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INSTRUMENTS, PROCEDURES, AND RATIONALE FOR MORBIDITY FORECASTIN--ETC(U)
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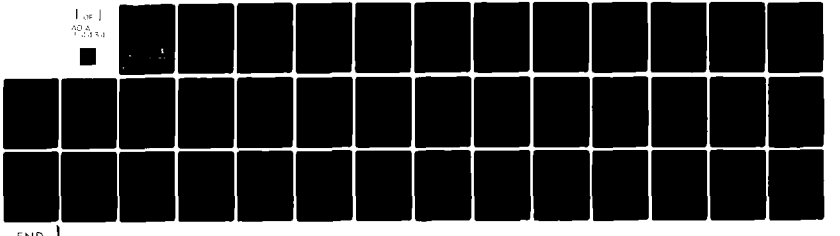

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INSTRUMENTS, PROCEDURES, AND RATIONALE FOR MORBIDITY FORECASTING ABOARD DEPLOYED NAVY SHIPS

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Instruments, Procedures, and Rationale for Morbidity Forecasting Aboard Deployed Navy Ships *

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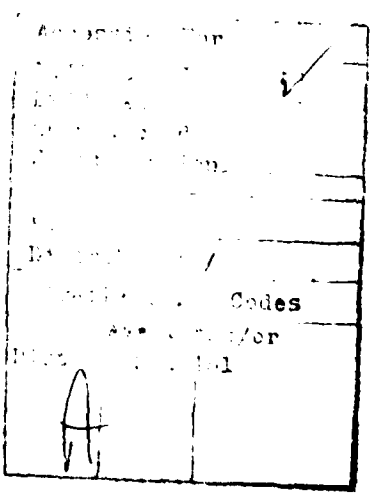


INTRODUCTION

Problem

Each ship in the U.S. Navy must maintain a constant state of readiness in order to fulfill its mission. Therefore, conditions that may affect readiness must be monitored so that prompt remedial actions may be taken when problem situations are anticipated. At present, systems exist for monitoring the mechanical and technical readiness of a ship, but the physical health of the personnel who operate these systems has received relatively little attention.

Objective

The objective of the present effort was to formulate a system for monitoring aspects of shipboard environments that affect illness incidence rates for deployed U.S. Navy ships. The system is further designed to generate expected illness incidence rates for the various shipboard environments. In order to make "in house" implementation of this system possible, the following points are discussed:

(1) the methods and instruments used to measure each of the environmental dimensions related to illness,

(2) scoring weights and parameter estimates, and

(3) a step by step outline of the computational procedures.

Background

While the direct effects of harsh physical conditions upon health are well known, recent investigators (Glass & Singer, 1972; Kagan & Levi, 1974; Kirtz & Moos, 1974) have suggested that environmental perceptions or psychosocial stimuli have important consequences for health. Data supporting this

position were reported by McDonald, Pugh, and Gunderson (1973) who found large differences in illness rates across six U.S. Navy combat ships. Although the differences in illness rates partially reflected differences in job factors and crew composition, the authors concluded that much of the illness variance between ships was a function of social and organizational qualities of the environment.

Subsequently, a research program was designed specifically to assess the combined effects of social conditons, personnel composition, and physical environment on health. Data were gathered during the overseas deployment of 18 destroyer type ships and two aircraft carriers. Half of these ships were deployed in the Atlantic and half in the Pacific. Analyses of the data showed that the physical demands associated with job type directly affected respiratory, dermal, and trauma illness rates. Further, different types of jobs, personnel composition (i.e., the training, abilities and maturity of the personnel in a division) further affected respiratory, dermal, and genitourinary illness rates. Finally, beyond the above influences it was found that the job challnege, leadership, cooperation, and esprit within the various divisions were associated with illness.

Because of the strength of the above relationships and the large number of data points used in the analysis, it is likely that such results will also be found in future samples. Thus, by using the parameters established in previous studies one can forecast which environments (divisions) aboard U.S. Navy ships are likely to show variations in types or rates of illness.

METHODS AND INSTRUMENTS

To develop a morbidity forecast procedure that would provide meaningful indices, a set of coefficients was derived which, when multiplied by a division's complement, would yield an expected monthly incidence rate for a given disorder. Thus, it is left to the command's judgment whether or not a given incidence rate is acceptable. The morbidity coefficients were developed in such a way as to simplify computation procedures yet retain precision. Further, procedures were employed to create more robust estimaters and thus enhance the stability of the morbidity coefficients. The rationale for converting parameters available from previous statistical analyses to the coefficients used to predict monthly incidence rates is given in Appendix A.

In order to generate expected division incidence rates for each type of illness, a step by step procedure was developed. In this procedure, the physical job demands, personnel composition, and work climate in the divisions of a ship must be assessed. The measurements obtained for each division are then used to select the proper coefficient to be used for predicting illness incidence rates. Accumulating a division's expected incidence rate of each type of illness provides an estimate of the total number of visits the members of that division would make in a month. Summing the values across divisions shows the expected frequency for each type of illness.

Step 1

To help organize the data and computations necessary to generate the expected illness incidence rates for the various divisions, a division summary sheet was devised. An example of a blank division summary sheet is shown in Figure 1. A separate summary sheet should be completed for each division on the ship. Begin each sheet by filling in the division name in

Figure 1

DIVISION SUMMARY SHEET

DIVISION:.....

NUMBER OF MEN:.....

PERSONNEL COMPOSITION:

	DIVISION AVERAGE	WEIGHT	PRODUCT
AVERAGE MONTHS OF SERVICE	.....	X 1 =	.....
AVERAGE AGE	.....	X 10 =	.....
AVERAGE PAYGRADE	.....	X 30 =	.....
AVERAGE YEARS OF EDUCATION	.....	X 33 =	.....
PROPORTION MARRIED	.....	X 120 =	.....
TOTAL (PERSONNEL COMPOSITION)		=	.....

