


# BMJ Open Fatigue and recovery among Malaysian doctors: the role of work-related activities during non-work time

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## ABSTRACT

**Objectives** This paper aims to estimate the level of acute fatigue, chronic fatigue and intershift recovery among doctors working at public hospitals in Malaysia and determine their inter-relationship and their association with work-related activities during non-work time.

**Design** Cross-sectional.

**Setting** Seven core clinical disciplines from seven tertiary public hospitals in Malaysia.

**Participants** Study was conducted among 330 randomly-sampled doctors. Response rate was 80.61% (n=266).

**Results** The mean score of acute fatigue, chronic fatigue and intershift recovery were 68.51 (SD=16.549), 54.60 (SD=21.259) and 37.29 (SD=19.540), respectively. All these scores were out of 100 points each. Acute and chronic fatigue were correlated ( $r=0.663$ ), and both were negatively correlated with intershift recovery ( $r=-0.704$  and  $r=-0.670$ , respectively). Among the work-related activities done during non-work time, work-related ruminations dominated both the more frequent activities and the association with poorer fatigue and recovery outcomes. Rumination on being scolded/violated was found to be positively associated with both acute fatigue (adjusted regression coefficient (Adj. *b*)=2.190, 95% CI=1.139 to 3.240) and chronic fatigue (Adj. *b*=5.089, 95% CI=3.876 to 6.303), and negatively associated with recovery (Adj. *b*=-3.316, 95% CI=-4.516 to -2.117).

Doing work task at workplace or attending extra work-related activities such as locum and attending training were found to have negative associations with fatigue and positive associations with recovery. Nevertheless, doing work-related activities at home was positively associated with acute fatigue. In terms of communication, it was found that face-to-face conversation with partner did associate with higher recovery but virtual conversation with partner associated with higher acute fatigue and lower recovery.

**Conclusions** Work-related ruminations during non-work time were common and associated with poor fatigue and recovery outcomes while overt work activities done at workplace during non-work time were associated with better fatigue and recovery levels. There is a need for future studies with design that allow causal inference to address these relationships.

## INTRODUCTION

Fatigue, a suboptimal psychophysiological condition caused by exertion,<sup>1</sup> is closely

## Strengths and limitations of this study

- Multicentre study involving seven core clinical disciplines from seven tertiary public hospitals.
- Multiple dependant variables which include acute fatigue, chronic fatigue and intershift recovery which are rarely explored simultaneously among doctors.
- Cover multiple independent variables which includes the rarely explored work-related activities during non-work time among doctors that are potentially associated with acute fatigue, chronic fatigue and intershift recovery.
- This study specifically involves doctors working at tertiary public hospitals and excludes house officers and specialists; therefore, the findings cannot be widely generalised to house officers, specialists and doctors in non-hospital settings.
- This is a cross-sectional study; thus it is unable to infer causation.

related to recovery, in which, in the absence of sufficient recovery, acute fatigue may commence into chronic fatigue.<sup>1-6</sup> In line with conservation of resources (COR) theory, fatigue is a manifestation of adverse psychological condition following loss of energy resources or a lack of energy resources replacement.<sup>7-9</sup> Acute fatigue is a normal adaptive response to work activity that is reversible, task-specific and disappears after a period of rest.<sup>4 6</sup> However, this adaptive response is dependent on adequate recovery during intershift, or non-work, period.<sup>5 6</sup> Inadequate intershift recovery of acute fatigue may begin a cycle of accumulated unrecovered fatigue which progresses to the chronic maladaptive fatigue<sup>5 6 10</sup> which is not task-specific<sup>4</sup> and cannot be alleviated by rest alone.<sup>11</sup>

The prevalence of fatigue among doctors is significant. Multiple studies among doctors found that prevalence of fatigue range from 28% to 91%.<sup>12-18</sup> The majority of them were experiencing high and frequent fatigue<sup>17 18</sup> with low and moderate intershift recovery.<sup>19</sup> These findings are not surprising as a doctor's

duty, especially in the hospital setting, is commonly associated with long work hours, frequent on-call duty, inadequate recovery time and night shift work.<sup>12 15–17 20 21</sup>

