

Impact of Fatigue Risk Management System on Fatigue and Situation Awareness of Surgical Intensive Care Unit Nurses

presented by

Dr Sarita Dara
AFOEM Stage B Trainee

RACP Congress 2019, Auckland 6-8 May 2019

Overview

- Background
- Objectives
- Methods
- Results and Discussion
- Conclusion

Fatigue

- Extended shifts, night shift work and rotating shift work are common in the intensive care unit
- Fatigue impacts
 - cognition and performance
 - health and safety of healthcare workers
 - patient safety



Harrington, J.M. (2001). Health effects of shift work and extended hours of work. *Occup Environ Med*, 58, 68-72

Barger, L.K., et al (2006). Impact of extended-duration shifts on medical errors, adverse events and attentional failures. *PLoS Medicine*, 3(12), 2440-2448

Situation Awareness (SA)

Level 1 SA PERCEPTION

Information not observed,
misperception of information

Level 2 SA COMPREHENSION

Assessment of current state
impaired

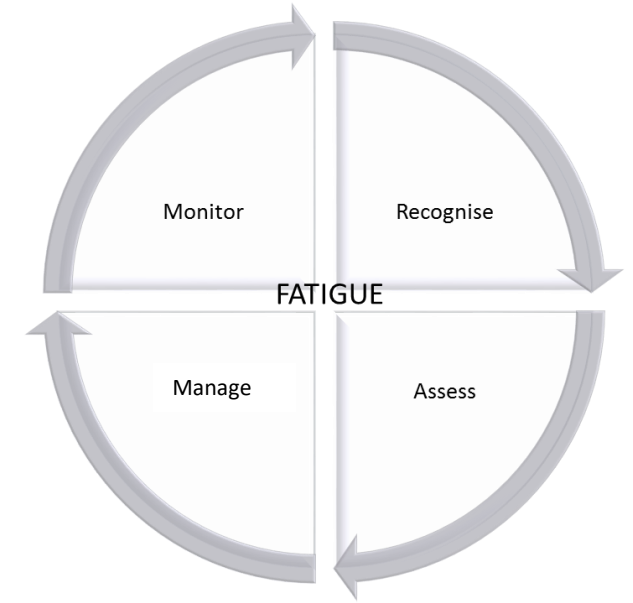
Level 3 SA PROJECTION

Failure of level 1 and 2 SA cascades
affects assessment of future state

Is there an association between fatigue and SA ?

Fatigue Risk Management System (FRMS)

- Fatigue Risk **Recognition** and **Assessment**
 - Identify risk groups
 - Timing of fatigue /shifts at increased risk- (likelihood)
 - Impact of fatigue (consequences)
- Fatigue Risk **Management** (Intervention)
- **Monitoring** effectiveness of FRMS (Pre versus Post intervention)



Are there any changes to fatigue and SA following implementation of FRMS?

Objectives

Objective (O)	Hypothesis (H)	Method for testing the hypothesis
Primary Objectives		
O[1] To study the relationship between fatigue and situation awareness in rotating shift workers.	H[1]: SA decreases with increase in fatigue and vice versa.	Fatigue and SA scores obtained from each shift were compared within a shift i.e., between start and end of shift as well as between shifts i.e., between morning, afternoon and night shift to study the relationship.
O[2]: To customize and evaluate an appropriate fatigue risk management system (FRMS).	H[2]: Implementation of FRMS reduces fatigue and improves SA in SICU nurses	Pre FRMS fatigue and SA scores were compared with Post FRMS fatigue and SA scores.