WORK CLIMATE:

Scale								Scale Total	No. of Compl Invent	Divn Score
CHALLENGE	A	-	B	+	F	=		÷		=
LEADERSHIP	G	-	C	=		÷		=		
COOPERATION	D	+	H	-	I	=		÷		=
ESPRIT	E	+	J	=		÷		=		

MORBIDITY COEFFICIENT MATRIX

	Respiratory	Dermal	Trauma	Gen/Urin	Gastr/Intest
COLUMN TOTALS:					
NUMBER OF MEN IN DIVISION:	X	X	X	X	X
INCIDENCE RATE:					

TOTAL

the space provided. Also, count the number of men in each division and enter that figure in the appropriate space just below the division's name.

Step 2

Obtain the following data on each enlisted person aboard the ship: division assignment, months on active duty, age, paygrade, years of formal education prior to enlistment, and whether presently married or single. Find each division's average score on each of these items. For example, the average age of the men in a division would be found by listing the ages (in years) for all the members of a division. The ages are then added together and the sum is divided by the number of people in the division. Use similar steps to compute average values for months of service, paygrade, and education. Proportion married is obtained by dividing the number of married division members by the total number of individuals in the division. Enter each of the above figures in the spaces provided on the division summary sheet under the heading "Personnel Composition."

Step 3

Compute the total personnel composition score on the division summary sheet by first multiplying each average value by the weight indicated. That is, multiply average months of service by one, average age by 10, average paygrade by 30, average years of education by 33 and the proportion married by 120. Then sum the resulting values to obtain the total personnel composition score. For example, in a division containing 40 crewmen, suppose the average months of service was 14 months, the average age was 18.6 years, and the average education was 12.2 years. Suppose further, that the average paygrade was 2.70 and that eight of the 40 individuals were married. The personnel composition score for that division would be computed and entered on the division summary sheet as follows:

	Division Average		Weight		Product
Average months of service	14.0	x	1	=	14.0
Average age	18.6	x	10	=	186.0
Average paygrade	2.70	x	30	=	81.0
Average years of education	12.2	x	33	=	402.6
Proportion married	.2	x	120	=	24.0
Total (Personnel Composition)				=	707.6

Step 4

Administer the one page questionnaire shown in Figure 2 to the enlisted personnel in each division. An effort should be made to have all the members in a division complete the form; but if that is not possible, the responses from at least half of the division members should be obtained. This questionnaire, called the Work Climate Inventory, was designed to assess the factors in the division's work climate that are most likely to influence health and accident rates. Assess the above qualities of each shipboard environment (i.e., each division) by administering the questionnaire to at least fifty percent of the enlisted personnel assigned to each division.

If possible, administer the questionnaire by divisions. When a majority of the personnel from one or more divisions are assembled, instruct them that:

> This short questionnaire asks you to describe your work environment aboard this ship. Your name is not required. Enter only your division name in the space provided. Your responses will be combined with the responses of other members of your division and the average value will be used to describe each work environment.

Step 5

Sort the completed questionnaires by division and transcribe the responses to each questionnaire on to the Division Assessment Worksheets. There are two

Figure 2

Work Climate Inventory

Division _____

Section I

For each of the items below, circle the number that best describes how much you personally agree or disagree with the statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. On this ship, we are encouraged to ask questions about the ship's affairs.	1	2	3	4	5
2. The people I work with cooperate to get the job done.	1	2	3	4	5
3. In my workgroup, a person is almost certain to hear about his mistakes but almost never hears about his successes.	1	2	3	4	5
4. I would definitely recommend the Navy to a prospective recruit.	1	2	3	4	5
5. There is good communication in my workgroup.	1	2	3	4	5
6. There is very little variety on my job, I do the same thing over and over.	1	2	3	4	5
7. On this ship, no one has to be afraid of expressing his opinion.	1	2	3	4	5
8. When I face a difficult job, the people I work with help me out.	1	2	3	4	5
9. My job is important to the functioning of the ship.	1	2	3	4	5
10. There are more opportunities to advance in the Navy than in civilian life.	1	2	3	4	5
11. The members of my workgroup trust each other.	1	2	3	4	5
12. My job is meaningfully related to other jobs on this ship.	1	2	3	4	5
13. If you work for it, the Navy offers many opportunities for growth and advancement.	1	2	3	4	5
14. In my workgroup, everyone works together as a team.	1	2	3	4	5

Section II

For the questions below, circle the number that best describes how much these conditions are present in your work environment.

	Not at All	To a Small Extent	To Some Extent	To a Great Extent	To a Very Great Extent
15. Is your immediate supervisor willing to listen to your problems?	1	2	3	4	5
16. Do you work on difficult and challenging problems on your job?	1	2	3	4	5
17. Does your supervisor set an example by working hard himself?	1	2	3	4	5
18. Is there friction in your workgroup?	1	2	3	4	5
19. Does your supervisor help you to solve job related problems?	1	2	3	4	5
20. Do you have a chance to do different jobs?	1	2	3	4	5
21. Does your supervisor show you how to improve your performance?	1	2	3	4	5
22. Do higher levels of command pay attention to ideas and suggestions from the crew?	1	2	3	4	5
23. Does your supervisor encourage his people to work as a team?	1	2	3	4	5
24. Does your job require a high level of training?	1	2	3	4	5
25. Does your immediate supervisor do a good job overall?	1	2	3	4	5
26. Is there a friendly atmosphere in your workgroup?	1	2	3	4	5

worksheets to be completed for each division: one for Section I (items 1 through 14) and another for Section II (items 15 through 26). These worksheets are shown in Figures 3 and 4. On the worksheet for Section I, enter the appropriate division name at the top and then transcribe from the first Work Climate Inventory the responses to items 1 through 14. For example, if the individual who completed the Work Climate Inventory circled a 4 in response to item one and then circled a 3 in response to item two, then the first two values entered onto the first line of the worksheet would be 4 and 3 (i.e., the values circled). In a similar manner, transcribe the individual's responses to items 15 through 26 onto the worksheet for Section II. After all the item responses on the first Work Climate Inventory have been transcribed, transcribe the responses of the remaining division members.