The non-work intershift period, which has been rarely explored, is equally critical in mitigating fatigue issue so that the doctor will arrive at the next working day with no residual fatigue.<sup>2</sup>

The non-work intershift period should be free from work-related activities to foster recovery,<sup>22</sup> or otherwise recovery will be hindered.<sup>23</sup> The work-related activities during non-work intershift period can be in the form of psychological rumination,<sup>24–26</sup> task<sup>23</sup> or communication.<sup>27</sup> Work-related ruminative thoughts include the rumination on being violated at work<sup>26</sup> which is not uncommon among doctors,<sup>28–30</sup> self-wrongdoing at workplace<sup>31</sup> and other workplace stressors.<sup>24</sup> Being violated at the workplace is known to be associated with rumination and fatigue.<sup>32–34</sup> Other risk factors of fatigue include pressures related to unresolved or forthcoming work, additional responsibilities (such as doing locum), specific work requirements (such as telephone consultations or handling work-related social media) and technology-assisted work-related task.<sup>20 27 35 36</sup> However, the role of work-related activities during non-work time in fatigue and recovery among doctors has rarely been explored.

Fatigue, which is closely related with poor recovery,<sup>1–6</sup> is harmful as it may compromise safety of the doctors such as through commuting accidents<sup>37</sup> and needlestick injury.<sup>38 39</sup> Additionally, fatigue doctors may jeopardise patients' safety<sup>40</sup> through diagnostic errors,<sup>41</sup> medical error,<sup>42</sup> clinical error<sup>43</sup> and inappropriate treatment.<sup>44</sup> Furthermore, studies among doctors found that fatigue can affect work and organisation such as less enjoyment in work<sup>18</sup> and high turnover intention.<sup>13</sup> Other consequences include adverse health and well-being, work-life dissatisfaction, low quality of life, job dissatisfaction and poor skill performance.<sup>40</sup>

Fatigue among doctors in Malaysia has just recently gained national attention.<sup>45 46</sup> Long work hours and lack of recovery opportunities have always been blamed for the fatigue suffered by doctors.<sup>45</sup> Multiple health-related and road safety-related organisations are demanding the government for actions such as an establishment of a safe work hours law to address this issue.<sup>45 47</sup> However, there is limited research on fatigue and recovery among doctors, particularly in Malaysia. The scientific information that is needed in order to develop evidence-based local legislation and policy, is therefore currently insufficient.

In Malaysia's healthcare setting, doctors, which includes house officers, medical officers and specialists, make a large portion of the health workforce,<sup>48</sup> especially in the core clinical disciplines, which include internal medicine, surgery, orthopaedic, paediatric, obstetrics and gynaecology, anaesthesiology and psychiatry.<sup>48</sup> The current practice in most core clinical disciplines at public hospitals in Malaysia is to have on-call duties from 08:00 hours to 17:00 hours of the next day.<sup>49</sup> After working continuously for 33 hours and finishing on-call duties at

17:00 hours, most of them are required to come back to work at 08:00 hours on the following day, corresponding to intershift duration of just 15 hours.<sup>45 49</sup> However, little is known on the work-related activities being done during this non-work intershift period by doctors in Malaysia, and their associations with fatigue and recovery.

Despite numerous studies related to work hours and fatigue,<sup>12–21</sup> there is limited study specifically on acute fatigue, chronic fatigue and intershift recovery as well as their association with work-related activities during non-work time among doctors. To date, no similar study has been done in Malaysia. Therefore, this study aims were to; (1) estimate the level of acute fatigue, chronic fatigue and intershift recovery among doctors working at public hospitals in Malaysia, (2) determine their inter-relationship and (3) determine their associations with work-related activities during non-work time.