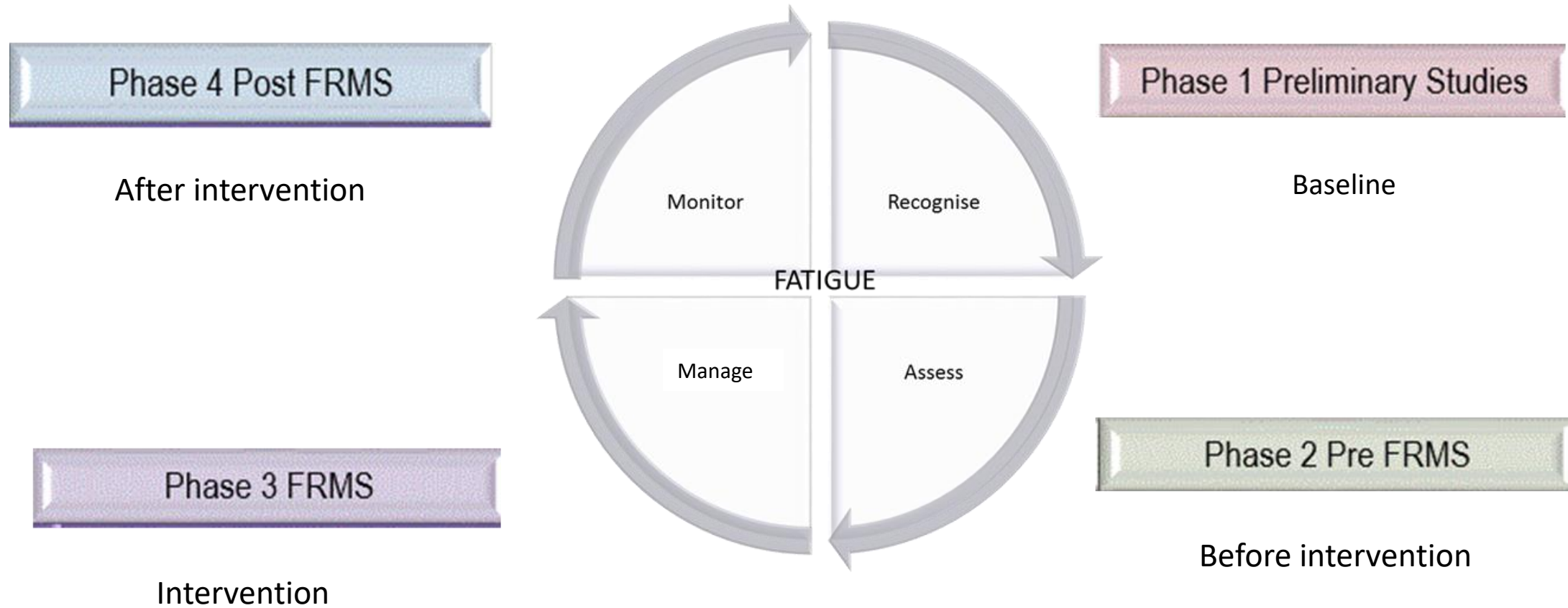
Objectives

Objective (O)	Hypothesis (H)	Method for testing the hypothesis
Secondary Objectives		
O[3]: To assess if fatigue in a healthcare worker varies within a shift i.e., between start of shift and end of shift.	H[3]: In a healthcare worker, fatigue is higher at the end of the shift as compared to start of the shift.	Fatigue scores obtained from each shift were compared within shift i.e., between start and end of shift.
O[4]: To assess if the situation awareness of a healthcare worker varies within a shift i.e., between start of shift and end of shift.	H[4]: In a healthcare worker, SA is lower at the end of the shift as compared to the beginning of the shift.	SART scores obtained from each shift were compared within a shift i.e., between start and end of shift.
O[5]: To assess if fatigue of a healthcare worker varies between different shifts when doing rotating shift work	H[5]: In a healthcare worker doing rotating shift work that includes morning, afternoon and night shift, fatigue varies across different shifts.	Fatigue scores that were obtained from each shift were compared between each of the rotating shifts - morning, afternoon and night shifts.
O[6]: To assess if SA of a healthcare worker varies between different shifts when doing rotating shift work	H[6]: In a healthcare worker doing rotating shift work that includes morning, afternoon and night shifts, situation awareness varies across different shifts.	In all the participants, SART scores that were obtained from each shift were compared between each of the rotating shifts - morning, afternoon and night shifts.

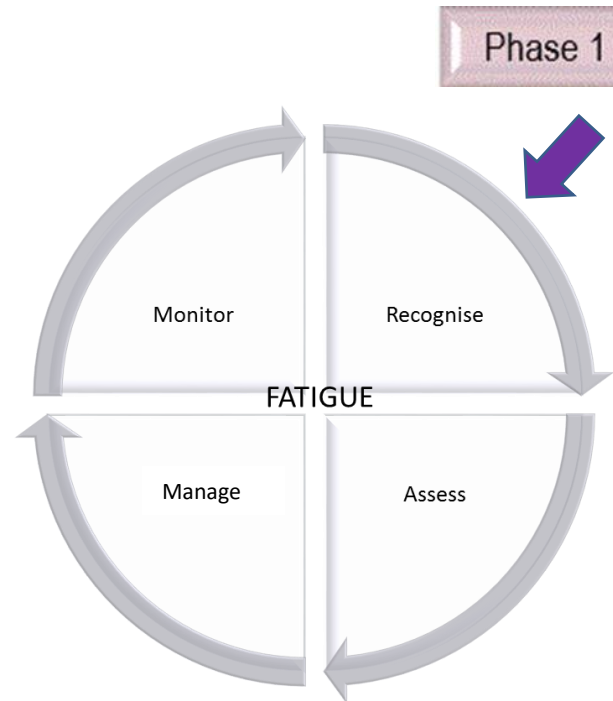
Study Design

- Institutional Review Board approval
- Naturalistic field setting
- Time Series (before and after intervention) - Phased approach
- Surgical Intensive Care Unit Nurses doing rotating shift work
- Informed consent
- Briefing of study protocol

