test Scores selama 5 menit. Dan ternyata bila pekerja-pekerja tersebut dibagi dua group yaitu yang diatas dan yang dibawah nilai Hb. 11 Gm/100 ml maka terdapat perbedaan yang menyolok sekali atas kemampuan pekerja tersebut didalam melakukan test fisik.

Hal ini sesuai dengan penyelidikan Veteri.

Perlu juga disini diketahui bahwa pekerja berasal dari Rentang dan Seladarma lebih banyak menggunakan tenaga kaki oleh karena selalu naik dan turun canal.

Kesimpulan penyelidikan ini adalah adanya pengaruh yang positip antara faktor makanan dan infeksi cacing dengan kemampuan bekerja yang dewasa ini amat diperlukan didalam pembangunan negara.

It has been hypothesized that one of the most important factors influencing the productivity of labor is the nutrition and health status of the labor force. This paper describes the results of a study in 1972 of 571 civil construction workers at Rentang canal, Seladarma canal, and Halim new international airport in Java.

The study was undertaken to determine if nutritional deficiencies or poor health was lowering worker endurence as measured by the Harvard Step Test, and whether a nutrition intervention study was warranted.

The findings indicate that prevalence of iron deficiency anemia and hookworm infestation is high, and there is a significant correlation between moderate to severe anemia and reduced physical endurance. Intakes of a number of nutrients are extremely low and are evidenced by clinical signs of nutritional deficiencies. Infection are also common and are probably associated with poor nutritional status.

As a result of this work, a nutrition intervention study was undertaken to measure the effect of iron supplementation on physical endurance and work performance of the labor force.

This paper describes a study of nutritional and health in a sample of male Indonesian construction workers. It served one aspect of the World Bank's Study of the Substitution of

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Labor and Equipment, the purpose of which is to assess the feasibility of labor substitution for equipment in certain aspects of civil construction (1).

The objective of this nutritional and health study was to determine whether there is sufficient evidence of nutritional deficiencies, particularly nutritional anemia, to interfere significantly with the physical endurance and to lower resistance to infectious diseases and thereby reduce work capacity. It was also to find out whether there are feasible nutritional measures that might improve physical endurance and hance work capacity.

Materials and Methods

The sample of workers were selected from three sites; Rentang canal 20 miles west of Cirebon, Saladarma canal 100 miles east of Jakarta, and Halim new international airport in Jakarta.

The types of work at the first and second sites were excavation, compaction, spreading, of earth, and manual labor for rehabilitation of canals. At the latter site different activities were found, such as trench digging, asphalt mixing, concrete mixing, iron bending, truck unloading, and stone, log, and plank carrying. The sample at each site was selected randomly. The overall organization of the study and the procedures followed were patterned after the survey conducted by the I.C.N.N.D. (2).

The clinical examination was done by a physician who inquired about the occurence of severe illness during the previous four-week period and the occurence of minor illness during the previous two-week period. He entered the diagnosis and the degree of severity in the subjects' records. Signs of nutritional deficiency were recorded. Both clinical and nutritional diagnosis were classified according to a scoring system based on degree of severity for statistical analysis.

Height and weight were measured without outer garments and shoes. The left fore arm circumference was measured in flexed at right angle position, at halfway down the arm between the tip of the acromion process of the scapula and the olecranon process of the ulna.

Finger-prick blood samples were taken for hemoglobin, hematocrit determinations and blood smear. Each blood sample was put into two standard heparinized microhematocrit tubes and centrifuged for 5 minutes in an International Micro-capillary centrifuged at 15,000 r.p.m. Hemoglobin was estimated as cyanmethemoglobin using a commercially obtained standard (3). On all individuals with hematocrit below 38 per cent, a 10 ml blood sample was drawn for determinations of serum iron (4), total iron binding capacity (5). Blood films were made to detect adnormalities in cell morphology related to deficiency diseases (6).

Fecal samples were obtained from the majority of the workers in plastic containers. As the distances of Rentang and Saladarma from the Parasitology Laboratory was far, an appropriate amount of fecal sample was transfered to a screw topped bottle and preserved in 1 per cent formalin for later examination. Immediate examination was, however, done on each sample from Halim. Stoll counts were made for egg concentration of positive sample for hookworm (7).

The Harvard Step Test, supervised by two trained personel, was performed on 537 of the 571 workers. The rest was excluded from the test for medical reasons, too young and too old. The procedure, evaluation, and interpretation followed the original test by Brouha et al (8), except that the bench was lowered to 19 inches on the basis of investigations by Harjadi Dhanutirto (9) (10).