## METHODOLOGY

### Study location

This study was conducted at all seven tertiary public hospitals located in the state of Selangor, Malaysia. Selangor is one of the most populated state with 20% of total Malaysian population.

### Study design and sampling

A cross-sectional survey was conducted among randomly-selected doctors from seven core clinical disciplines which practised on-call system, that is, internal medicine, surgery, orthopaedic, paediatric, obstetrics and gynaecology, anaesthesiology and psychiatry at these hospitals.

Our target population was non-resident and non-specialist doctors who worked at tertiary public hospitals in Malaysia. All seven tertiary public hospitals in the state of Selangor were chosen as the sample population to represent tertiary public hospitals in Malaysia. These hospitals represent 20% of all tertiary public hospitals in Malaysia. On the other hand, the sample population represents almost 25% of target population. The inclusion criteria were Malaysian doctors who are permanently (not temporary nor contractual) appointed under civil service sector and has been working at current workplace for at least 1 month. The exclusion criteria are house officers, specialists and postgraduate candidates, and those medically diagnosed as, or on treatment for, sleep disorder or mental illness. Sampling frame was obtained from the office of respective department at each hospital. We conducted probabilistic simple random sampling procedure by combining all the names into one master list, followed by random selection using Microsoft Excel to select the number of participants based on the calculated sample size.

Based on the calculated sample size of one-group analytical study with 95% CI, power of 0.80 and expected correlation coefficient of 0.16,<sup>50</sup> 304 participants were required. Alternatively, based on calculated sample size with 95% CI, power of 0.80 and fatigue prevalence of

0.84,<sup>15</sup> 0.91<sup>16</sup> and 0.79,<sup>17</sup> we required 207, 126 and 255 participants. Hence, 330 questionnaires were randomly distributed to participants from seven core clinical disciplines at seven tertiary hospitals. These 330 randomly-selected participants represent about 15% of total sample population.

### Study instruments

Data was collected using a specially designed questionnaire. It was designed through discussion among authors. It contained sociodemographic information, occupational-related information, self-constructed 7-point Likert-scale work-related activities during non-work hours and 15-items Occupational Fatigue/Exhaustion Recovery (OFER-15) scale.<sup>6</sup> Sociodemographic and occupational-related information were collected to describe the participants characteristic and act as controlled variables. On the other hand, work-related activities during non-work hours scale and OFER-15 act as independent and dependent variables, respectively. In general, the coverage and relevance of the contents were validated by experts in occupational health from both the academic (university) and civil service sectors (state health department). The overall questionnaire was pretested to ensure face validity. It was then piloted among 30 participants to assess reliability and reassess face validity. The Cronbach's alpha for acute fatigue, chronic fatigue and intershift recovery were 0.737, 0.828 and 0.704, respectively.

OFER-15 is a validated questionnaire containing three subscales, that is, acute fatigue, chronic fatigue and intershift recovery.<sup>6</sup> Each subscale consists of five items with 7-point Likert scale scoring from 0 (strongly disagree) to 6 (strongly agree). Each subscale sums the five items; thus, each subscale may produce score of 0 to 30. The total score for each subscale was divided by 30, followed by multiplication of 100 to produce comparable score of 0 to 100.<sup>6</sup> Higher scores for acute and chronic fatigue indicate higher acute and chronic fatigue, respectively, whereas higher scores for intershift recovery reflect higher intershift recovery.

The work-related activities during non-work hours scale is a self-constructed 23-items 7-point Likert-scale. The points are 0 (never), 1 (less than once per month), 2 (once per month), 3 (more than once per month), 4 (once a week), 5 (more than once a week) and 6 (daily). The list of activities was developed through interview with source population, authors' experiences, expert opinion and literature review. Fourteen medical doctors, or two from each core clinical disciplines, were purposively approached to list and describe any work-related activities during non-work time as many as possible. Three occupational health experts were also purposively approached and given similar task. All authors, who are also medical doctors, share own experiences throughout working life as medical doctors among themselves, and added the findings into the list. We also employed scoping literature search specifically on type of activities during non-work time being done by general employees and suited

