The Influence of Seafarers' Malnutrition upon Maritime Safety

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Abstract The results of seafarers' nutrition surveys from some countries reflect that seafarers' malnutrition is still a problem in the world maritime community. After synthesizing the published data of the Chinese oceangoing seafarers' nutrition surveys in the last ten years, the Chinese seafarers' nutrition status is discussed. Vitamin C, vitamin B_2, vitamin A and calcium are determined as the susceptible nutrients in shortage for Chinese oceangoing seafarers during navigation. Seafarers' malnutrition is thought to be a contributing factor to human error which is reported to be the dominant factor in maritime accidents, contributing to 80% to 85% of incidents. The influence of seafarers' malnutrition upon maritime safety is discussed through the analysis of the relationship of malnutrition, the third status, disease, fatigue, human error and maritime safety. The influence of improper diet, improper response to stress, sleep deprivation and lack of exercise on seafarers' malnutrition is also analyzed. Suggestions for improving the situation are raised which touch seafarers' nutrition training and education, improvement of food storage technology aboard ship, nutritional supplements and fortified products, Dietary Reference Intakes, further improvement of living and working conditions aboard, and establishing a ship's living and working condition management system.

Keywords seafarer; diet; nutrition; human error; maritime safety

0 Introduction

Human error continues to be the dominant factor in maritime accidents, contributing to 80% to 85% of incidents. USCG[1] data analyzed for all accidents over the reporting period of 1999 to 2001 confirm the approximate 80% to 85% human error involvement. About 50% of maritime accidents were initiated by human error, and another 30% were associated with it. In MARS reports, mariners note human error in the majority of reports and chiefly attribute accidents and near misses to lack of competence, lack of knowledge and ability, human fatigue, workload, manning, complacency and risk tolerance. Although the maritime community has done much work to try to eliminate human errors, the above statistics still show a high percentage of human

error as a contributing cause to maritime accidents. So we still need to seek approaches to reduce accidents caused by human error. In the last ten years, medical researchers in the United States[2], Australia[3], Poland[4, 5], Finland[6], Russia[7], China [9-12], Japan and other countries have carried out nutrition surveys and investigations on board vessels and have drawn the conclusion that many seafarers are malnourished. But the important role of seafarers' malnutrition in maritime accidents has not been set forth clearly. On one side, the medical researchers are discussing their seafarers' nutrition survey results; on the other side, the maritime community is seeking the ways to decrease the maritime accident rate and paying attention to a number of influencing factors in maritime accidents. In the author's view, seafarers' malnutrition is a major problem aboard ships throughout the world. It is the dominant contributing factor to human error and the maritime accidents herein produced. It is important to identify the dominant influencing factor and clarify the relationship of it with the others. Since the nutrition statuses of seafarers are different in different countries, the author illustrated his view with the Chinese oceangoing seafarers' nutrition survey results and offers some strategic suggestions for improving the situation.

1 The Nutrition Status of Chinese Oceangoing Seafarers

So far no Dietary Reference Intakes (DRI) exists for merchant marine seafarers in China[8]. Researchers making assessments of seafarers' nutritional status have to use the DRI usually employed for ordinary residents of the country. Even with this standard and without consideration for the particularity of seafarers' living and working conditions, the malnutrition status of Chinese seafarers has been revealed by researchers in China through nutrition surveys. In the last ten years, Ji Hongguang[9], Zhong Jinyi[10], Zhang Yanbin[11], Yao Yuxiang[12] and others have conducted diet and nutrition surveys on board Chinese oceangoing vessels and published their results jointly or respectively. The author of this paper synthesized the data of the surveys on board 15 vessels and presented the situation of the nutritional status of Chinese seafarers (Table 1). Although the surveys were carried out on a limited number of ships, the identity of their results reflected the possibility that seafarers' malnutrition is a prevalent problem among Chinese seafarers and needs further study.