As cooperation on the part of the subject was needed, preliminary explanation, demonstration and trial were given prior to the test. To motivate the subjects, an incentive of 100 rupiahs was offered to individuals who could continue the test for 5 minutes. At Rentang and Saladarma, this amount was equal to 50 per cent of their daily salary, and at Halim

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it was about 25 per cent. The subjects stripped to the waist and stood in front of the bench. Each was instructed to step up and down from the bench at two-second intervals in as even a pace as possible. A tape recorder with a knocking sound at two second intervals was used to maintain the proper rhythm. The supervisors always encouraged the subjects to do their best and to maintain the recommended rhythm. They were asked to continue for 5 minutes and not to stop unless exhausted.

Table 1. Nutritional and clinical findings by per cent *prevalence*.

	Rentang n = 129	Saladarma n = 124	Halim n = 305
Nutritional status, good	24.8	19.3	25.9
fair	31.8	41.9	39.7
poor	43.4	38.8	34.4
Suspected vit.B deficiency	2.3	3.2	2.6
Suspected vit.C deficiency	1.6	4.0	3.9
Clinical, healthy	36.4	35.5	51.5
Suspected anemic	40.3	32.2	21.9
Cardiovascular disease	0	8	1.6
Hypertensive Heart disease	.8	0	0
Hypertension	3.2	4.8	.6
Influenza	1.6	.8	3.3
Pulmonary Tuberculosis	.8	0	0
Enteritis	0	.8	.3
Malaria	0	0	.3
Conjunctivitis	1.6	0	.3
Perforated Otitis Media	0	0	.3
Cheilosis	.8	0	0
Pyodermia (fever)	.8	0	0
Cystitis	0	.8	0
Ulcer	0	0	.6
Wound	0	.8	.3
Furuncle	0	0	.3
Suspected liver disease	.8	1.6	0
Gastritis	4.6	14.5	5.9
Hernia	.8	0	.3
Dermatitis/eczema	0	0	.6
Urticaria	0	1.6	.3
Tinea Versicolor	13.2	14.5	12.4
Arthralgia	0	.8	.9
Fatigue	3.2	3.2	2.6
Pterygium	0	.8	.3
Invalid	0	.8	.3
Ischalgia 1)	.8	0	0

1) a general term denoting vague pains in lower back area

If a irregular rhythm could not be corrected within two minutes, the test was terminated. At the end of the test the subject was instructed to sit down quietly for three and a half minutes. After one minute the pulse was counted according to the "slow method", in which three pulse counts (p) are taken from 1 to 1½, 2 to 2½ and 3 to 3½ minutes after exercise. The score was calculated as follows:

$$\text{Score} = \frac{(\text{Duration of test}) \, 100}{2(P_1 + P_2 + P_3)}$$

Table 2. Age and anthropometric of the workers.

		Rentang n=129	Saladarma n=124	Halim n=297
Age, year	Mean	28.5	28.7	25.7
	S.D.	7.6	9.4	8.2
Height, Cm	Mean	160.6	160.5	159.8
	S.D.	5.3	5.4	5.2
Weight, Kg	Mean	51.2	50.5	49.2
	S.D.	5.0	4.9	4.8
Arm circ, Cm	Mean	25.9	26.7	26.6
	S.D.	2.0	1.6	2.2

A score of 90 or greater is considered excellent, 80 – 89 good, 65 – 79 average, 55 – 64 low, and less than 55 poor.

nutritionist through individual inquiries of 25 per cent subsample, using a combination of techniques from Burke et al (11), Klerks (12), and the Directorate of Nutrition of Indonesia (13). The nutrient content of the diet was calculated from the Indonesian Food Composition Table (14).

Results and Discussion

The results of clinical examination are shown in Table 1. The nutritional status of three quarters of the workers at three sites was judged to be poor to fair. These findings are in good agreement with the anthropometric data.

The clinical (non-hematological) diagnosis of anemia was made by using a group of signs such as pale conjunctivae, atrophic papillae, etc., and subjective complaints consistent with

anemia. The same approach was used for suspected vitamin B and vitamin C deficiency syndromes. More than 30 per cent of the workers were diagnosed as anemic, the percentage ranging from 22 at Halim to 40 at Rentang.