them into medical doctors' career. The list was finally combined into one master list. Literature reviews revealed items related to rumination, unfinished task, work-related conversation with multiple parties and technology-assisted work-related communication during non-work time.<sup>20 23–27 32–36</sup> Interview with target population revealed items, apart from findings from literature reviews, related to extended unpaid working hours for training, meeting, discussion and clients-related task, as well as instruction received through technology-assisted communication devices. Others included locum and handling organisation website or social media. Expert opinions involving occupational health physician consensually endorsed all these generated items. The final 23-item inventory contained work-related activities that covers different type of activities (ie, rumination, task, communication), mediums (ie, psychological, physical, virtual) and interaction groups (ie, superior, colleague, patients/clients, partners, self).

### Data analysis

Responses from questionnaires were categorised and coded. Data were analysed by using SPSSV.21. Univariable data were analysed and presented descriptively as mean and SD or frequencies and percentages. Bivariable data were analysed by using simple linear regression. Multiple linear regression analysis was subsequently conducted to identify factors associated with acute fatigue, chronic fatigue and intershift recovery. All independent variables, consisting of sociodemographic profile, occupational profile, work-related activities during non-work time and work-home commuting profile, were initially included and elimination was done by stepwise method. Data were presented as adjusted regression coefficient (Adj. *b*), 95% CI and *p* value. Significant level was set at *p*<0.05.

### Patient and public involvement statement

PPI representatives partially worked with us to refine the research question on work-related activities during non-work time; however, it was difficult to involve PPI in other areas of the study design due to data protection restrictions. PPI representatives will assist us in dissemination of study information to their peers.

## RESULTS

We received 266 completed questionnaires out of the 330 questionnaires distributed. Thus, the response rate was 80.61%

### Participants' profile

Table 1 described participants profile. Majority were women with mean age of 31.04 (SD=3.357) years. They work in average of 4.31 (SD=2.865) years as doctors. All of them used WhatsApp as work-related communication technology medium, and some used dual medium. Interestingly, 86.5% of participants perceived that work-related communication medium push them to do, or to ruminate on, work-related matters during non-work time.

**Table 1** Participants characteristic (n=266)

Variables	Minimum	Maximum	N (%)	Mean (SD)
Age, years	26.00	49.00		31.04 (3.357)
Gender				
Male			98 (36.8)	
Female			168 (63.2)	
Marital status				
Single			92 (34.6)	
Married			171 (64.3)	
Divorced/ separated			3 (1.1)	
Number of household members	0.00	8.00		2.55 (1.569)
Work tenure, years				
As doctors	0.42	17.00		4.31 (2.865)
At current department	0.08	13.00		2.68 (2.033)
Departments				
Anaesthesiology			60 (22.6)	
Paediatric			41 (15.4)	
Orthopaedic			40 (15.0)	
Psychiatry			40 (15.0)	
Surgery			29 (10.9)	
Internal medicine			28 (10.5)	
Obstetrics and gynaecology			28 (10.5)	
Work schedule				
Working hour per month	78.00	315.00		209.71 (39.951)
Total number of on-call per month	0.00	8.00		3.88 (1.808)
Work-home commuting				
Distance, km	0.02	96.00		21.49 (15.271)
Duration, min	1.80	90.00		34.95 (17.731)
Method of work-home commuting				
Self-driving/self-riding			251 (94.4)	
Others			15 (5.6)	
Work-related communication medium				
WhatsApp			100 (100.0)	
Email			112 (42.1)	
Facebook			12 (4.5)	
Telegram			6 (2.3)	
Others			7 (2.6)	
Perceived that work-related communication medium push them to do or ruminate on work-related matters during non-work time				
Yes			230 (86.5)	
No			36 (13.5)	

### Work-related activities during non-work time

Table 2 listed the 23 work-related activities during non-work time. Generally, work-related rumination dominated the more frequent activities done by the doctors. In contrast, task-related activities particularly locums and meetings were the least frequently done work-related activities during non-work time.