Methods

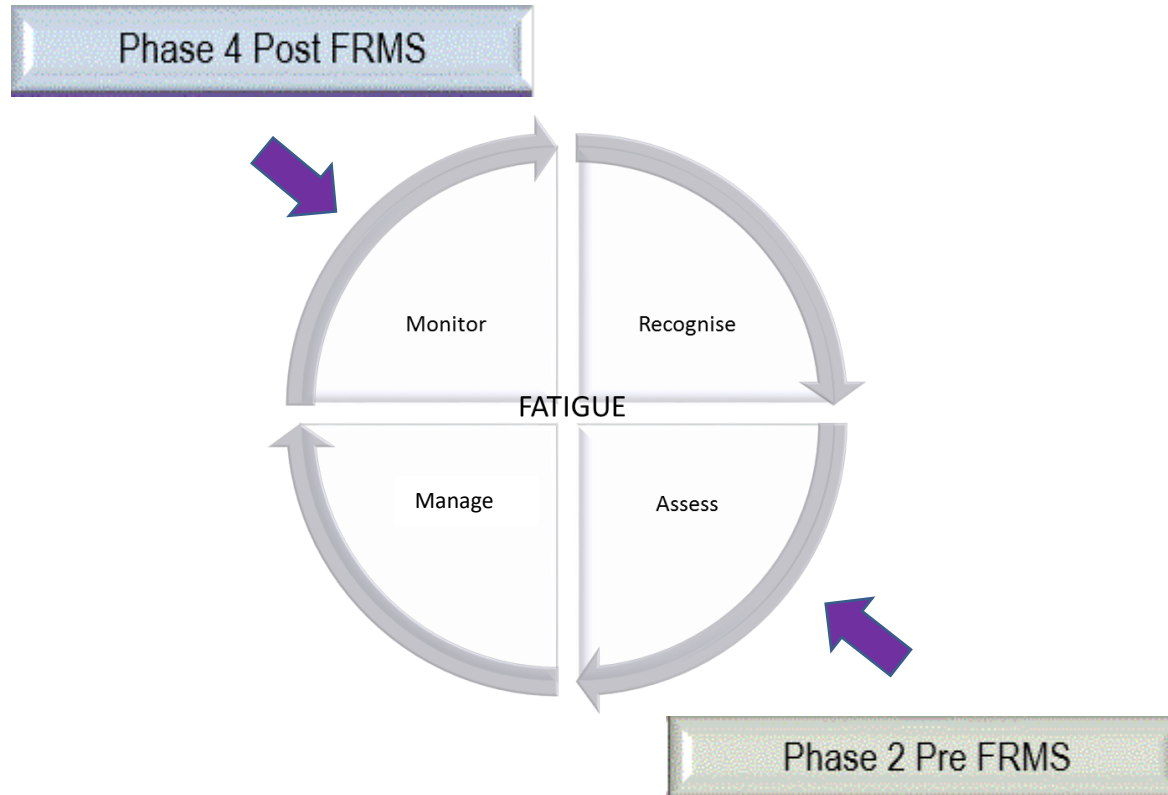


Phase 1 studies: Baseline Assessments



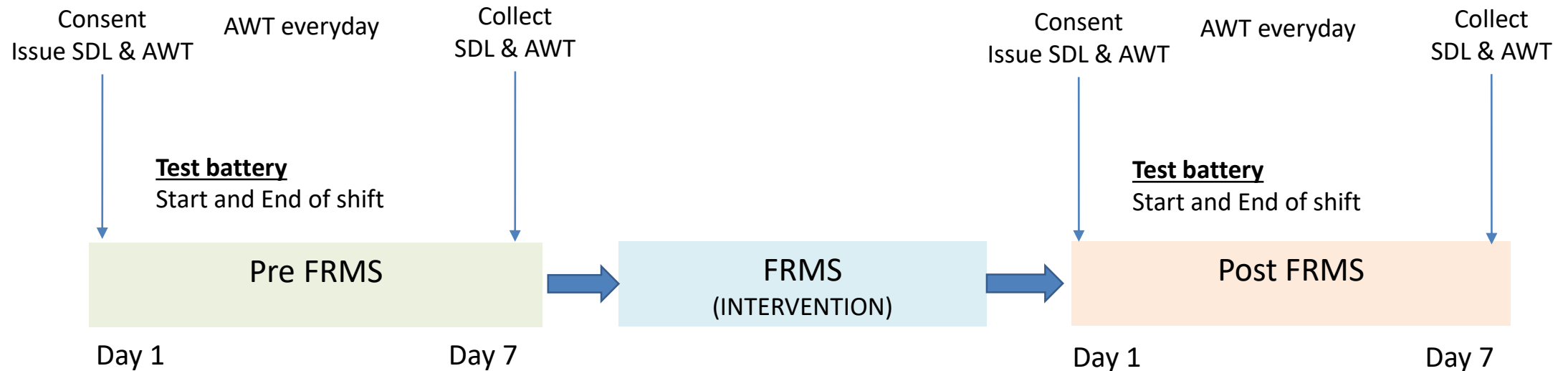
- A. Work Roster Analysis (Australian Medical Association Fatigue Risk Assessment Tool)
- B. Fatigue Survey (Questionnaire)
- C. Identification of safety critical task for SA measurement (via Task Analysis = Administration of medication)

Phase 2 and 4: Before and after intervention



- Data collection
 - Study protocol is same for Phase 2 Pre FRMS and Phase 4 Post FRMS

Study Protocol : Phase 2 and 4



Day 1 – Briefing on the study protocol and consent ; issue **sleep and duty log (SDL), Actiwatch (AWT)**

Day 7 – Collect SDL and Actiwatch

Actiwatch to be used for entire study period

Test battery to be done start and end of shift

Test battery

S.No.	Measures	Assessment tool	Purpose	Data points
1	Fatigue	SP Fatigue Checklist	Subjective assessment of fatigue	Start and end of shift
2	Sleepiness	ESS	Subjective assessment of general level of sleepiness	Start of Pre FRMS phase and Post FRMS phase
		KSS	Subjective assessment of acute sleepiness	Start and end of shift
3	Sleep duration	SL	For subjective sleep duration	For the study duration
		Actiwatch	For objective sleep duration	For the study duration
4	Duty periods	DL	For recording shift type	For the study duration
5	SA	SART	For subjective assessment of SA	Start and end of shift
6	Task performance	PVT	Objective assessment of task performance	Start and end of shift