In Table 1, the data of nutrients in the diet are calculated using the weighing method, and the data of metabolic index of serums and urine are obtained from laboratory tests. The values of the nutrients in daily diet are given with average values except for vitamin C. The value of vitamin C is given with a range of value since the lack of vitamin C typically happens in the late period of a long voyage. RDA1 and RDA2 refer to the recommended daily allowance for Chinese ordinary adults with light work and moderate work respectively. The recommended values are given by nutrition scientists. The evaluation results are based on the comparison of the nutrient average values with their relevant RDA1, RDA2 or the recommended values as well as the judgment of nutrition professionals. The percentages of daily intakes of protein, fat and carbohydrate are 13%, 36% and 51% respectively. The average daily intake of protein is 106.9g which exceeds the value of RDA2 by 18.7%. The average intake of fat is 131.6g which exceeds the value of RDA2 by 64.5%. The recommended percentages for the intake of the three energy nutrients are protein: 10%~12%, fat: 20%~25% and carbohydrate: 55%~65% respectively. So the intake of fat is unsuitable in both its amount and its percentage. The mean daily energy intake is 13.9JM exceeding RDA2 by 11.2%. It is a contributing factor for seafarers to get fat. The intakes of

calcium, vitamin A, vitamin B_2 are insufficient. The intake of vitamin C is severely insufficient during the late period of a long voyage. In addition, the ratios of PUFA: SFA and Ca: P are also unsuitable. The shortage of sodium was reported to be probably caused by seafarers' working under high temperature.

Table 1 Chinese Seafarer's Individual Daily Nutrients Intakes and Evaluation

	Methods of survey	Sample	Average	RDA1	RDA2	Recommended value	Evaluation
Protein	Estimated intake(g)	508	106.9	80.0	90.0		Suitable
Fat	Estimated intake(g)	508	131.6		80.0		Unsuitable
Chlesterol	Estimated intake Lab test (mmol/L)	36 249	384 4.4			300 2.3-5.6	
Triglyceride	Lab test (mmol/L)	249	1.3			0.3-1.9	
PUFA:SFA	Estimated intake	36	2.2:1			1.25-1.5:1	Unsuitable
Carbohydrate	Estimated intake(g)	508	431.7		480.0		
Protein:Fat: Carbohydrate	Estimated intake	508	13%:36%:51%			Protein: 10%-12%, Fat: 20%-25%, Carbohydrate: 60%-65%	Unsuitable
Diet fibre	Estimated intake(g)	370	7.1		6.0-8.0		Suitable
Daily energy	Estimated intake(JM)	406	13.9	10.9	12.5		Unsuitable
Na	Estimated intake(mg) Content in serum(C/ μm□L^{-1})	36 81	5881.4 125.8			131.8-147.8	Unsuitable
K	Content in serum(C/ μm□L^{-1})	81	4.1			3.3-5.0	Suitable
Ca	Estimated intake(mg) Content in serum(C/ μm□L^{-1})	473 81	603 3.0	800.0	800.0	2.2-3.3	Unsuitable
P	Estimated intake(mg)	36	1246.6				
Ca:P	Estimated intake	218	1:2.21			1:1-1:1.5	Unsuitable
Mg	Content in serum(C/ μm□L^{-1})	81	1.1			0.7-1.2	Suitable
Fe	Estimated intake(mg) Content in serum(C/ μm□L^{-1})	473 81	27.7 20.3	12.0	12.0	10.9-26.7	Suitable Suitable
Zn	Estimated intake(mg) Content in serum(C/ μm□L^{-1})	473 81	12.6 17.9	15.0	15.0	13.8-20.0	Suitable Suitable
Cu	Estimated intake(mg) Content in serum(C/ μm□L^{-1})	370 81	2.4 14.6		2.0-3.0	14.1-18.5	Suitable Suitable
Se	Estimated intake(μm)	36	64.4	50.0	50.0		Suitable
Vit A Retinal equivalent Vit A	Estimated intake(μm) Serous content(C/ μm□L^{-1})	320 148	617.7 385.9	800.0	800.0	300-900	Unsuitable Unsuitable
Vit E	Estimated intake(mg)	36	68.1	10.0	10.0		Suitable

