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Exploring of Offshore Medical Emergency Response System Challenges in Oil and Gas Environment

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Abstract

This paper explored the challenges present in the offshore medical emergency response (MER) system from the perspective of offshore medics by reflecting on their experiences in handling delays in emergency medical evacuation cases. We conducted qualitative interviews using the critical incident technique method. The participants recruited using the purposive sampling method comprise of 8 experienced offshore medics working on various types of oil and gas offshore facilities across the Malaysian Offshore. Data analysis was performed using qualitative content analysis. The in-depth individual interviews have resulted in the identification of 114 critical incidents for analysis. Seven themes emerged on MER system challenges including communication, decision making, facility layout, logistics problems, offshore medic responds, SOP and protocols as well as weather conditions. Decision-making was found to be one of the major challenges. The results suggest that the MER system needs to be revised in its current practice and we have proposed revisions to the industrial guidelines on response time tiers. This study has added a new understanding on the challenges found in the MER system from a different perspective.

Keywords: Abrasive blasting, Control measures, HIRARC, Pressure vessel fabrication plant, Risk assessment

1 Introduction

The necessity of the Medical Emergency Response (MER) system in reducing health, safety and environment risks in the offshore work environment has been highlighted. The offshore work environment is categorized as a high risk to the health, safety and environment of workers due to the nature of this environment as it is located at remote areas and has dynamically hazardous operations [1,2]. These mean that offshore workers do not have immediate access to healthcare facilities especially in medical emergencies while the risks of injury and illness are well known. Therefore, it is an expectation in the offshore oil and gas industry that each operation site should have a MER system in accordance to industry guidelines regardless of whether specific country legislation requirements exist [3,4]. However, having a MER system in place is futile without effective implementation.

Thus, the major players in the global oil and gas industry have continuously improved their MER system to ensure system effectiveness. The changing trends of injuries and illnesses, advances in medical treatment and delays in emergency medical evacuation (medevac) have urged the revision of the MER system for continuous improvement [5, 6, 7, 8]. The revision lead to the identification of challenges in implementing the MER system that were categorized as communication, personnel skills and competency, decision making, logistics problem, equipment and clinic facility; standard of procedure (SOP) and protocols.

Fig 1 illustrates the general MER system practiced by oil and gas companies operating in the Malaysian Offshore. Since the international oil and gas companies standardized their MER system across the world, the current MER system practiced in Malaysian Offshore is similar to the reported literature [5, 6]. The process of evacuating the injured/ill person (IP) in emergencies (medevac) is outlined by a tiered response time starting from the medical event occurring at an offshore facility until the IP arrives at a shore-based medical facility.

Delays in emergency medevacs from the standard expected response time remains a concern especially for companies operating in the Malaysian Offshore. The delay in medevacs not only reflects on the ineffective system in place, it also indirectly incurs high costs to the operations due to a possible decrease in survival rates as well as longer recovery times and high compensations. Even if studies on indirect cost are difficult to conduct, a few studies on the direct cost of medevacs have been reported. Based on cases that were collected retrospectively between 2008 and 2012 from 102 oil rigs and platforms operating in the US Gulf Coast, it was revealed that an average cost of 44,333 to 54,167USD has been charged by three different helicopter providers per medevac (2 to 3 hours flight) [8]. On the other hand, a total of 2.81 million in cost was involved for 2982 medevac cases that were recorded between 1989 and 1992 [9]. Of that total cost, musculoskeletal (1,251,020USD), respiratory (399,730USD) and injury (268,380USD) cases were the top three highest costs incurred by the company. It is expected that the higher costs will be revealed if indirect costs such as the replacement of the medevaced worker, lost man-hours and compensation were included in the calculation.

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The challenges of the MER system have been investigated from an administrative perspective, but little is known regarding the experience of offshore medics in MER system challenges when handling delayed emergency medevacs. As primary healthcare providers in the field, offshore medics are in a unique position in the MER system [3]. Hence, they are an important source of information in understanding the challenges of the MER system that leads to delays in medevac.