Step 6

After all the responses from the members of a division have been transcribed, sum the responses to each item and enter the total in the space provided on the Division Assessment Worksheets. And after a total has been computed for each item place the total in the box located below each item. These boxes are arranged so that they are on five different levels which correspond to five letters on the bottom right hand portion of the page. Add together the values within the boxes at the same level and place the result in the lettered box on the right hand side of the page. For example, the boxes on the first level of the worksheet for Section I are located under items 9 and 12. Therefore, these totals (i.e., the totals for items 9 and 12) are added together and the result is placed in the box to the right labeled "A". At the second level is the total for item 6; and since there are no other boxes at the second level, the value placed in the box labeled "B" is simply the total for item 6. After summing the values at

Figure 3

DIVISION ASSESSMENT WORKSHEET
Section I

*Division*_____

ITEM

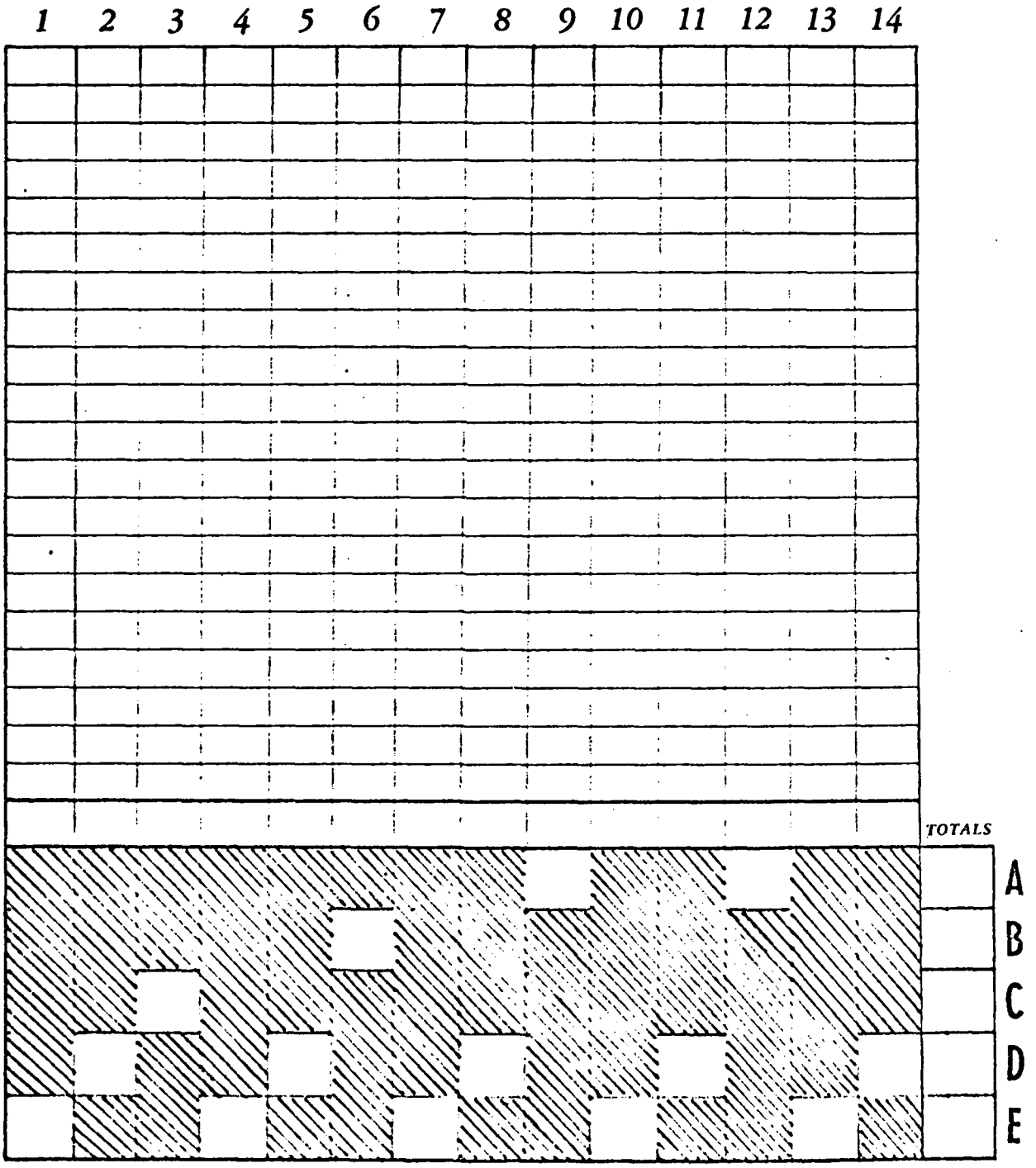
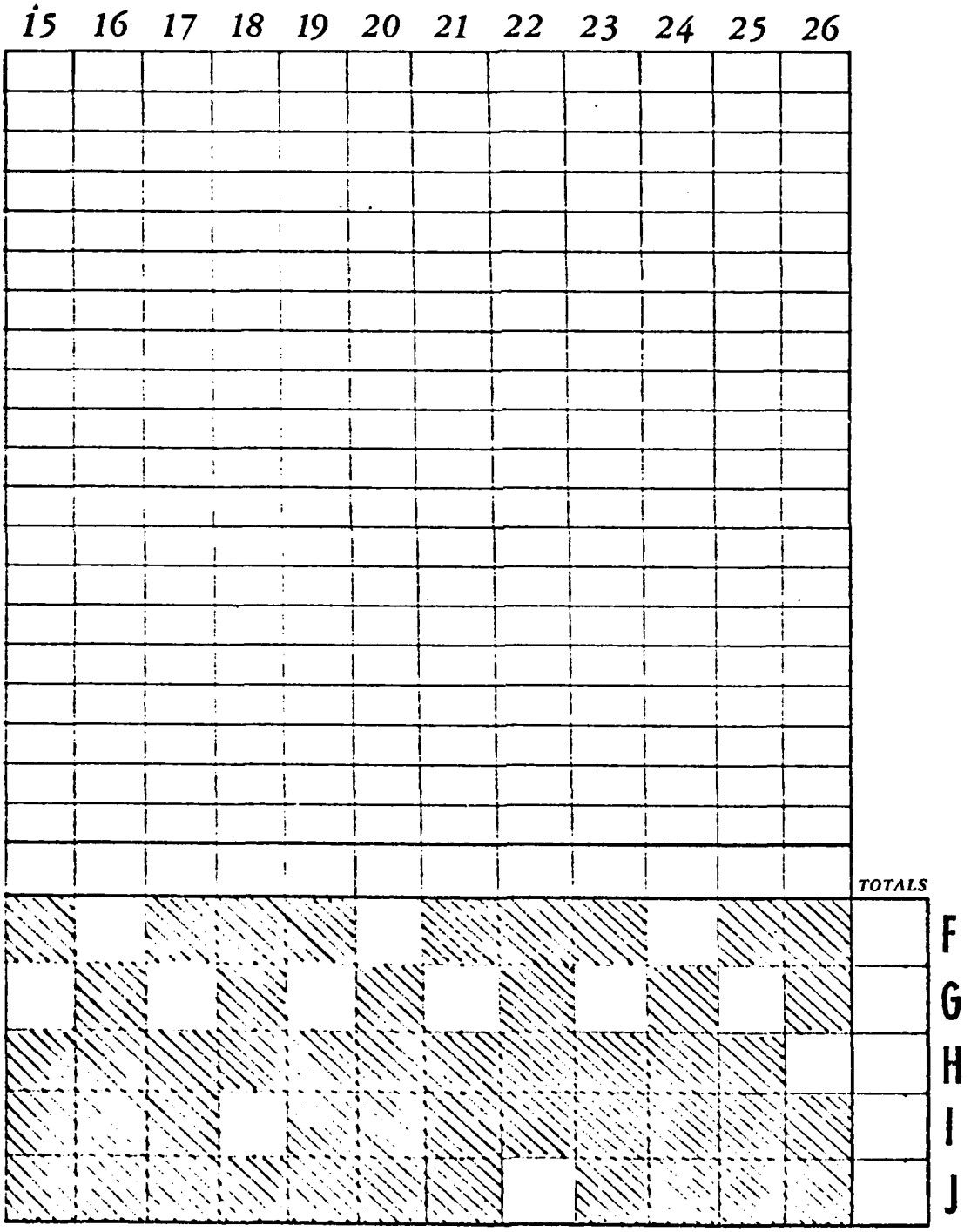