Vit B_1	Estimated intake(mg)	473	1.8	1.3	1.5		Suitable
	Urine load test(m/μm)		204.3			≥200.0	Suitable
	TPP effect (%)		14.8			≤16.0	Suitable
Vit B_2	Estimated intake(mg)	473	0.96	1.3	1.5		Unsuitable
	Urine load test(m/ μm)	157	337.8			≥350.0	Unsuitable
	Content in RBC (C/ μm□L^{-1})	145	139.1			≥200.0	Unsuitable
Niacin	Estimated intake(mg)	473	17.3	13.0	15.0		Suitable
	Urine load test N'-Me(m/ μm)	157	4.3			≥3.0	Suitable
Vit C	Estimated intake(mg)	473	47.6-130.1	60.0	60.0		Unsuitable
	Urine load test(m/ μm)		1.9			≥3.0	Unsuitable
	Content in WBC		75.1			≥106.4	Unsuitable
	(ω/mol·g^{-1})		14.1			≥20	Unsuitable
	Content in WBC (mg/kg)						
Vit B_6	Serous	81	16.8			--	
	GOT(ξ/mol□s^{-1}□L^{-1})	81	3072.0			--	
	RBC-GOT (ξ/mol□s^{-1}□L^{-1})						

RDA1: Recommended daily allowance for Chinese adults with light work

RDA2: Recommended daily allowance for Chinese adults with moderate work

[Information synthesized from surveys done by Ji Hongguang, Zhong Jinyi, Zhang Yanbin, Yao Yuxiang, et al.]

The symptoms found during the survey periods were reported to be gum swelling and pain (24.1%~67.7%), oral mucosa ulcer (17.2%~51.6%), scrotum eczema (13.2%), constipation (31.4%), insomnia (48.8%), the time for dark adaptation prolonged, overweight and obesity, which were said to be in close relation with the malnutrition status.

2 Malnutrition

2.1 The possible impairment of malnutrition

Both insufficient of nutrition and excessive of nutrition are malnutrition.[8] Malnutrition may produce "the third status", weak immune system and diseases. The basic function of the nutrients which are deficient in Chinese seafarers and the possible impairment due to their deficiency can be described as follows:

Vitamin A assists in the formation and maintenance of healthy skin, hair and mucous membranes; aids in the ability to see in dim light (night vision); assists in proper bone growth, teeth development, and healthy reproduction. Deficiency of vitamin A may produce night blindness; rough skin and mucous membranes; infection of mucous membranes; drying of the eyes; impaired bone growth and poor tooth enamel. Vitamin B_2 mainly helps release energy from carbohydrates, proteins, and fats; and aids in the maintenance of mucous membranes. Deficiency of vitamin B_2 may produce skin disorders, especially around the nose and lips; cracks at corners of the mouth;

and sensitivity of eyes to light. Vitamin C is mainly to aid in the formation of collagen; help maintain capillaries, bones, and teeth; help protect other vitamins from oxidation; may block formation of cancer-causing nitrosamines. [13]

Since the function of vitamins involves assisting enzymes to function, any shortfall of vitamins may terminate or change the biochemical reactions in the human body and impair the process of normal metabolism. A long period of abnormal metabolism may produce "the third status", a degraded immunity system and chronic diseases. For the Chinese seafarers in short of several kinds of vitamins and minerals, they were in "the third status" or in a development of chronic disease or even already suffering disease.

2.2 The main factors causing malnutrition

2.2.1 Improper diet

The cause of malnutrition in respect to diet is the unbalanced intake of nutrients and bad diet habits. Table 2 shows the daily diet structure of seafarers on board 14 Chinese oceangoing vessels during navigation. The values in the table are averages calculated using the data of the diet surveys on board the vessels. To synthesize the results of the surveys and the studies in other countries the causes of improper diet can be listed.

Table 2 Diet structure of Chinese oceangoing seafarers during navigation

Type of food	In the early days		In the later days		Reference structure
	Quantity(m/g)	%	Quantity(m/g)	%	%
Grain	456.3	35.8	490.0	43.1	32.5
Yam	25.4	2.0	58.5	5.1	6.3
Bean	27.9	2.2	34.0	3.0	4.2
Sugar	20.4	1.6	19.6	1.7	1.4
Plant oil	76.8	6.0	75.6	6.6	1.4
Meat	111.8	8.8	118.1	10.4	5.6
Fish	67.4	5.3	46.4	4.1	1.4
Dairy	1.5	0.1	1.0	0.1	4.6
Egg	47.0	3.7	38.0	3.3	3.8
Fruits & vegetable	440.3	34.5	256.3	22.5	38.8

[Information synthesized from surveys done by Ji Hongguang, Zhong Jinyi, Zhang Yanbin, Yao Yuxiang, et al.]