Phase 2 and 4: Assessment Tools

Shift Start Date / time	SP Fatigue Checklist	KSS	Shift End Date / time	SP Fatigue Checklist	KSS

SAMN PERELLI FATIGUE CHECKLIST	
1	FULLY ALERT
2	VERY LIVELY
3	OKAY
4	A LITTLE TIRED
5	MODERATELY TIRED
6	EXTREMELY TIRED
7	COMPLETELY EXHAUSTED

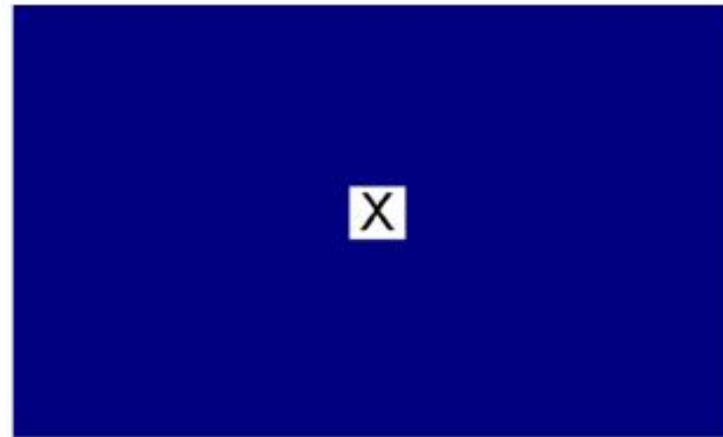
KAROLINSKA SLEEPINESS SCALE

Rate	State
1	very alert
2	
3	alert
4	
5	neither alert nor sleepy
6	
7	sleepy, but no difficulty staying awake
8	
9	very sleepy, fighting against sleep, requiring great effort to stay awake

Phase 2 and 4: Assessment Tools

Psychomotor Vigilance Test (PVT)
measures
Response time (RT)

The screenshot shows the 'Dery: Level 1 Reaction Time Tester' software interface. It is divided into several sections: 'Active Dataset' with a 'Subject ID' field; 'Simple Reaction Time' with settings for 'Number of Practice Tests', 'Number of Experiment Tests', 'Response Range (ms)' (From: 750, To: 1500), and 'Inter Stimulus Interval (ms)' (From: 7000, To: 2000); 'Choice Reaction Time' with settings for 'Number of Practice Tests', 'Number of Experiment Tests', 'Response Range (ms)' (From: 200, To: 1500), 'Inter Stimulus Interval (ms)' (From: 1000, To: 2000), and four 'CRT Key Box' options; and 'System Settings' with 'Create Study', 'Save Settings', and 'Load Study' buttons.



Screen shots of Vigilance test



Phase 2 and 4: Assessment Tools

Situation Awareness Rating Technique (SART) measures Subjective SA

SART probes

Demands on attention

Supply of attention

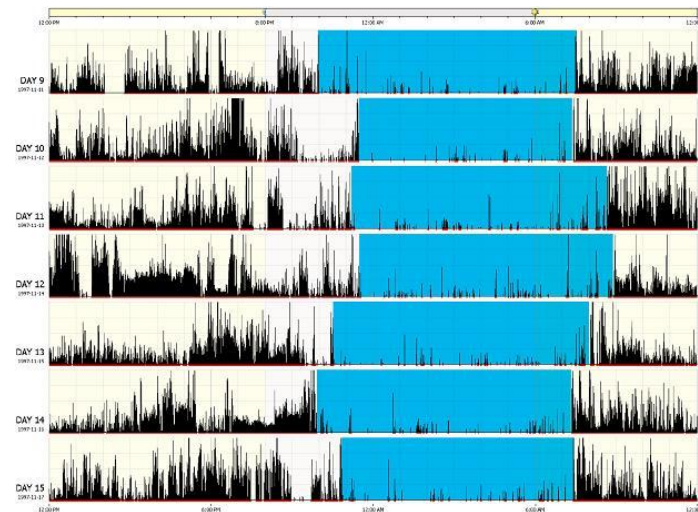
Understanding of situation

SART	DAY 1	
Questions:	Start of Shift time:	End of Shift time:
How changeable is the medication order for this patient? Is the medication order by the doctor likely to change suddenly (High)? Or is it not likely to change (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
How complicated is the preparation of medication? Do you have to calculate dosage of medicine (High) based on the doctor's order? Or is the preparation simple and straightforward (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
How variable is the method of administering this medication? Are there a large number of factors varying (High) such as new route of administration or are there few variables changing (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
Are you alert and ready for administering the medication (High) or do you have a low degree of alertness (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
Do you have to concentrate a lot to prepare the medicine for (High) or does the medicine preparation require low levels of attention (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
Do you have to do many tasks while preparing and administering medication (High) or are you focused on only one medication (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
Do you have spare mental capacity to attend to the different aspects of preparing medication (High) or you do not have any spare capacity (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
Do you have to do a lot of steps to prepare and administer medication (High) or very little steps to prepare medication (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
Is the knowledge regarding patient's medication preparation and administration very routine (High) or is it a new situation (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
Do you have a great deal of experience in preparation of medication (High) or a new method is required in preparation of medication (Low)?	1 2 3 4 5 6 7 Low High	1 2 3 4 5 6 7 Low High
For researcher's scoring only	Score:	Score:

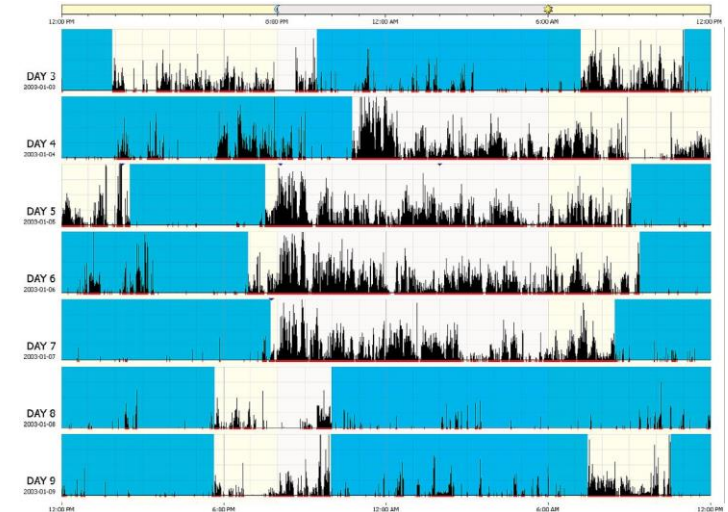
Phase 2 and 4: Assessment Tools

Actigraphy is a method used to study sleep-wake patterns by assessing wrist movements

Actiwatch



Normal Sleep



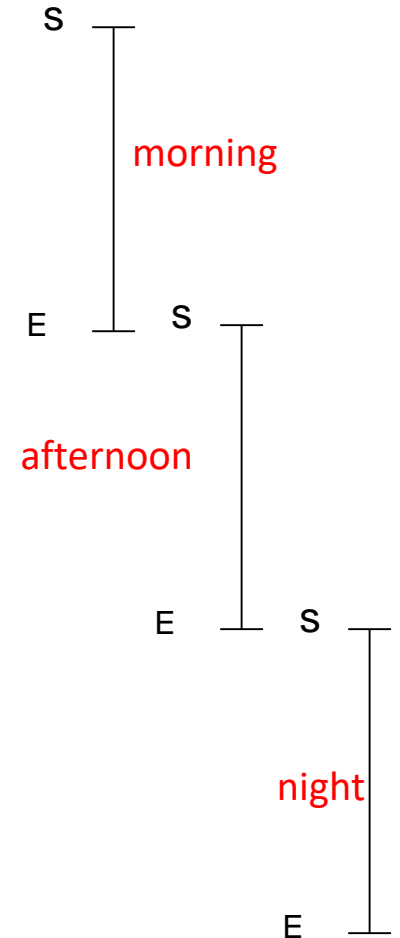
Sleep pattern in shift work

Data points

- The following scores were compared for each person
 - *SP Checklist (start and end of shift)*
 - *KSS (start and end of shift)*
 - *RT (start and end of shift)*
 - *SART (start and end of shift)*
- Sleep Duration and Naps
 - *Actiwatch data versus Sleep log*

Intra shift score trending and comparison
Inter shift score trending and comparison
Pre and Post FRMS score comparison

Rotating Shift workers



Statistical Analysis

ANOVA to compare dependant variables for the three groups of shift patterns (fatigue scores, sleepiness scores, SA scores and RT)

Paired t tests to further explore the differences

Phase 3: FRMS interventions on SICU Work Roster

- Participatory design with focus groups
- Multimodal interventions
- Work Roster interventions
 - Limit night shifts to no more than 2 per week
 - Eliminate or minimise Afternoon Morning shift
 - Increase frequency of rest breaks from 1 to 2 or more
 - Rest opportunity of at least 1 day after 5 days of continuous work
 - Adopt forward shift rotation
 - Predictable work roster (at least 48 hour notification of roster change as far as practicable)