Figure 4

DIVISION ASSESSMENT WORKSHEET
Section II

*Division*_____

ITEM



levels C, D, and E, and entering the totals in the respective boxes, complete the worksheet for Section II in the same way. A completed worksheet for Section I is shown in Figure 5.

Step 7

Copy the values in the lettered boxes on the worksheets into the boxes provided on the Division Summary Sheet. For example, the values in the boxes labeled "A", "B", and "F" should be placed in the three boxes following the Work Climate scale called Challenge. After all the values have been copied into the appropriate box, add and subtract these as indicated on the Division Summary Sheet in order to arrive at a total scale score for each scale. For example, the scale score for Challenge would be found by subtracting the value in box "B" from the value in "A" and then adding the value in "F".

Step 8

Determine the number of completed Work Climate Inventories for each division by counting the number of lines of item responses on the Division Assessment Worksheets. Enter this number in each of the boxes under the heading "No. of complete Inventories" on the Division Summary Sheet. Now, divide each Scale Score by the number of complete inventories in order to compute a division score for each scale.

Step 9

Complete the matrix of morbidity coefficients using the values listed in Appendix B. To use Appendix B, one must first locate the table that applies to the division being scored. In order to simplify this task, divisions were grouped by level of physical job demand generally existing in the tasks performed and within level of job demand they were ordered by level of personnel composition as shown below:

Figure 5

DIVISION ASSESSMENT WORKSHEET

Section I

Division Deck

ITEM

1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	3	1	3	4	3	3	4	3	2	4	4	2	4
2	2	2	4	4	4	1	4	1	1	3	3	3	5
3	2	1	2	5	3	1	4	4	3	2	2	3	3
2	3	2	2	4	4	4	3	2	2	2	2	2	3
3	4	3	5	5	1	3	3	2	2	3	3	3	3
1	4	2	3	2	1	5	4	3	4	3	4	2	3
1	3	4	4	2	3	2	5	1	1	2	4	1	4
2	3	3	3	3	2	5	2	1	3	3	3	2	3
3	3	4	3	3	2	3	4	4	4	5	3	1	5
5	5	2	2	4	4	1	3	3	2	2	3	2	2
2	2	2	1	3	1	4	4	4	2	5	4	2	5
5	5	3	2	4	3	2	3	3	1	3	4	4	3
3	3	3	1	2	5	2	3	3	2	3	3	3	3
1	4	3	1	5	2	3	2	1	1	3	2	1	3
4	3	3	2	3	5	1	2	1	1	4	2	4	4
2	3	3	2	3	3	1	5	4	3	4	3	2	4
2	2	4	2	3	4	4	4	3	2	3	3	2	3
3	2	3	1	4	1	3	5	5	1	2	2	3	2
1	5	3	2	4	1	3	4	2	2	2	3	1	2
1	4	2	2	3	3	2	4	5	2	3	3	2	3
50	65	53	47	70	55	53	72	55	41	61	60	45	67