(1) Limited quantity of fresh fruits and vegetables on board and stored in refrigerator. The water soluble vitamins in fruits and vegetables decrease with the lapse of time.

(2) Some crew members have to work in a dark environment. The consumption of vitamin A should increase. The lack of vitamin A has a negative effect on seafarers who work in the dark.

(3) Stress, anxiety, depression etc. make seafarers consume more micro-nutrients.

(4) Lack of exercise puts seafarers in a state of positive energy metabolism balance.

(5) The diet with more frying food, refined sugar, refined starch and less whole grain, beans, dairy, fresh vegetables and fruits makes seafarers consume more energy nutrients, less vitamin and mineral.

(6) Consuming more beverages containing alcohol, refined sugar and caffeine.

(7) Irregular work shifts, night work and other temporary work cause poor or hasty eating habits and this, in turn, can impair the seafarers' digestive systems.

(8) Smoking consumes more micro-nutrients.

(9) Seasickness causes seafarers to take less food and nutrients.

2.2.2 Stress

"Stress" refers to the stimulus causing the stress reaction. These stimuli are now referred to as stressors. Nearly anything can be a stressor.[14] Stress occurs when a person is confronted with an environment that poses a threat or demand, and the individual becomes aware of his/her inability or difficulty in coping with the environment. Stress is the body's knee-jerk reaction to a threat. It is one of those survival-of-the-species basic instincts dating back to the beginning of life.[15] Some things are stressful in a positive way or even fun. Others are stressful in a negative way. It is not the stress itself but the reaction of people to the stress in the environment that depletes their immune systems and leads to illness.[16]

Stress and nutrition are closely intertwined. A person is more vulnerable to nutritional deficiencies when stressed than during almost any other time in life, and these nutrient deficiencies amplify the stress. Any type of stress upsets nutritional balance, which in turn makes the stress just that much worse. If the stress is short lived and the person is already well-nourished, he/she will handle the situation with less anxiety and the stress is not likely to significantly affect nutritional status. However, if a person is marginally nourished prior to a stressful situation and/or the situation lasts for some time, he/she overuses body's ability to handle this high-stress period and therefore impairs his/her health unless immediate action is taken to improve diet and coping skills.

For seafarers, stress is induced by sleep deprivation, work load, intense time schedules, improper relationship with other crew members, work in dark, dangerous situation, engine or equipment failure, bad weather, unwell body, etc. Since working on board ship is a relatively dangerous job and seafarers are always reminded to be alert to the dangers around them, they are actually in a state of stress all the time on board ship. This is one of the most important influencing factors in the deterioration of the marginal or malnutrition status of seafarers.

Physiologic responses to stressors include the central nervous system (CNS), hypothalamic-pituitary-adrenal (HPA) axis, and the autonomic nervous system (ANS). Hormones play a particularly key role in the adaptive coping response by the organism to the stressor stimulus. The secretion of glucocorticoids by the HPA axis, and the release of catecholamines by the ANS are among the most fundamental responses to stressors[13]. Liu Kaiji, et al. [17] measured the 24-hour urinary excretion values of 17-hydroxycorticosteroids (17-OHCS), 17-ketosteroid (17KS), catecholamine (CA), epinephrine (E) and norepinephrine (NE) of 344 ocean-going seamen as well as the self-rating anxiety scale (SAS) scores of 34 of them during different periods of a 61-day voyage and 60 days later after the voyage, to investigate seafarers' psychosomatic disorder morbidity and its possible relationship with their psychological stress. Liu Kaiji's team concluded that the seafarers' psychosomatic disorder morbidity was intensive and they were under psychological stress during the voyage. The stress tended to become more intense as the voyage

proceeded and was relieved only after a period of off-ship vacation. The stress was more intensive in the morbidity group than that in the non-morbidity group, which suggested that the seamen's psychosomatic disorder was related to psychological stress.