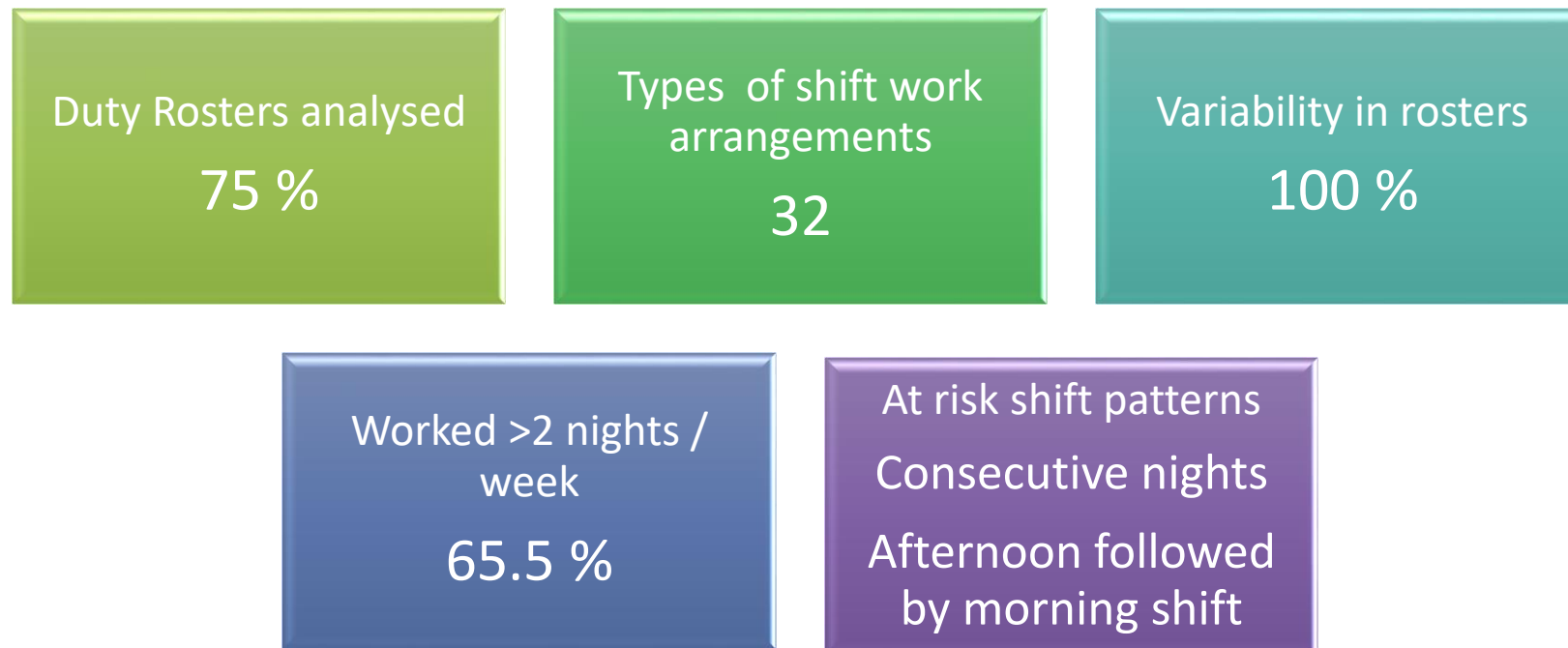
Phase 3: FRMS interventions at SICU

- Work Environment interventions
 - Identification of workplace nap zones
 - Sleep environment modification (lighting, noise)
- Nap duration up to 45 minutes for night shift nurses
- Fatigue management training
 - Sleep physiology
 - Fatigue recognition
 - Personal Coping strategies – sleep hygiene and other behavioural measures



Results: Phase 1 Preliminary Studies-Work roster analysis

Australian Medical Association Fatigue Risk Assessment Matrix and risk scores calculated for each individual based on 7 day duty roster



Results: Phase 1 Preliminary Studies-Work roster analysis

- Average working hours over a 7-day period : 43.5 hours
- Fatigue risk score for rosters increased with every consecutive night shift
- Major contributors to fatigue risk were
 - Number of night shifts in 7 days
 - Duration of rest opportunity in between shifts
 - Number of breaks during shift
 - Nature of shift rotation
 - Unpredictable changes to roster

Results: Phase 1 Preliminary Studies- Fatigue Survey

Response rate
73.7 %

Never or rarely woke up feeling refreshed
25%

Responded Yes to error due to fatigue
28 %

Average sleep duration
(work day)
6.1 hours

Average sleep duration
(rest day)
7.4 hours

55% difficulty staying awake
during work hours (particularly night
and morning shift)

“I have made a serious medication error during my night shift around 3-4 am. I read doctor’s description wrongly and administered the wrong dosage. I think it's mostly due to fatigue.”

84% indicated that they had not had any prior education about shiftwork and personal strategies for management of fatigue at workplace

Participant profile for Phases 2, 3 and 4

- Gender Profile : 100% women
- Age Profile : Average age 26.7 years (Range 21- 48 years)
- Pre FRMS (n=36) ; FRMS (n=34) and Post FRMS (n=28)
- Participant attrition between Pre and Post FRMS (n=8) – 6 long leave/resigned , 2 withdrew as not keen to continue

Fatigue Scores

H3: Pre FRMS Fatigue (SP)	H5: Morning	Afternoon	Night	Overall
Start	3.77	3.17	3.23	3.45
End	4.82	4.81	5.34	4.83
Trend (Start vs. End)	↑	↑	↑	↑
Statistical significance	Yes			

H3: Post FRMS Fatigue	H5: Morning	Afternoon	Night	Overall
Start	3.30	2.6	2.85	2.93
End	3.96	3.56	5.19	4.2
Trend (Start vs. End)	↑	↑	↑	↑
Statistical significance	Yes	Yes		Yes

SAMN PERELLI FATIGUE CHECKLIST	
1	FULLY ALERT
2	VERY LIVELY
3	OKAY
4	A LITTLE TIRED
5	MODERATELY TIRED
6	EXTREMELY TIRED
7	COMPLETELY EXHAUSTED

H2: Fatigue	Start of shift	End of shift
Pre FRMS	3.45	4.83
Post FRMS	2.93	4.2
Trend (Pre vs. Post)	↓	↓
Statistical significance	Yes	Yes

Sleepiness Scores

H3:Pre FRMS KSS	H5:Morning	Afternoon	Night	Overall
Start	4.43	3.46	3.42	3.79
End	5.25	5.07	6.26	5.49
Trend (Start vs. End)	↑	↑	↑	↑
Statistical significance	Yes	Yes		

H3:Post FRMS KSS	H5: Morning	Afternoon	Night	Overall
Start	4.22	3.13	3	3.51
End	4.72	3.85	6.23	4.94
Trend (Start vs. End)	↑	↑	↑	↑
Statistical significance				