TOTALS

								55			60			115	A
					55									55	B
		53												53	C
	65			70			72			61			67	335	D
50			47			53			41			45		236	E

Level of Physical Job Demand	Level of Personnel Composition	Table Number
Low (e.g., Electronics and Operations)	Low	1
	Medium	2
	High	3
Medium (e.g., Guns and Missiles)	Low	4
	Medium	5
	High	6
High (e.g., Deck and Engineering)	Low	7
	Medium	8
	High	9

There, Tables 1-3 apply to jobs with low physical demands and list the coefficients for divisions such as Electronics, Operations, and Administration. Tables 4-6 apply to divisions which require moderate levels of physical exertion or adaptation such as Guns, Missiles, Antisubmarine Warfare, and Supply. Finally, Tables 7-9 apply primarily to the various Deck and Engineering divisions that tend to place the heaviest physical demands on their members.[1]

Once you have the physical demands score to turn to the proper set of tables in Appendix B, you must use the division's total personnel composition score to decide on the exact table to be used. For a division with a total personnel composition score anywhere between 0 and 836, you would use the first table in the series (i.e., Table 1, 4, or 7). For a division with a total personnel composition score between 837-907, you would use Table 2, 5, or 8, and finally, for a division with a total personnel composition score of 908 or greater, Table 3, 6, or 9.

---

[1] If a particular division is not listed on any of the tables in Appendix B, use the tables which list divisions that place a similar level of physical demands on their members.

Step 10

Once the proper table has been located, enter on the Division Summary Sheet the morbidity coefficients that correspond to the division's score on the four Work Climate Inventory scores. For example, if Table 7 applied to a particular division where the scale scores computed in Step 7 were 11.5, 13.1, 16.8, and 14.2 respectively, the morbidity coefficient matrix would be completed as follows:

	Division Score	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge	11.5	.080				
Leadership	13.1	.049	.034		.040	
Cooperation	16.8			.118		
Esprit	14.2		.027			.055

Step 11

Complete the Division Summary Sheet by computing the expected monthly incidence rate for each type of illness. First, sum the morbidity coefficients in each column of the matrix. Then multiply each total by the number of men in the division. The result is the expected monthly incidence rate for each illness for the division.[2] Finally, the incidence rate for each type of illness can be added together resulting in a total incidence rate.

To better illustrate the computations in this step as well as the computations in Steps 3 through 10, a completed Division Summary Sheet is presented in Figure 6. The computations are based upon the data from a Deck division consisting of 40 enlisted men having the personnel composition described in Step 3. The work climate data is derived in Steps 4 through 8 and

[2]These incidence rates represent the number of different illness episodes and do not indicate follow-up visits.

Figure 6

DIVISION SUMMARY SHEET

DIVISION: DECK

NUMBER OF MEN: 40

PERSONNEL COMPOSITION:	DIVISION AVERAGE		WEIGHT		PRODUCT
AVERAGE MONTHS OF SERVICE	14.0	X	1	=	14.0
AVERAGE AGE	18.6	X	10	=	186.0
AVERAGE PAYGRADE	2.7	X	30	=	81.0
AVERAGE YEARS OF EDUCATION	12.2	X	33	=	402.6
PROPORTION MARRIED	.20	X	120	=	24.0
TOTAL (PERSONNEL COMPOSITION)				=	707.6

WORK CLIMATE:

Scale							Scale Total	No. of Compl Invent	Divn Score
CHALLENGE	A 115	− B 55	+ F 170				= 230	÷ 20	= 11.5
LEADERSHIP		G 315	− C 53				= 262	÷ 20	= 13.1
COOPERATION	D 335	+ H 69	− I 68				= 336	÷ 20	= 16.8
ESPRIT		E 236	+ J 48				= 284	÷ 20	= 14.2

MORBIDITY COEFFICIENT MATRIX

	Respiratory	Dermal	Trauma	Gen/Urin	Gastr/Intest	
	.080					
	.049	.034		.040		
			.118			
		.027			.055	
COLUMN TOTALS:	.129	.061	.118	.040	.055	
NUMBER OF MEN IN DIVISION:	x 40	x 40	x 40	x 40	x 40	
INCIDENCE RATE:	5.16	2.44	4.72	1.60	2.20	TOTAL 16.12

was based upon a sample of fifty percent of the division members (20 men) whose responses to Section I of the Work Climate Inventory are summarized in Figure 5 (Step 6).

The completed Division Summary Sheet indicates that from the particular Deck division being assessed one would expect approximately 5 cases of respiratory illness per month, between 2 and 3 visits for dermal disorders, and approximately 5 traumas (injuries) per month. Thus, within a month a total of 16 separate illness episodes from all causes. If no individual had more than one illness episode this would mean that forty percent of the division members would be expected to make a sick call visit during a month. However, due to probability that multiple illnesses will be incurred by some individuals, the percentage of division members expected to report to ship's dispensary during one month would be somewhat less than forty percent.

Step 11

Use the completed Division Summary Sheets completed from each division to create an overall ship summary. A form designed to provide such a summary is shown in Figure 7, and an example of a completed form is shown in Figure 8. Division titles and the number of men in each division are entered along the left side of the page and the incidence rates from the Division Summary Sheets are placed in the row following the division name. The expected total monthly incidence rate for a particular illness was generated by summing incidence rates down each column. Finally, summing either the division total incidence rates (row totals) or the overall rates for each type of illness (column totals) yields an expected total number of separate illness episodes to be treated during the period of one month.[3]

[3]The total number of visits to the ship's dispensary will probably exceed the expected incidence rate because treatment of a disorder often requires follow-up visits.