There were six work-related activities during non-work time occurring at least once a week. They are rumination

on patients/clients (M=4.84, SD=1.699), doing work task at workplace (M=4.73, SD=1.817), informal conversation with colleague virtually (M=4.46, SD=1.753), physical communication with patients/clients (M=4.38, SD=2.381), rumination on upcoming work (M=4.18, SD=2.016) and rumination on unfinished task (M=4.16, SD=1.959). Even though most of the task-related activities were less likely to be done by the doctors during their non-work time, doing work task at workplace was very

**Table 2** Work-related activities during non-work time (n=266)

Work-related activities during non-work time	Types	Mean (SD)*
1. Rumination on patient/clients	Rumination	4.84 (1.699)
2. Doing work task at workplace	Task	4.73 (1.817)
3. Informal conversation with colleague virtually	Communication	4.46 (1.753)
4. Physical communication with patients/clients	Communication	4.38 (2.381)
5. Rumination on upcoming work	Rumination	4.18 (2.016)
6. Rumination on unfinished task	Rumination	4.16 (1.959)
7. Informal conversation with colleague physically	Communication	3.84 (2.117)
8. Rumination on self-wrongdoing	Rumination	3.66 (1.911)
9. Physical conversation with partner	Communication	3.48 (2.389)
10. Rumination on being scolded/violated	Rumination	3.31 (1.976)
11. Virtual conversation with partner	Communication	2.94 (2.402)
12. Instruction from superior via text message/email	Communication	2.76 (1.830)
13. Doing work task at home	Task	2.74 (1.756)
14. Instruction from superior via phone call	Communication	2.71 (1.896)
15. Physical conversation with parent	Communication	2.58 (1.947)
16. Virtual conversation with parent	Communication	2.01 (2.093)
17. Handling email/website/social media	Task	1.79 (1.924)
18. Attending work-related meeting physically at workplace	Task	1.63 (1.422)
19. Attending work-related training	Task	1.33 (1.424)
20. Virtual communication with patients/clients	Communication	0.95 (1.541)
21. Attending work-related meeting virtually	Task	0.77 (1.439)
22. Locum at private health facilities	Task	0.81 (1.463)
23. Locum at government health facilities	Task	0.43 (0.996)

\*Higher mean refers to higher frequency.

common that it was the second occurring activities among the list being studied. Doing work task at home (M=2.74, SD=1.756) did occur among these doctors but at a much less frequency. Receiving instruction from superior via text message/email or via phone call were also found to occur once per month (M=2.76, SD=1.830 and M=2.71, SD=1.896, respectively).

#### Level and correlation of acute fatigue, chronic fatigue and intershift recovery

Table 3 showed mean level of acute fatigue, chronic fatigue and intershift recovery, and the correlation among them. The mean score of acute fatigue, chronic fatigue and intershift recovery were 68.51 (SD=16.549), 54.60

(SD=21.259) and 37.29 (SD=19.540), respectively. All these scores were out of 100 points each. Acute fatigue was moderately and positively correlated with chronic fatigue, and both were moderately and negatively correlated with intershift recovery.

#### Factors associated with acute fatigue, chronic fatigue and intershift recovery

Table 4 demonstrated the factors associated with acute fatigue, chronic fatigue and intershift recovery. Age, gender, marital status and monthly work hours did not associate with fatigue and recovery. There were significant linear relationships between seven independent variables and acute fatigue ( $R^2=0.32$ ), five independent variables

**Table 3** Level of acute fatigue, chronic fatigue and intershift recovery and correlation among them (n=266)

Variables	Mean (SD)	Pearson correlation		
		Acute fatigue	Chronic fatigue	Intershift recovery
Acute fatigue	68.51 (16.549)	1	0.663*	-0.704*
Chronic fatigue	54.60 (21.259)	0.663*	1	-0.670*
Intershift recovery	37.29 (19.540)	-0.704*	-0.670*	1