2.2.3 Sleep deprivation

Sleep deprivation is also one of the important factors, which leads to the shortfall of nutrients in seafarers' bodies and to a negative balance of energy metabolism. Sleep appears to have a basic role in the physiologic recovery of waking metabolic functions, especially in relation to the brain. Based upon an evaluation of the physiologic correlates of sleep deprivation, there is evidence that sleep serves a fundamental role in the maintenance of balanced energy expenditure for the whole organism. Rechtschaffen et al.[18] showed in a large number of elegant experiments that sleep-deprived rats developed a negative energy balance through a doubling of energy expenditure (mean = 210%~270% of baseline), based upon increased food intake (hyperphagia) accompanied by weight loss. It appears the sleep-deprived animals underwent an increase in basal energy expenditure not evident in work, waste, or weight.

Shift work and night operations on board ships are common. The traditional 8~9 hours per day of sleep for people living on land cannot be guaranteed on board oceangoing vessels. Psychological studies reveal that sleep duration less than 7 hours a day results in cumulative sleep debt, waking neurobehavioral impairments and metabolic deficiencies, both of which are associated with potentially lethal outcomes such as traffic accidents.

2.2.4 Exercise

Although there is still much work for scientists to do in respect to the relationship between exercise and nutrition, it is clear that exercise is an important factor in regulating the energy metabolic balance. Since the Chinese seafarers are in the state of positive energy balance and have the risk of overweight and obesity, increasing exercise during navigation is one of the strategies to maintain a balanced energy metabolism.

3 The influence of Malnutrition upon Maritime Safety

3.1 The third status

Seafarers who have been diagnosed with certain kinds of disease and deemed to be not competent for their position on board ships are not permitted to work on board ship and will be sent to receive proper treatment in hospital ashore. As patients staying ashore for treatment, their health status does not create any threat to maritime safety. However before they are diagnosed as suffering from diseases and therefore not suitable for work on board ships, if they are malnourished, their bodies' organ functions and tissue structures have already begun declining. They might have some recognitions of this state, but believe it is not so serious as to affect their holding certificates of competence. They are in a state between total health and disease. This state is called "the third status" or "sub-health" in medicine. Although there isn't a worldwide accepted definition for it, descriptions about it do exist. It is described as a state where the structure of the human body is declining; physiological function is becoming weak; and mental function is unbalanced. It usually has no clinical manifestation and physical symptoms.[19] The third status

includes:

(1) Uneasy feeling physically or mentally, but difficult to be diagnosed as a certain disease;

(2) In the period before some clinically diagnosed diseases;

(3) Syndrome with unknown cause, such as climacteric syndrome, neurasthenia, fatigue syndrome;

(4) The state carrying pathogens, such as hepatitis B virus carriers, tubercle bacillus carriers;

(5) At the state of highest or lowest limit values by clinical tests, such as hypertension, hyperglycemia, hyperlipemia, hypocalcemia and hypopotassemia, etc.;

(6) High pathogenic risk factors, such as overweight, smoking and over stress.

It is reported that 45% to 70% of people are in the third status. According to this reported percentage and considering that seafarer's fatigue belongs to the third status and half or even more seafarers on board are in a malnourished state, especially during the late period of voyage, in the author's view, at least half of the active seafarers aboard are in the third status.

3.2 Continuing work on board with disease

Some seafarers are still permitted to stick on their positions on board ships even though they have been diagnosed to be suffering certain kinds of chronic diseases if only mild diseases so far. It is obvious that they are susceptible to fatigue. According to the health examination analyzing results of 101 entry-exit Chinese seafarers at Huidong Port published by Xiaomeng Zhu and Xiaozhong Wu[20], 131 person-times were abnormal among the seafarers under surveillance. A high percentage of seafarers were suffering from positive HBsAg, ALT, hypertension and hyperlipemia, TG, CHOL, UA and peptic ulcers which are connected with malnutrition (Table 3). Hypertension examinations were done on 500 seamen of a coastal ship shipping company and 18.06% of them were found suffering from hypertension.[21] At the same time, the national adult hypertension rate was 3%~9% and the worldwide hypertension rate was 8%~18% according to the WHO. Although these data are not based on a widely systematic survey, they reflect to some extent that approximately 20% Chinese seafarers are active on board ships with chronic diseases.