Figure 7

Ship's Illness Summary

Division		Expected Incident Rate					
Name	No. of Men	Respiratory	Dermal	Trauma	G.U.	G.I.	Total
Totals							

Figure 8

Ship's Illness Summary

Division		Expected Incident Rate					
Name	No. of Men	Respiratory	Dermal	Trauma	G.U.	G.I.	Total
Deck	40	5.16	2.44	4.72	1.60	2.20	16.12
Repair	20	3.67	1.98	2.14	1.02	2.01	10.82
Boiler	24	3.45	2.13	3.54	2.01	1.49	12.62
Machine	25	2.98	2.32	3.49	2.18	1.03	12.00
Guns	12	1.04	1.37	1.14	1.93	.89	6.37
Missiles	10	1.46	1.51	1.73	1.12	1.25	7.07
ASW	8	.91	.58	1.10	1.43	2.31	6.33
Supply	25	2.17	1.83	2.94	2.71	1.68	11.33
O.E.	8	.83	.97	1.17	1.01	2.11	6.09
O.I.	12	1.71	.95	1.90	1.41	1.84	7.81
Communication	15	1.50	1.14	1.36	1.43	1.31	6.74
Navigation	8	1.25	1.07	1.49	1.03	.92	5.76
Totals		26.13	18.29	26.72	18.88	19.[illegible]4	109.06

Model Applications

The morbidity forecast model described here is a tool which can be applied at many levels. Corpsmen provided with such information can determine whether the medical and pharmaceutical supplies are sufficient to meet expected demands. The expected incidence information can help in the acquisition of more supplies and such information might also suggest appropriate preventive medicine techniques.

Providing morbidity forecast information to the captain of a ship would give an indication of potential manpower losses due to illness, thereby allowing him to anticipate shortages that might interfere with the ship's mission. If severe shortages were anticipated, he might initiate remedial action whether through the medical department (e.g., preventive medicine) or through personnel management (e.g., personnel changes among divisions).

Ship type commanders might use information provided by the morbidity forecast model in a similar fashion. Information might be gathered as part of refresher training exercises or as part of the overseas readiness inspection. Instituted at these times, the morbidity forecast model would function to give a more complete picture of the ship's overall readiness.

In addition to the above applications, the morbidity forecast model provides a foundation which one can build upon by integrating into it more factors in the etiology of various illnesses. For example, more refined assessments of critical aspects of shipboard environments might result in predictions that are superior to those achieved with the global measures used in the present report. This possibility is supported by results reported by Pugh, Erickson, and Jones (1976) which indicate that specific features of work environments such as the quality of the work equipment

are useful when predicting injury rates. Similarly, Harvey, Hermansen, and Jones (1978), report that particular aspects of the food service area aboard ships can be used to predict the incidence of gastrointestinal illness. A more complete model also might include changes that occur during a deployment. For example, Erickson, Dean, and Gunderson (1977) report data to support the hypothesis that gastrointestinal infections are often incurred as the result of a port visit and that the risk of infection was greater in some ports than others.

Because the morbidity forecast model as presented in this report does not include refinements such as those suggested above, the expected incidence rates that are generated should be regarded as a baseline for evaluating actual illness rates during an overseas deployment. For example, the expected gastrointestinal incidence rate computed with the present procedures provides one with an estimate for average circumstances but one would need to adjust this rate depending upon the conditions in the food service areas and the ports visited.

Finally, it should be noted that the parameter estimates used in the present report are based upon data from a sample of destroyer-type ships. Thus, the degree that the illness predictions can be generalized to new samples, particularly samples representing different ship types, has yet to be determined. Although some adjustment in the level of illness between different ship types might be necessary, preliminary indications are that the present model will reflect the differences in illness rates of environments within a given ship and among ships of the same type.

APPENDIX A

Rationale for Deriving Morbidity Coefficients

A series of three-way analyses of variance were used to evaluate the effects of physical job demands (J), personnel composition (P), and each dimension of the social environment (S) (Pugh, 1978). Therefore, in addition to the main effects (J, P, and S) the two-way interactions (J x P, J x S, and P x S) and three-way interaction (J x P x S) were evaluated. These effects can be expressed in terms of mean incidence of a particular illness per man per month known as frequency weight scores (Kendall & Stuart, 1966, p. 12) as follows:

Term	Score	
J	$E_1 = \bar{y}_{i\cdot\cdot} - \bar{y}_{\cdot\cdot\cdot}$	(1)
P	$E_2 = \bar{y}_{\cdot j\cdot} - \bar{y}_{\cdot\cdot\cdot}$	(2)
S	$E_3 = \bar{y}_{\cdot\cdot k} - \bar{y}_{\cdot\cdot\cdot}$	(3)
J x P	$E_4 = \bar{y}_{ij\cdot} - E_1 - E_2 - \bar{y}_{\cdot\cdot\cdot}$	(4)
J x S	$E_5 = \bar{y}_{i\cdot k} - E_1 - E_3 - \bar{y}_{\cdot\cdot\cdot}$	(5)
P x S	$E_6 = \bar{y}_{\cdot jk} - E_2 - E_3 - \bar{y}_{\cdot\cdot\cdot}$	(6)
J x P x S	$E_7 = \bar{y}_{ijk} - E_1 - E_2 - E_3 - E_4 - E_5 - E_6 - \bar{y}_{\cdot\cdot\cdot}$	(7)

where

$\bar{y}_{\cdot\cdot\cdot}$ = the grand mean illness rate

$\bar{y}_{i\cdot\cdot}$ = the mean for the i^{th} level of physical job demands

$\bar{y}_{\cdot j\cdot}$ = the mean for the j^{th} level of personnel composition

$\bar{y}_{\cdot\cdot k}$ = the mean for the k^{th} level of a particular work climate condition (e.g., challenge or leadership)

$\bar{y}_{ij\cdot}$ = the mean for the i^{th} level of physical job demands and the j^{th} level of personnel composition

$\bar{y}_{i\cdot k}$ = the mean for the i^{th} level of physical job demands and the k^{th} level of a work climate condition

$\bar{y}_{\cdot jk}$ = the mean for the j^{th} level of personnel composition and the k^{th} level of a work climate condition

$\bar{y}_{ijk}$ = the mean for the i^{th} level of physical job demands, j^{th} level of personnel composition and the k^{th} level of a work climate condition.