KAROLINSKA SLEEPINESS SCALE

Rate	State
1	very alert
2	
3	alert
4	
5	neither alert nor sleepy
6	
7	sleepy, but no difficulty staying awake
8	
9	very sleepy, fighting against sleep, requiring great effort to stay awake

H2: KSS	Start of shift	End of shift
Pre FRMS	3.79	5.49
Post FRMS	3.51	4.94
Trend (Pre vs. Post)	↓	↓
Statistical significance		Yes

Response Time on 5 min Vigilance task



H3: Pre FRMS RT	H5: Morning	Afternoon	Night	Overall
Start	360.58	338.07	336.73	344.86
End	387.75	373.14	399.26	386.11
Trend (Start vs. End)	↑	↑	↑	↑
Statistical significance		Yes	Yes	Yes

H3: Post FRMS RT	H5: Morning	Afternoon	Night	Overall
Start	375.65	356.47	374.1	368.54
End	382.86	388.73	418.21	395.70
Trend (Start vs. End)	↑	↑	↑	↑
Statistical significance		Yes		Yes

H2: RT	Start of shift	End of shift
Pre FRMS	344.86	386.11
Post FRMS	368.54	395.70
Trend (Pre vs. Post)	↑	↑
Statistical significance	Yes	

SART Scores

H4: Pre FRMS SA	H6: Morning	Afternoon	Night	Overall
Start	23.38	21.38	23.28	22.68
End	22.61	21.38	22.14	22.03
Trend (Start vs. End)	↓	↔	↓	↓
Statistical significance				

H4: Post FRMS SA	H6: Morning	Afternoon	Night	Overall
Start	23.86	23.38	24	23.74
End	22.68	23.38	24.6	23.52
Trend (Start vs. End)	↓	↔	↑	↓
Statistical significance				

H2: SA	Start of shift	End of shift
Pre FRMS	22.68	22.03
Post FRMS	23.74	23.52
Trend (Pre vs. Post)	↑	↑
Statistical significance		

Background

Objectives

Methods

Results &
Discussion

Conclusion

Phase 2 and 4: Fatigue and SA

H1 Category	Fatigue			SA
	SP	KSS	RT	
Pre-FRMS Start	3.45	3.79	344.86	22.68
Pre-FRMS End	4.83	5.49	386.11	22.03
Post-FRMS Start	2.93	3.51	368.54	23.74
Post-FRMS End	4.2	4.94	395.70	23.52

Limitations

- Limitations of the tools used for fatigue and SA measurement
- Limited duration of observation
- Naturalistic field setting, limitation in controlling for confounding variables
- Objective SA tools could not be applied in a field setting
- Lack of baseline data under optimal sleeping conditions
- Effectiveness of individual FRMS interventions were not possible to analyse

Conclusion

- Association between fatigue and SA
 - Results suggest that when fatigue \uparrow , SA \downarrow
- Role of FRMS
 - Results show \downarrow fatigue and \uparrow SA with implementation of FRMS
- In SICU nurses, FRMS decreases fatigue and improves Situation Awareness

Acknowledgements

- Participants and Management, CGH, Surgical Intensive Care Unit, Singapore
- Faculty, Nanyang Technological University, Human Factors Lab, Singapore

Thank you

A. Work Roster Analysis

- 7 day work roster for all SICU nurses
- Australian Medical Association (AMA) National Code of Practice – Hours of work, shift work and rostering for hospital doctors
- SICU roster codes based on shift start and end times

S. No	Risk factor	Low (1 point)	Significant (2 points)	High (3 points)
1	Hours worked	<50 hours	50 - 70 hours	>70 hours
2	Shift length	All shifts \leq 10 hours	Any 1 shift up to 14 hours	Any 2 shift \geq 14 hours
3	Scheduled shift hours	As per scheduled shift hours	Any 1 shift longer than scheduled , but < 24 hours	Any shift longer than scheduled , but \geq 24 hours
4	Breaks	\geq 3	1 - 2	0
5	Overtime	0 -10 hours	>10 hours	>20 hours
6	On call (days)	0-2 days	3-6 days	7 days
7	Night shift	0 -1	2	\geq 3
8	Rest opportunity in between shifts	Minimum 10 hours break and \geq 2 days free of work	Minimum 10 hours break and 1 day free of work	< 10 hours break on at least 2 work periods and no full day free of work
9	Shift rotation	Forward rotation and predictable cycle	Forward rotation and changed cycle	No stable direction or speed of rotation
10	Roster changes	No changes without notice	Changes to roster but schedule predictable	Changes to roster , unpredictable schedule
11	Max sleep opportunity	\geq 2 full nights	\geq 1 night of sleep	< 1 night of sleep
	Total points	11	22	33

SA in Health care

- Level 1 – Perception – nurse taking note of patients vital signs
- Level 2 – Comprehension – nurse understanding the status of the patient based on signs and symptoms
- Level 3 – Projection – anticipate progress based on significance of current state