\*p<0.05

**Table 4** Factors associated with acute fatigue, chronic fatigue and intershift recovery (n=266)

Variables	Acute fatigue		Chronic fatigue		Intershift recovery	
	Adj.b (95% CI)	P value	Adj.b (95% CI)	P value	Adj.b (95% CI)	P value
Work tenure, years						
As doctor	1.142 (0.539 to 1.745)	<0.001	0.712 (0.001 to 1.422)	0.05	-1.143 (-2.147 to -0.140)	0.026
At current department						
Work schedule						
Monthly work hours						
Total number of on-call per month						
Work rumination during non-work time						
Rumination on unfinished task						
Rumination on being scolded/violated	2.190 (1.139 to 3.240)	<0.001	5.089 (3.876 to 6.303)	<0.001	-3.316 (-4.516 to -2.117)	0.009
Rumination on upcoming work	2.065 (1.031 to 3.099)	<0.001	3.417 (1.999 to 4.835)	<0.001		<0.001
Rumination on patient/clients			-1.739 (-3.351 to -0.234)	0.024		
Rumination on self-wrongdoing						
Work-related task during non-work time						
Doing work task at home	1.265 (0.107 to 2.424)	0.032				
Doing work task at workplace					1.651 (0.489 to 2.812)	0.006
Attending work-related training					1.704 (0.235 to 3.174)	0.023
Locum at government health facilities	-3.516 (-5.313 to -1.719)	<0.001	-3.645 (-5.703 to -1.587)	0.001	3.562 (1.477 to 5.647)	0.001
Locum at private health facilities	-1.684 (-2.892 to -0.476)	0.006				
Attending work-related meeting physically						
Attending work-related meeting virtually						
Handling work-related email/web/social media						
Work communication during non-work time						
Physical conversation with partner					1.889 (0.543 to 3.234)	0.006
Virtual conversation with partner	1.395 (0.212 to 2.579)	0.021			-2.270 (-3.611 to -0.929)	0.001
Physical conversation with parents						
Virtual conversation with parents						
Physical communication with patients/clients						
Virtual communication with patients/clients						
Informal work conversation with colleague physically						
Informal work conversation with colleague virtually						
Instruction from superior via message/email						
Instruction from superior via phone call						

Adj.b, adjusted regression coefficient.

and chronic fatigue ( $R^2=0.40$ ) and nine independent variables and intershift recovery ( $R^2=0.28$ ).

All the three types of work-related activities had factors that were associated with dependant variables. With regards to the work-related ruminations that were done during non-work time, all except one (rumination on self-wrongdoing) of the work-related ruminations found to have significant associations with at least one of the dependent variables. Rumination on being scolded/violated was found to be associated with higher level of both acute fatigue (Adj.*b*=2.190, 95% CI=1.139 to 3.240) and chronic fatigue (Adj.*b*=5.089, 95% CI=3.876 to 6.303) and lower level of recovery (Adj.*b*=-3.316, 95% CI=-4.516 to -2.117). Rumination on upcoming work was associated with higher acute fatigue (Adj.*b*=2.065, 95% CI=1.031 to 3.099) and chronic fatigue (Adj.*b*=3.417, 95% CI=1.999 to 4.835), while rumination of unfinished task was associated with lower recovery (Adj.*b*=-1.647, 95% CI=-2.881 to -0.412). In contrast, rumination on patients/clients was the only work-related rumination that was found to be associated with lower level of chronic fatigue (Adj.*b*=-1.739, 95% CI=-3.351 to -0.234).