Thus, in the ANOVA paradigm

$$y = \bar{y}... + \sum_{q=1}^{7} E_q + R. \tag{8}$$

Where, R is a residual term representing unmeasured effects and/or measurement error occurring between individuals with the same values of i, j, and k.

Eliminating R from equation 8, we obtain

$$y' = \bar{y}... + \sum_{q=1}^{7} E_q = \bar{y}_{ijk}. \tag{9}$$

That is, the individual cell means of the ANOVA data matrix capture any criterion effects due to the assessed attributes of the environment. However, the data analyses that were performed showed that only some of the effects (E_q) were significant (i.e., would be expected to be found in other samples). In order to include only the significant effects, each one was weighted. Scores corresponding to significant effects received a weight of one and all others received a zero weight. Therefore, a new set of illness estimates can be represented as follows:

$$y'' = \bar{y}... + \sum_{q=1}^{7} W_q E_q \tag{10}$$

where W was the vector of unit and zero weights used to eliminate non-significant effects.

Even though the y'' score eliminates variance due to measurement error, unmeasured effects, and chance differences, one more modification was introduced. This procedure was designed to reduce the number of parameters that needed to be estimated, thus giving each estimate added stability. This goal was accomplished

by computing y'' values for each of the cells in the original 3 x 3 x 3 ANOVA design (i.e., a total of 27 y'' scores). The scores were then rank ordered from the lowest to highest value. During this process, an address vector (A) containing the i, j and k coordinates for each y'' was constructed in order to retain the original location of each y'' score. Thus, a_1 represents the i, j and k values of the lowest y'' score, so that

$$y_{a_1}'' < y_{a_2}'' \ldots . < y_{a_{27}}'' \tag{11}$$

From this information, a set of y''' values were derived as follows:

$$y_u''' = \left(\sum_{m=s}^{t} y_{a_m}'' n_{a_m}\right) / \left(\sum_{m=s}^{t} n_{a_m}\right) \tag{12}$$

where u assumes values of 1, 2, 3, 4, and 5 for which s and t assume the values 1 and 3, 4 and 9, 10 and 18, 19 and 24, and 25 and 27, respectively. For example,

$$y_1''' = \sum_{m=1}^{3} y_{a_m}'' n_{a_m} / \left(\sum_{m=1}^{3} n_{a_m}\right) \tag{13}$$

These y''' values were then returned to the original 3 x 3 x 3 matrix via the address vector A in the following manner:

Value	Location Returned to*
y_1'''	a_1 to a_3
y_2'''	a_4 to a_9
y_3'''	a_{10} to a_{18}
y_4'''	a_{19} to a_{24}
y_5'''	a_{25} to a_{27}

*Note: Address ranges correspond to s and t values above.

Finally, the amount of criterion variance predicted by these y''' values was contrasted to the amount predicted by the y' and y'' values. This step was performed to determine if reducing the number of parameters estimated had an

appreciable effect on the amount of variance accounted for. It was found that the amount of criterion variance predicted by the y''' values was in no case significantly less than the amount predicted by either the y' or y'' values.

APPENDIX B

Morbidity Coefficients

Tables 1-9

Table 1

Illness incidence rates for divisions with:

- Low physical demands
  - Electronics
  - Intelligence
  - Communications
  - Navigation
  - Administration
- Personnel composition scores ranging from 0 to 836

		Range	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.065				
	(Med)	12.30 to 14.09	.176				
	(High)	14.10 to 24.00	.105				
Leadership:	(Low)	0.00 to 12.29	.101	.021		.113	
	(Med)	12.30 to 15.09	.067	.109		.080	
	(High)	15.10 to 29.00	.101	.034		.113	
Cooperation:	(Low)	0.00 to 17.19			.055		
	(Med)	17.20 to 19.19			.032		
	(High)	19.20 to 29.00			.083		
Esprit:	(Low)	0.00 to 14.59		.087			.055
	(Med)	14.60 to 18.09		.019			.066
	(High)	18.10 to 30.00		.045			.079

Table 2

Illness incidence rates for divisions with:

- Low physical demands
  - Electronics
  - Intelligence
  - Communications
  - Navigation
  - Administration
- Personnel composition scores ranging from 837 to 907

		Range	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.038				
	(Med)	12.30 to 14.09	.065				
	(High)	14.10 to 24.00	.065				
Leadership:	(Low)	0.00 to 12.29	.080	.034		.040	
	(Med)	12.30 to 15.09	.049	.021		.017	
	(High)	15.10 to 29.00	.067	.028		.058	
Cooperation:	(Low)	0.00 to 17.19			.032		
	(Med)	17.20 to 19.19			.083		
	(High)	19.20 to 29.00			.055		
Esprit:	(Low)	0.00 to 14.59		.027			.055
	(Med)	14.60 to 18.09		.034			.079
	(High)	18.10 to 30.00		.034			.066

Table 3

Illness incidence rates for divisions with:

- Low physical demands
  - Electronics
  - Intelligence
  - Communications
  - Navigation
  - Administration
- Personnel composition scores of 908 and above

			Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.105				
	(Med)	12.30 to 14.09	.065				
	(High)	14.10 to 24.00	.080				
Leadership:	(Low)	0.00 to 12.29	.080	.043		.058	
	(Med)	12.30 to 15.09	.067	.028		.040	
	(High)	15.10 to 29.00	.067	.034		.080	
Cooperation:	(Low)	0.00 to 17.19			.032		
	(Med)	17.20 to 19.19			.055		
	(High)	19.20 to 29.00			.083		
Esprit:	(Low)	0.00 to 14.59		.027			.100
	(Med)	14.60 to 18.09		.034			.050
	(High)	18.10 to 30.00		.034			.066

Table 4

Illness incidence rates for divisions with

- Medium physical demands
  - Guns
  - Missiles
  - Antisubmarine
  - Supply
- Personnel composition scores ranging from 0 to 836