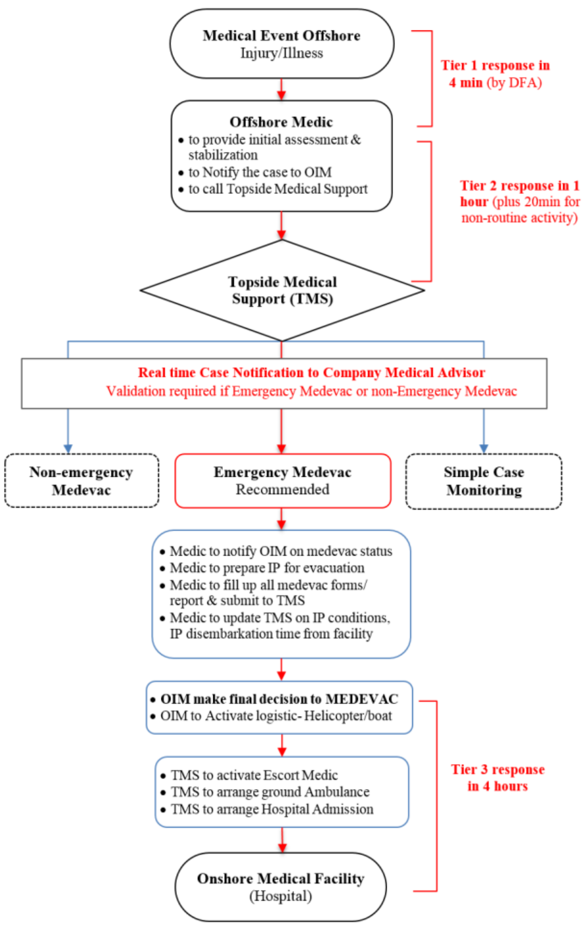

Fig. 1: MER System

This study aims to explore the challenges of the MER system from the perspective of offshore medics' through reflections of their experiences in handling delayed emergency medevac cases. We gained a new understanding of the MER system challenges from the study findings and it can be useful for improving the industry practice in MER system implementation.

2. Methodology

In this research, qualitative interviews were conducted using the critical incidence technique (CIT) to collect retrospective cases from experienced offshore medics. Since it was introduced in 1954, CIT is widely used in service research and health care especially to improve systems and solve practical problems [11, 12].The principle of CIT is to capture stories from the participants who have experienced or observed the events in search of the essence of the problems to be solved [13].

We used semi-structured questions to collect the critical incidents experienced by the participants. This will allow participants to provide information as detailed as possible. The limitation in semi-structured interviews is the difficulty to code the transcript, but this will able to reduce researcher bias [14]. We constructed the questions based on relevant literature and the researcher's experiences in the field.

To draw out the participant's focus and encourage them to express a detailed description of the topic, we asked questions as follows; 'In this interview, please assume that I am not an offshore medic and I do not know anything regarding your job. Think of recent emergency medevac cases in which you handled the case and it resulted in delayed evacuation.' Then we proceed by addressing the pre-constructed questions as follow:

1. Choose one of the cases and describe the event in as much detail as you can recall.
2. Based on this case, what are the complaints raised by the client or other related parties post-medevac, if any?
3. What are the other delayed emergency medevac cases within the past 3 years that you are willing to share? (Back to question 1).

Consequently, we asked careful probing questions to encourage the participants to express in-depth and recall the critical incident event but we did not ask leading questions. For example 'what time did the case happen?' and 'please describe more on...?' Yet, the participants were not asked to interpret the situation but only to tell the whole story.

2.1 Participants

We recruited the participants using a purposive sampling strategy. Offshore medics with at least three year working experience with experience in handling delayed emergency medevacs were considered to be eligible to participate in this study. The potential participants were extracted from email and telephone contacts known to the researcher. According to Burns et al.[15], participants in CIT studies are more willing to share information with people who are familiar with them compared to strangers. Then, we sent them an email of invitation with the inclusion and exclusion criteria. A returned signed consent form was considered as volunteering to participate in the study. The participants who volunteered were asked to choose the date, time and the preferred method of interview (telephone or face-to-face).

Eight offshore medics volunteered to participate in this study. The participants consisted of five medical assistants and three registered nurses, all of whom had diploma qualifications. All participants possessed valid skills-competency certificates in Advanced Cardiac Life Support and International Trauma Life Support as a standard work requirement. Three participants were working on production platforms, four on drilling rigs and one on the work barge. The maximum population on board (POB) for these facilities ranged between 60 and 148 (mean=106, mode=110). The participants were all male with ages ranging between 28 and 40 years old (mean=34). Additionally, the participants' working experiences as offshore medics were varied between 4 and 10 years (mean= 6).

2.2 Ethical Considerations

This study gained ethical approval from the Ministry of Health Malaysia, Medical Research and Ethics Committee. The participants involved in this study were informed regarding the purpose of the study and their confidentiality were assured. Cases were identified using code numbers (e.g., C5).

2.3 Data collection

The data collection was conducted between December 2015 and March 2016. We conducted 5 face-to-face interviews and 3 telephone interviews. The critical incidents we enquired about were the most recent and happened within the past 3 years. However, the accuracy of the critical incidents reported did not only depend on the time they happened but also depends on the level of detail in the information being offered [13]. In this study, the first author (ASH) who is a registered nurse and experienced offshore medic was the interviewer. The data collected were recorded using either an audio recording device or telephone call recorder application as well as note taking.

The interviews have resulted in a collection of 11 delayed emergency medevac cases that met the study criteria for analysis. The cases did not involve non-routine activities (e.g., confined space victim, man overboard) which add an extra 20 minutes response time for off shore medics. The information in Table 1 presents the case characteristics.

Table 1: Case characteristics

No.	Case Types	Type of Facility	Offshore Location
1	Heart	Drilling	Kerteh
2	Heart	Platform	Miri
3	Neurology	Platform	Kota Kinabalu
4	Neurology	Drilling	Kerteh
5	Injury	Drilling	Miri
6	Injury	Work barge	Kuala Terengganu
7	Heart	Drilling	Kota Kinabalu
8	Injury	Drilling	Kerteh
9	Injury	Platform	Kerteh
10	Injury	Drilling barge	Bintulu
11	Injury	Drilling	Labuan

The 11 cases are classified into 5 medical emergency cases and 6 injury cases. To maintain confidentiality, the information provided in Table 1 is purposely organized without synchronizing the information between the different columns. The cases that had happened at various offshore locations are representative enough of the Malaysian offshore in which the oil and gas exploitation activities are being carried out.