Opportunities for future work

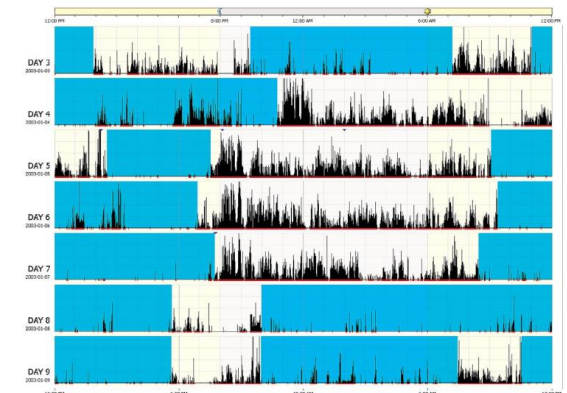
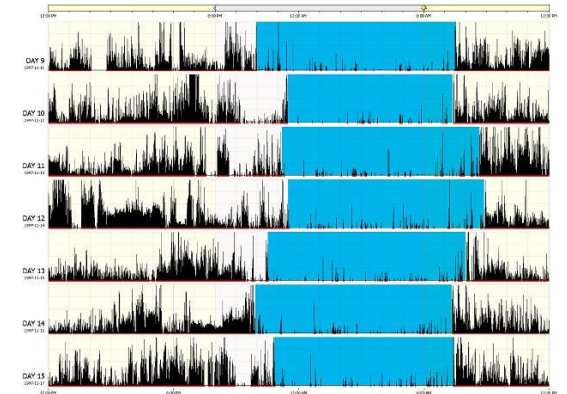
- Enhanced duration of observation
- SA assessment using objective methods (may require laboratory setting to introduce SA probes)
- Having baseline data for optimal sleeping conditions
- Studying effectiveness of each FRMS intervention individually (rather than the holistic assessment in this study)
- Future work can build on this research

Phase 2 and 4: Sleep Duration

Sleep Duration

Pre FRMS Mean Sleep Duration	Morning	Afternoon	Night
Subjective (Sleep Log)	8h	7h 44m	5h 43m
Objective (Actiwatch)	9h 1m	8h 18m	5h 54m

Post FRMS Mean Sleep Duration	Morning	Afternoon	Night
Subjective (Sleep Log)	8h 5m	7h 21m	5h 43m
Objective (Actiwatch)	9h 1min	8h 30m	5h 48m



Research questions

- Is there an association between fatigue and SA ?
- Does fatigue impact situation awareness before and after the implementation of a Fatigue Risk Management System?

Objectives

Primary

- To study the relationship between fatigue and situation awareness in rotating shift workers
- To customise and evaluate fatigue risk management system (FRMS)

Secondary

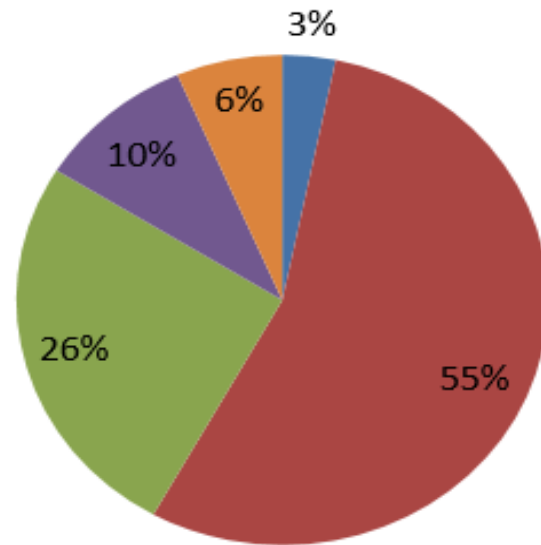
- To assess if fatigue varies within a shift
- To assess if SA varies within a shift
- To assess if fatigue varies between shift (rotating shift work)
- To assess if SA varies between shifts (rotating shift work)
- To assess if there is difference in subjective and objective sleep duration data

Phase 3: Results & Discussion

Sleep Physiology and Fatigue Management Workshop

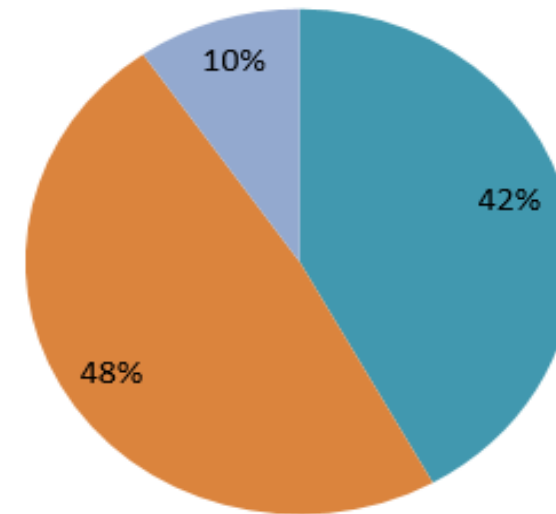
Pre Training Knowledge Scores (n=31)
1 = Very little knowledge and 7 = Excellent Knowledge

■ 1 ■ 2 ■ 3 ■ 4 ■ 5 ■ 6 ■ 7



Post Training Knowledge Scores (n= 31)
1 = Very little knowledge and 7 = Excellent Knowledge

■ 1 ■ 2 ■ 3 ■ 4 ■ 5 ■ 6 ■ 7



C. Identification of Task for SA Analysis

- Review of nurses tasks in SICU
- Task selection criteria :
 - Common task in all shifts for all nurses
 - Safety critical task
 - Task relies on cognitive presence
 - Task is part of routine work
- Task analysis : Administration of medication
- SA Probe development for Situation Awareness assessment