In terms of task-related activities, doing locum at government health facilities were associated with lower level of both acute fatigue (Adj.*b*=-3.516, 95% CI=-5.313 to -1.719) and chronic fatigue (Adj.*b*=-3.645, 95% CI=-5.703 to -1.587) and higher level of recovery (Adj.*b*=3.562, 95% CI=1.477 to 5.647). However, doing locum at private health facilities was only associated with lower level of acute fatigue (Adj.*b*=-1.684, 95% CI=-2.892 to -0.476). As for work task, doing it at home was found to be associated with higher acute fatigue (Adj.*b*=1.215, 95% CI=0.107 to 2.424) while doing it at workplace was associated with higher level of recovery (Adj.*b*=1.651, 95% CI=0.489 to 2.812). Attending work-related training was also found to be associated with higher level of recovery (Adj.*b*=1.704, 95% CI=0.235 to 3.174).

As for work-related communication, virtual conversation with partner was associated with both higher acute fatigue (Adj.*b*=1.395, 95% CI=0.212 to 2.579) and lower recovery (Adj.*b*=-2.270, 95% CI=-3.611 to -0.929). However, face-to-face conversation with partner was associated with higher level of recovery (Adj.*b*=1.889, 95% CI=0.543 to 3.234).

## DISCUSSION

Our study showed that participants generally experienced lower level of intershift recovery relative to their respective level of acute fatigue and chronic fatigue. Acute fatigue was moderately and positively correlated with chronic fatigue, and both were moderately and negatively correlated with levels of intershift recovery. Among the work-related activities done by participants during non-work time, work-related ruminations were relatively more common and most of them were associated with poorer level of fatigue and recovery. The strength of our study is in the multiple dependant variables that simultaneously cover aspects

of occupational fatigue and recovery, while the independent variables cover the rarely studied work-related activities during non-work time among doctors. However, this study findings cannot infer causation nor be generalised to non-doctor population. The use of self-reported questionnaires may raise issue of common-method bias despite the use of validated questionnaire to measure the dependant variables.

The moderate inter-correlations among acute fatigue, chronic fatigue and intershift recovery were in the expected direction. Previous studies also found similar results.<sup>6-51</sup> These are consistent with conceptualisation of fatigue and recovery which highlighted that acute fatigue may progress into chronic fatigue in the absence of sufficient recovery.<sup>1-6</sup> These findings are also in line with COR theory that outline opposite concept of fatigue (ie, energy-depleted or loss state) and recovery (ie, energy-rich or gain state),<sup>7-9</sup> and thus a negative correlation. In contrast, chronic fatigue is a consequence of accumulated unrecovered acute fatigue, and thus positive correlation.<sup>7-9</sup> Similar moderate strength of inter-correlation among them may suggest the equal importance of intershift recovery for both types of fatigue. Therefore, a study of fatigue among doctors should consider including both types of fatigue as well as recovery if one wants a holistic intervention on fatigue. Nevertheless, as previously noted, correlation does not imply causation.

Work-related ruminations generally exert mental effort and consume energy resources<sup>7-8</sup> that associated with poorer fatigue and recovery outcome. These are consistent with most of our findings on work-related ruminations. First, work-related rumination on being scolded or violated, which is not uncommon in healthcare setting,<sup>28-30</sup> may cause psychological injury which requires a longer time to recover.<sup>32</sup> Previous study found that those involved in workplace violence were more likely to have chronic fatigue.<sup>33</sup> Second, rumination on upcoming work may make it difficult to mentally disengage from work<sup>52</sup> with the accumulation of acute fatigue into chronic fatigue.<sup>5</sup> Alternatively, chronic fatigue may cause this rumination as it is associated with anxiety and low attentional control.<sup>53-55</sup> Third, rumination on unfinished tasks may cause difficulty in disengaging from work, and hence poor recovery.<sup>56</sup> Nevertheless, we found that rumination on patients/clients was associated with lower level of chronic fatigue, probably due to its positive nature<sup>57</sup> arising from successfully treated patients.<sup>58</sup> Contrariwise, it could be that those with chronic fatigue are less likely to ruminate on patients/clients as they are already in state of poor concentration and loss of motivation.