		Range	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.105				
	(Med)	12.30 to 14.09	.038				
	(High)	14.10 to 24.00	.065				
Leadership:	(Low)	0.00 to 12.29	.080	.043		.017	
	(Med)	12.30 to 15.09	.049	.021		.017	
	(High)	15.10 to 29.00	.101	.028		.040	
Cooperation:	(Low)	0.00 to 17.19			.083		
	(Med)	17.20 to 19.19			.055		
	(High)	19.20 to 29.00			.083		
Esprit:	(Low)	0.00 to 14.59		.019			.055
	(Med)	14.60 to 18.09		.034			.066
	(High)	18.10 to 30.00		.027			.079

Table 5

Illness incidence rates for divisions with:

- Medium physical demands
  - Guns
  - Missiles
  - Antisubmarine
  - Supply
- Personnel composition scores from 837 to 907

		Range	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.080				
	(Med)	12.30 to 14.09	.080				
	(High)	14.10 to 24.00	.065				
Leadership:	(Low)	0.00 to 12.29	.080	.028		.058	
	(Med)	12.30 to 15.09	.067	.034		.040	
	(High)	15.10 to 29.00	.067	.028		.080	
Cooperation:	(Low)	0.00 to 17.19			.055		
	(Med)	17.20 to 19.19			.118		
	(High)	19.20 to 29.00			.083		
Esprit:	(Low)	0.00 to 14.59		.045			.055
	(Med)	14.60 to 18.09		.027			.079
	(High)	18.10 to 30.00		.027			.066

Table 6

Illness incidence rates for divisions with:

- Medium physical demands
  - Guns
  - Missiles
  - Antisubmarine
  - Supply
- Personnel composition scores of 908 and above

		Range	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.038				
	(Med)	12.30 to 14.09	.080				
	(High)	14.10 to 24.00	.080				
Leadership	(Low)	0.00 to 12 29	.080	.034		.058	
	(Med)	12.30 to 15.09	.080	.028		.058	
	(High)	15.10 to 29.00	.080	.034		.080	
Cooperation:	(Low)	0.00 to 17.19			.055		
	(Med)	17.20 to 19.19			.083		
	(High)	19.20 to 29.00			.083		
Esprit:	(Low)	0.00 to 14.59		.019			.100
	(Med)	14.60 to 18.09		.034			.050
	(High)	18.10 to 30.00		.034			.066

Table 7

Illness incidence rates for divisions with:

- High physical demand
  - Deck
  - Boiler
  - Machine
  - Repair
  - Aux. Repair
  - Engineering
- Personnel composition scores ranging from 0 to 836

		Range	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.080				
	(Med)	12.30 to 14.09	.080				
	(High)	14.10 to 24.00	.080				
Leadership:	(Low)	0.00 to 12.29	.080	.043		.058	
	(Med)	12.30 to 15.09	.049	.034		.040	
	(High)	15.10 to 29.00	.101	.034		.080	
Cooperation:	(Low)	0.00 to 17.19			.118		
	(Med)	17.20 to 19.19			.083		
	(High)	19.20 to 29.00			.147		
Esprit:	(Low)	0.00 to 14.59		.027			.055
	(Med)	14.60 to 18.09		.034			.066
	(High)	18.10 to 30.00		.034			.079

Table 8

Illness incidence rates for divisions with:

- High physical demands
  - Deck
  - Boiler
  - Machine
  - Repair
  - Aux. Repair
  - Engineering
- Personnel composition scores ranging from 837 to 907

		Range	Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.105				
	(Med)	12.30 to 14.09	.105				
	(High)	14.10 to 24.00	.080				
Leadership:	(Low)	0.00 to 12.29	.101	.043		.080	
	(Med)	12.30 to 15.09	.080	.034		.058	
	(High)	15.10 to 29.00	.101	.043		.113	
Cooperation:	(Low)	0.00 to 17.19			.118		
	(Med)	17.20 to 19.19			.147		
	(High)	19.20 to 29.00			.118		
Esprit:	(Low)	0.00 to 14.59		.045			.055
	(Med)	14.60 to 18.09		.045			.079
	(High)	18.10 to 30.00		.045			.066

Table 9

Illness incidence rates for divisions with

- High physical demands
  - Deck
  - Boiler
  - Machine
  - Repair
  - Aux. Repair
  - Engineering
- Personnel composition scores equal to 908 and above

			Respiratory	Dermal	Trauma	Genito-urinary	Gastro-intestinal
Challenge:	(Low)	0.00 to 12.29	.176				
	(Med)	12.30 to 14.09	.176				
	(High)	14.10 to 24.00	.105				
Leadership:	(Low)	0.00 to 12.29	.133	.109		.058	
	(Med)	12.30 to 15.09	.133	.109		.040	
	(High)	15.10 to 29.00	.133	.043		.058	
Cooperation:	(Low)	0.00 to 17.19			.118		
	(Med)	17.20 to 19.19			.118		
	(High)	19.20 to 29.00			.147		
Esprit:	(Low)	0.00 to 14.59		.087			.100
	(Med)	14.60 to 18.09		.045			.050
	(High)	18.10 to 30.00		.087			.066

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A system designed to assess aspects of shipboard environments that affect illness incidence rates aboard deployed U.S. Navy ships is presented in a step-by-step fashion. Included are all procedures, instruments, and parameter estimates necessary for computing expected incidence rates for respiratory illness, dermal disorders, trauma, gastrointestinal illness, and genitourinary illness. These illness rates are computed for each division (work group) on a ship and are organized in a way which provides overall ship summary showing

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(a) the expected monthly incidence of each type of illness for each division, (b) the expected monthly incidence of each type of illness across divisions, and (c) the expected total monthly illness rate for each division. These expected incidence rates are intended to help corpsmen and those in a ship's command anticipate the effects of conditions which adversely affect health so that corrective action can be promptly initiated. In addition the expected incidence rates provide a baseline to which actual illness rates can be compared.