Table 2 shows the mean ages of the workers at Rentang, Saladarma, and Halim were 28.5, 28.7 and 25.7 years respectively. No significant in height and arm circumference were observed among workers at the three sites. Significant differences in body weight existed only between workers at Rentang and Halim. In effect, most workers were in a borderline nutritional state, and showed a considerable amount of physical stunting due to protein and calorie deficiencies in early childhood.

Table 3 shows the frequency distribution of hemoglobin and hematocrit values. The data confirmed the high incidence of anemia among workers, in particular at Rentang and Saladarma. Mild anemia (Hb 11.0 to 12.9) was

Table 3. Distribution of Hemoglobin and Hematocrit values of workers.

(per cent)

	Rentang n=131	Saladarma n=125	Halim n=137
Hemoglobin (gm per cent)			
15.0 and over	8.4	12.8	18.9
13.0 – 14.9	41.2	43.2	49.6
11.0 – 12.9	34.3	32.0	23.9
9.0 – 10.9	12.3	6.4	4.4
8.9 and less	3.8	5.6	3.2
Hematocrit (per cent)			
44.0 and over	13.0	13.6	15.8
38.0 – 43.0	57.2	56.0	63.8
32.0 – 37.0	23.7	24.0	17.3
26.0 – 31.0	5.3	6.4	2.2
25.0 and less	0.8	0.0	0.9

Microscopic examination of blood films indicates that microcytosis hypochromic target cells, and anisocytosis were common, and hypersegmented white cells were frequently seen. Anisocytosis, hypochromia, and microcytosis have been suggested at useful criteria for iron deficiency (18). The incidence of Eosinophilia were extremely high at all sites. These were commonly observed in association with parasitic infestation (19). Table 5 and 6 very common. Based on WHO criteria, where anemia would be considered to exist in those whose hemoglobin levels are below 13.00 Gm/100 ml. (15), the incidence of anemia was 52 per cent at Rentang, 43 per cent at Saladarma, and 28 per cent at Halim.

Table 4 shows the iron status of the anemic workers as based on hematocrit values below 38. Plasma iron below 50 mg/100 ml is usually found in iron deficiency anemia (16). Based on this value, iron deficiency was 89.5 per cent at Rentang, 73 per cent at Saladarma, and 15 per cent at Halim. Based on transferrin saturation value 15 per cent as criterium for iron deficiency (17), the incidence was higher at all sites.

Table 4. Serum iron, total iron binding capacity, transferrin saturation of anemic workers*. (per cent).

	Rantang n = 38	Saladarma n = 33	Halim n = 89
Serum Iron (mcg per cent)			
70 and over	2.6	8.1	16.9
50 – 69	7.9	18.9	28.1
30 – 49	57.8	45.9	39.2
10 – 29	23.8	24.4	12.4
9 and less	7.9	2.7	3.4
T.I.B.C. (mcg per cent)			
325 and less	0.0	0.0	0.0
400 – 326	7.9	21.6	10.1
475 – 401	55.3	59.4	74.2
550 – 476	26.3	16.3	13.5
551 and over	10.5	2.7	2.2
Transferrin Saturation (per cent)			
20 and over	0.0	8.1	5.6
15 – 19	7.9	13.5	15.7
10 – 14	26.4	24.3	39.4
5 – 9	47.3	40.6	29.3
4 and less	18.4	13.5	10.1

Based on hematocrit value below 38

shows the incidence of worm infestation and its relation to blood status.

Table 5. Incidence of intestinal helminths (per cent)

	Rentang n=102	Saladarma n=75	Halim n=168
Ancylostoma	87.3	84.0	85.1
Ascaris lubricoides	75.5	66.7	58.3
Trichuris trichura	63.7	58.7	58.3

Table 6. Relation of stoll count with hemoglobin and hematocrit values taken from workers of Halim new airport,

Eggs per ml of feces	n	Rating	Hb	Ht
less than 100	25	normal	13.7	40.9
100 – 699	18	very light	13.9	41.2
700 – 2.599	38	light	13.6	41.6
2.600 – 12.599	48	moderate	13.0	39.1
12.600 – 25.099	12	heavy	11.9	38.7
25.100 and over	1	very heavy	12.4	36.0