Task-related activities during non-work time, can happen at either home or workplace. In general, these types of activities exert physical and mental effort, and limits the time for recovery. However, all but one of our findings are opposite to this hypothesis. Doing work task at home was the only task-related activities that is associated with higher acute fatigue which probably causes failure to experience psychological detachment from work.<sup>22</sup> In contrast, doing work task at workplace during non-work time was associated with higher recovery, which probably contributed by non-permeation

of work-related demand into the home domain<sup>59</sup> and avoidance of rumination on the unfinished task at home.<sup>56 60 61</sup> Attending to work-related training during non-work time was also associated with higher recovery, which is possibly due to the benefit of knowledge gain that supports recovery through mastery experiences.<sup>62</sup> In addition, doing locum at health facilities was associated with better outcome of fatigue and/or recovery. These are probably due to the motivation-driven effort or reward of financial gain that provides resilience to energy loss from work-related exertion.<sup>63 64</sup> However, due to the cross-sectional design, it could be that those in a state of higher recovery or lower fatigue are those who are more likely to spend extra hour at work, attending work-related training or involve in a locum.

In terms of communication, we generally postulate that work-related conversation with partner generally enriches personal resources secondary to supportive social climate.<sup>8</sup> However, it was found that physical conversation with partner did associate with higher recovery but virtual conversation with partner was associated with poor outcome of fatigue and recovery. These differential outcomes could be due to the presence of other unexamined confounders.<sup>65</sup> Virtual means can be reached easily and immediately, thus fatigued doctors may likely express their work-related matter to their partners once finished their work such as during commuting home. Once at home, physical conversation with partner takes place in a more conducive environment that enhances recovery. However, this is just a speculation that require further study to look at the cause-effect relationship and examine other possible confounders.

Our study supports the growing concern about high levels of fatigue with low recovery among doctors, and the need to implement safe working hours legislation. However prescriptive traditional hour's rules have limited benefit<sup>66-68</sup> and do not alone effective hazard control.<sup>66 69 70</sup> Fatigue risk management system (FRMS) with multiple levels of controls allow greater flexibility<sup>66 71-73</sup> through organisational policies and procedures.<sup>66 74</sup> Therefore, we recommend a hybrid of prescriptive hours of service rule and FRMS health risk management approach<sup>66</sup> that is locally-tailored to target population. First, a prescriptive schedule design. We propose health managers to implement a buffer zone schedule system for doctors to finish the unfinished task at workplace to avoid from bringing it home. For example, doctors who work until 17:00 hours should only be allowed to be on formal duty until 16:00 hours. The remaining 1 hour buffer period should be spent on finishing the unfinished task at workplace. Second, a FRMS approach. It is a shared-responsibility approach that incorporates the risk assessment, mitigation, monitoring and review process.<sup>66</sup> The health managers should be responsible to tackle the negative work-related rumination such as rumination on being violated at workplace at their root causes by providing safe and healthy work environment.<sup>66</sup> In contrast, the doctors should be responsible for self-assessment of fatigue risk and disengage themselves from work during non-work time. They should also seek expert help in managing work-related rumination that is associated with poor outcome

of fatigue and recovery. Third, a written policy minimising the spillover of work-related demand into home domain should be developed. For instance, 'Right to Disconnect' law in France allow the workers to negotiate the conditions on the work after the working hours.<sup>75</sup> It provides flexibility for organisations to deal with communication and task-related activities during non-work according to the FRMS approach.

Future studies should consider longitudinal design to allow causal inference among fatigue, recovery and work-related activities during non-work time. A day-level study design should be considered to examine the day-level fluctuation of energy resources which denotes fatigue (energy loss) and recovery (energy gain). Finally, predictors or confounders at organisational and individual level such as use of work-related communication technology, motivation and rewards should be included in evidence to develop policy.

## CONCLUSION

Participants generally experience higher level of acute and chronic fatigue as compared with intershift recovery, which are moderately correlated with each other and are associated with multiple work-related activities during non-work time. Work-related ruminations during non-work time were common and mostly associated with poor fatigue and recovery outcomes while overt work activities done at workplace during non-work time were associated with better fatigue and recovery levels.

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