Table 3 Health examination results of entry-exit Chinese seafarers at Huidong Port, 2003

Diseases	Cases found	Rate found
HBsAg	18	17.82
ALT	14	13.86
hydrotension	18	17.82
TG	22	21.78
CHOL	25	24.9
UA	10	9.9
Peptic ulcer	10	9.9
Siphilis	1	0.99

3.3 Fatigue

Fatigue has been discussed in the maritime community in recent years which is thought to be a

contributing factor to human error. Alertness is the optimum state of the brain that enables seafarers to make conscious decisions. Fatigue has a proven detrimental effect on alertness. When a person's alertness is affected by fatigue, his/her performance on the job can be significantly impaired physically and mentally, such as in decision-making, response time, judgment, hand-eye coordination and countless other skills. Fatigue can affect an individual's ability to respond to stimuli, perceive stimuli, interpret or understand stimuli. It also takes longer for seafarers to react to stimuli once they have been identified. Fatigue is known to affect a person's performance detrimentally and may reduce individual and crew effectiveness and efficiency; decrease productivity; lower standards of work, and may lead to errors.

So far the role of nutrition in central fatigue is still an ongoing subject for scientists to study.[22] The focus is on the neurotransmitter serotonin because of its role in depression, sensory perception, sleepiness and mood. No matter what the mechanism is, any shortage of vitamins and calcium may impair the mechanism since it needs energy and the energy is produced through body metabolism from energy nutrients and uses vitamins as coenzymes. The neurotransmitter and neuron need calcium. The lack of vitamins and calcium impairs the body energy metabolism and the activity of the nerve system. As a result vitamin and mineral deficiency degrades the performance of seafarers.

3.4 Human error and maritime safety

Human error is an unavoidable incident for human beings. It is impossible to eliminate it. But in some circumstances influenced by some factors, the frequency of human error may increase. In these circumstances with effective measures, human error can be diminished. Malnutrition is an abnormal metabolic state. If it lasts for some time, the third status develops. Fatigue is one of its manifestations. Seafarers in this situation show degraded performance. The frequency of human error increases. The risk of maritime accident increases and maritime safety is threatened.

3.5 Summary

Nutrients supply energy and material for the metabolism of seafarers' body to keep it running and recovering from any tissue damage. The shortfall of nutrients, such as vitamin A, vitamin B_2, vitamin C and calcium impairs the metabolic process. A long-period of this status makes a weak immune system, the third status and even disease. The usual circumstance for seafarers on board vessels is fatigue which is one of the manifestations of the third status or disease. Since more than 50% of the crew members aboard are in the third status or 20% of the crew members work on board despite disease, this situation impairs the effectiveness and efficiency of the seafarers' performance, increases the frequency of human error and the risk of maritime accidents. As a result, maritime safety is threatened.

4 Suggestions for Improving the Situation

Since seafarers' malnutrition is an actual problem and has a close relation with maritime safety, it is important to reach a common approach or strategy of coping with it for maritime community which includes shipping companies, insurance companies and regulators as well as the seafarers. In the author's view, the following points should be considered.

(1) Training and education There are three points to consider in regard to seafarers' nutrition training and education. The first is the seafarers' awareness of their marginal nutritional status. If seafarers are not aware that their nutritional status is in a marginal state and any carelessness or indulgence in unsuitable foods and beverages, any further sleep deprivation or stress may induce further malnutrition, any efforts to improve the situation will not be rewarded as expected. The second is that seafarers should have basic nutrition knowledge. The third is the food management aboard, the ordering and storage of food and the cooking skills of the ship's cook. Nutrition is a new science compared with medicine. It is reported that clinical nutrition had not emerged as an important discipline in modern medicine until recent years.23 In the USA, Australia, China and some other countries nutrition training is given to solders. So offering a nutrition course in the merchant marine seafarers' training class is a new idea. If we decide to improve maritime safety further through a seafarers' diet and nutrition approach, training and education of nutrition is absolutely necessary. An elective course about seafarers' nutrition has been offered by the author to the undergraduate students in Dalian Maritime University since February 2005. Nearly half the of the 100 students who elected the course were in the nautical science and engineering.