Table 7. Dietary intake of workers at three sites

		Rentang n = 31	Saladarma n = 37	Halim n = 71
		per cent	per cent	per cent
Calorie 2500 and over	high	39	9	15
2200 –	acceptable	29	18	25
1900 –	low	26	24	39
below 1900	deficient	6	48	20
Protein, Gm/Kg body weight				
1.5 and over	high	0	0	0
1.0 –	acceptable	29	6	4
0.5 –	low	71	73	93
below 0.5	deficient	0	21	3
Iron, mg[2]				
12 and over	high	39	3	30
9 –	acceptable	10	18	35
6 –	low	41	39	27
below 6	deficient	3	39	8
Vitamin A, I.U				
5000 and over	high	3	0	0
3500 –	acceptable	3	6	0
2000 –	low	13	9	1
below 2000	deficient	81	85	99
Vitamin C, mg				
50 and over	high	6	9	1
30 –	acceptable	13	9	1
10 –	low	32	36	51
below 10	deficient	48	45	46
Vitamin B_1, mg/1000 Cal				
0.5 and over	high	3	0	7
0.3 –	acceptable	0	0	69
0.2 –	low	13	12	18
below 0.2	deficient	84	88	5

1) The rating follows the ICNND'S Manual for Nutrition Survey 1963
2) This does not adequately take into account the low absorption of iron from sources.

Chronic hookworm infestations may be grouped into three types according to severity (19) (20): a. Light infestations, in which blood loss in compensated for and symptoms are absent, although the infested individual may have a lowered resistance to extraneous disease. b. Infestations where the blood loss is not compensated and the individual shows undernourishment, intestinal disorders, anemia, lack of energy, and physical retardation. c. Severe infestations with lack of compensation, leading to physical exhaustion and cardiac failure. Table 6 will indicate that most workers in this study fall into the first category. Undoubtedly, hookworm infestations cause a imbalance iron metabolism and induce, in the long run, the moderate to severe iron deficiency anemia.

Table 7 shows that most diets are not adequate. Most workers at Rentang had adequate Calorie, and the reverse was true at Saladarma. Workers at these sites bring their lunch from home or purchase at local vendors. The workers at Halim have free lunches from their contractor. Lunch is a very heavy meal in Indonesia food pattern, it has great influence upon daily nutrient intake. Most of the protein intakes fall into low to acceptable category. This was mainly due to the big consumption of rice.

Iron intakes were relatively high at Rentang and Halim. It was apparent that the chief source of iron was "ontjom" made from fermented peanut presscake and fermented soy products. However this does not adequately take into account the low absorption of iron from plant sources.

Dietary findings, like those of a study in Latin America, have not been helpful in explaining the iron deficiency (21).

Table 8 shows that small percentage of workers had a Harvard Step Test Score below 65. The mean scores for Rentang, Saladarma and Halim were 78.2, 80.0 and 69.1 respective-

Table 8. Frequenty distribution of Harvard Step Test Score

score	rating	Rentang n = 126	Saladarma n = 114	Halim n=297
		per cent	per cent	per cent
90 and over	excellent	23.1	31.6	12.1
80 – 89	good	34.1	29.8	21.9
65 – 79	average	29.4	23.7	36.4
55 – 64	low	5.5	3.5	3.9
below 55	poor	7.9	11.4	25.9
The Mean Scores		78.2	80.0	69.1
per cent Completed 5 min.		83.3	72.8	63.9

ly. More than 80 per cent of the workers at Rentang, 73 per cent of those at Saladarma, and 64 per cent of those at Halim were able to complete 5 minutes test.

Hoeldtke (22) and Viteri (23) in their studies in Guatemala found that anemia affects the Harvard Step Test Scores. To see whether in the present study the same result is true the subjects were divided into anemic and non-anemic groups and the Harvard Step Test scores were compared.

Table 9 indicates that when the anemia cutoff point is taken at hemoglobin levels of 13 Gm/100 ml according to W.H.O. criteria. there is no significant difference between anemic and non-anemic workers in their ability to perform in the test, with the exception of those at Halim. However, when the cutoff point for anemia is taken at hemoglobin levels of 11 Gm/100 ml, then there are significant differences in Harvard Step Test scores at all three sites between anemic and non-anemic workers. This precisely confirms Viteri's recent findings (23) i.e., that differences in Harvard

Table 9. Harvard Step Scores of anemic and non anemic workers (high cutoff point)

Hemoglobin		Rentang	Saladarma	Halim
13 and over	n	62	65	194
	Mean	80.9	81.1	72.4
	S.D.	13.5	17.8	19.2
below 13	n	63	48	103
	Mean	76.8	77.6	62.2
	S.D.	18.6	19.4	21.5
	difference	4.1	4.2	10.2^{++}
	(low cutoff point)			
11 and over	n	106	103	274
	Mean	80.4	81.1	70.7
	S.D.	15.6	18.6	18.4
below 11	n	19	10	23
	Mean	61.9	66.7	51.7
	S.D.	21.3	18.3	21.1
	difference	18.5^{++}	14.4^{+}	19.0^{++}

+ significant at 5 per cent level
++ significant at 1 per cent level

Step Test scores between anemics and non-anemics are significant only when cutoff points for anemia are taken at hemoglobin levels of 11 Gm/100 ml or hematocrit levels of 32 per cent.