(2) New storage technology So far cold storage is the typical method for food storage aboard. Meat, fish, poultry, etc. are stored under 18□C; vegetables and fruits stored from 0□C to 4□C; rice, flour, oil, dried vegetables and caned food, etc. stored from 1□C to 10□C.[9] Water soluble vitamins, especially vitamin C, in the food decrease with the lapse of time under these conditions. Seafarers usually show malnutrition symptoms in the late period of a long voyage. One of the reasons is that the foods they take contain less quantity of vitamin. Complete natural food is the best source of nutrients. There is a need to have better techniques for keeping food fresh and maintaining their nutrients for a longer time.

(3) Nutritional supplements and fortified products Since the living and working conditions on board ships cannot be thoroughly changed and time is needed to develop new food storing techniques, it is necessary and practicable for seafarers to use suitable supplements and fortified products. Chinese researchers studied and tested supplements on board vessels.[24, 25, 26] In recent years, the health care product industry has developed very quickly in China. A variety of supplements has been promoted in the markets of China and some other countries. Which products are suitable for seafarers? It is not easy for seafarers to make an informed decision. One man's meat is another man's poison. Actually one kind of supplement effective for some people, may not be effective for others. Here it comes back to the education issue. People without enough nutritional knowledge may be manipulated by the product manufacturers or misuse supplements which could impair their health. How seafarers can take advantage of supplements and fortified products is a new question for the maritime community. For the shortfall of vitamin C, vitamin B2, vitamin A and calcium, for instance, seafarers can deal with them with different ways according to their personal situations. However it is better to take vitamin A through the foods which are rich of vitamin A or carotinoid because it is harmful to take too much vitamin A. They also can take proper doses of carotinoid supplements. The other kind of nutrients can be supplemented through fortified food or suitable supplement products.

(4) DRI for seafarers The Nutrition Association of China has developed Dietary Reference Intakes (DRI) for ordinary residents of China. It can be used as reference standard for evaluating the nutrition status of them. Although the researchers have applied it to the evaluation of Chinese

seafarers' nutrition state in their surveys, actually it is not suitable. However, currently they have to do so because there isn't any DRI especially for seafarers. So it is necessary to develop a DRI for Chinese seafarers. In order to develop the DRI for Chinese seafarers, it is necessary to organize a comprehensive and systematic seafarers' nutrition survey.

(5) Further improvement of living and working conditions Although there have already been some standards and regulations for ships' construction, such as the standards for the structure of ships' accommodation and bridge, noise in engine room, etc. in the conventions and standards concerned, they are the basic requirements. In the long run, the seafarers' living and working conditions on board ships should be improved in line with the upgrade of the living and working conditions on land, since all the people in a society have the need to enhance their spiritual and material living standards. We shall be aware that maritime safety is maintained mainly by the physically and mentally healthy seafarers. How can we look to the seafarers in malnutrition status and fatigue to enhance the safety standard of the ship management system? It is the time to consider further improvement of the seafarers' living and working conditions aboard, the problem of manning, sleep deprivation, malnutrition, stress, noise, etc.

(6) Ship's living and working conditions management system In order to deal with the influencing factors as well as the seafarers' malnutrition status, it is necessary to establish a ship's living and working conditions management system. The objective of the system is to make the seafarers aboard healthy, safe and efficient. It can be either an independent system or a subsystem of the ship safety management system which has already been running. The system may have a structure similar to the ship safety management system and in addition includes doctors and persons well trained in seafarers' nutrition and mental issues. The ship's captain is no doubt the first responsible person aboard. The competent authority of the government is responsible for supervising the system's running in light of the standards and regulations concerned. A professional hospital or medical institute is the designated supporter which supplies necessary biochemical tests and health examinations. Based on such a management system, nutrition education and training, taking supplements, improving the living and working conditions and other necessary measures can be implemented effectively. Crew Endurance Management System proposed by USCG[27] is a system aimed at improving seafarers' living and working conditions on board ships. The structure of the system and the rationale for sleep management can be used for reference.

Acknowledgement

I am very grateful to President Leonard Tyler, Dean John Barlow, the faculty and staff of Maine Maritime Academy, the USA, for their kind and positive support and help while I was doing this study there. I also want to thank Professor Laurie Stone of Maine Maritime Academy and Professor Anne S. Bosch of Canada for their reviewing the paper and checking some of the words and expressions in it.

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