Looking at the results from Halim, where all those with anemia regardless of cutoff point did show significant differences in Harvard Step Test scores, it is noted that the workers at Halim differ from those of the other two sites in several respects. At Rentang and Saladarma the workers had been conditioned to far more vigorous physical exercise. The work at these two canal rehabilitation sites consisted mostly of climbing up and down the very steep slopes of the canals with rocks or earth loaded onto shoulder baskets. The type of work at Halim was far easier and put a minimum of strain on the leg muscles.

To the workers at Rentang and Saladarma the Harvard Step Test as it is undertaken did not present sufficient challenge, and thus the differences in performance between anemic and non-anemic at those sites were not so apparent. At Halim, however, it was fairly obvious that the Harvard Step Test severely taxed the workers. They were not used to the new demands and strain on their leg muscles. These demands posed even more of an obstacle to those suffering from anemia.

The fact that adaptation to heavy exercise, especially of leg muscles, in an important factor in Harvard Step Test performance may be confirmed by a study done in Indonesia on "betja" drivers. Most of these pedicab

Table 10. Correlation matrix for general analysis
Rentang n = 126 Saladarma n = 114 Halim n = 297.

		Height	Weight	Arm	Harvard	Hb	Ht	Clin	Nutr
Height	R	1.000							
	S	1.000							
	H	1.000							
Weight	R	.661	1.000						
	S	.664	1.000						
	H	.606	1.000						
Arm circ	R	.068	.562	1.000					
	S	.188	.654	1.000					
	H	.168	.546	1.000					
Harvard Step	R	.012	.113	.121	1.000				
	S	.019	.032	.009	1.000				
	H	.019	.066	.008	1.000				
Hemoglobin	R	−.112	.024	.288	.196	1.000			
	S	−.122	−.078	.131	.114	1.000			
	H	.078	.086	.191	.284	1.000			
Hematocrit	R	−.090	.073	.226	.269	.838	1.000		
	S	−.031	.005	.150	.137	.845	1.000		
	H	.064	.080	.140	.278	.838	1.000		
Clin. diagn	R	.002	.053	.077	.019	.198	.234	1.000	
	S	.012	.151	.228	.000	.008	.222	1.000	
	H	.027	.112	−.214	.149	.304	.304	1.000	
Nutr. diagn	R	.024	.236	.291	−.033	−.120	−.179	.678	1.000
	S	.117	.316	.377	.045	.028	.041	.596	1.000
	H	.162	.362	−.443	.092	.186	.211	.406	1.000

underlined = significant at 5 per cent level

drivers had good to excellent Harvard Step Test scores (10).

Motivation may also have affected Harvard Step Test scores. At Rentang and Saladarma, the workers were being given the equivalent of half their daily pay as reward for performing the full 5 minutes test. At Halim, where the workers were used to a much higher salary, the bonus was only 25 per cent of their daily pay. In any case, those tested at Halim, regardless of whether they were anemic or not, had generally higher dropout and lower mean scores than those at Rentang or Saladarma (see Table 8).

Looking at the correlation matrix (see Table 10) for all three sites, it is clearly seen that correlation at 5 per cent level were found between all three anthropometric data, Hemoglobin and Hematocrit, Nutritional and Clinical diagnosis. Correlation between Harvard Step Test score and blood values were found only at Halim.

Summary and Conclusions

Data were collected from 571 male workers at three construction sites in Jawa, by a survey team through clinical examinations, laboratory tests, physical endurance tests, and nutritional interviews.

The findings indicate that the prevalence of iron deficiency anemia and hookworm infestation is high at all three sites.
Infections are common. Intakes of a number of nutrients are very low and are evidenced by clinical signs of nutritional deficiency.

There is sufficient evidence of anemia to interfere significantly with worker's physical endurance as measured by the Harvard Step Test.

The findings call for concentrated attacks upon nutritional deficiencies among these workers who have significant roles in national economic development.

In intervention study should be conducted in which workers found to have anemia are given specific treatment for its correction with measurements of physical endurance and work capacity before and after such treatment.

Efforts should be made to prevent nutritional deficiencies by efficient and effective measures.

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