During the interview session, we showed the participants the general MER system in Fig 1. Then, they were required to reflect whether they are practicing a similar MER system. All participants confirmed that the general MER system is similar to their current practice. This initial finding has established two points. First, it confirms that the current MER system practiced in Malaysian offshore is primarily identified from literature. Second, it can reduce bias in analysing data collected from participants as differences in the MER system practiced can offer alternative explanations on the critical events being investigated.

2.4 Data Analysis

We conducted data analysis using a conventional content analysis approach [16]. Initially, we determined that the unit of analysis is the critical incident itself. In this study, critical incident means any event or combination of events that contributes to the delay in emergency medevac. This is appropriate in keeping with the current concept of risk management as placing emphasis on shared responsibilities towards improvement instead of the culture of blame [17]. Therefore, it is believed that multi-factors instead of a single factor contribute to the occurrence of any incident.

Next, the interview transcripts were read through repeatedly to get a sense of the whole data with an open mind. Then, the critical incidents that are the units of analysis were selected from the interview transcripts to be included for analysis. To do that, the first author (ASH) independently coded the interview transcripts by repeated and careful reading. Finally, 114 critical incidents were found for analysis. Examples of data analysis are illustrated in Table 2. After completing the coding process, the first author reviews the existing codes to reflect on the developing ideas.

Table 2: Example of data analysis

Critical Incident	Code	Category	Theme
At 1500 hours, almost 2 hours from the case starts, I asked OIM regarding the status of medevac. So, waiting for medevac confirmation from town. They still not giving the confirmation yet. (C4)	Delay client decision	Stakeholders decision	Decision making

Subsequently, the data analysis proceeds by sorting the 114 critical incidents into sub-categories and categories, which constitute the manifest content. This was done by comparing the critical incidents based on differences and similarities. At this point, both authors (ASH, RM) revised the tentative categories before the confirmed categories were sorted into themes. We used NVivo 10 software to aid the data analysis process and facilitate in tracking the original data.

Finally, we conducted a second round of interviews with the participants to validate the relevancy of tentative categories and themes generated from interview transcripts on the first interview. This was done by randomly selecting 3 participants from the first interview. The participants agreed on the accuracy of the information provided from the first interview and the critical incidents identified by the researcher. Furthermore, they did not find any missing information and did not offer additional information. Lastly, the participants agreed on the relevancy of the critical incidents categorization and themes emerged which represented their experiences. Therefore, no amendments were required after the second interview.

3 Results and Discussion

The MER system challenges experienced by offshore medics elicited through reflections on their experience in handling delayed emergency medevac cases were developed into seven themes. The themes were communication, decision making, facility layout, logistics problem, medic response, SOP and Protocols; and weather conditions.

The case rate was calculated and we used a rate of 25percent to determine the significant themes as previously recommended [17]. The rate was calculated by identifying the total number of cases citing the particular theme, and then it was divided with the total number of cases. Based on case rates in Table 3, it was revealed that six themes are significant except for the theme 'weather condition'. The model of MER system challenges was developed and illustrated in Fig 2.

Table 3: MER system Challenges Themes, Case Rates and Critical Incidents

MER System Challenges Themes	N of Cases	Case Rates %*	N of Critical Incidents
Communication	5	45.5	18
Decision Making	11	100	33
Facility Layout	4	36.4	9
Logistics Problem	9	81.8	26
Offshore Medic Responds	6	54.5	10
SOP and Protocols	5	45.5	14
Weather Condition	2	18.2	4
	Total Critical Incidents		114

*Significant rates at 25%

3.1 Communication

The communication theme covers all critical incidents related to instructions, changes, telephone, email, and radio and communication system. When there were changes in the MER system, the changes were ineffectively communicated or not communicated before the emergency medical event happened. The changes were only informed when the event happened, right at the moment when the medics were handling the case. One of the participants reflected.

'*After I called topside, then company man [operator company representative] came. He said I have to call Clinic Y… By right, I don't have to call Clinic Y according to MERP*.' (C8)

Another communication issue was inappropriate instructions. Critical incidents include, when there were unnecessary and irrelevant instructions given, resulting in the delay of the emergency response. In one occasion, the offshore medics received inappropriate instructions from the onsite supervisors. For example, the OIM asked the medic to expose the injured limb after it was treated. That meant that the procedure to had to be repeated, to re-dress the injured limb while the offshore medic was supposed to communicate with Topside Medical Support (TMS) and prepare the paperwork. One of the participants described:

'*After I have completed the dressing, then only OIM [offshore installation manager] and safety officer came. They insist want to see the wound. What a nonsense work like that. They want me to remove the dressing…I told them that I have took the photos and they can look at it. Nope, they still want to see the wound. So, I remove it.*' (C9)

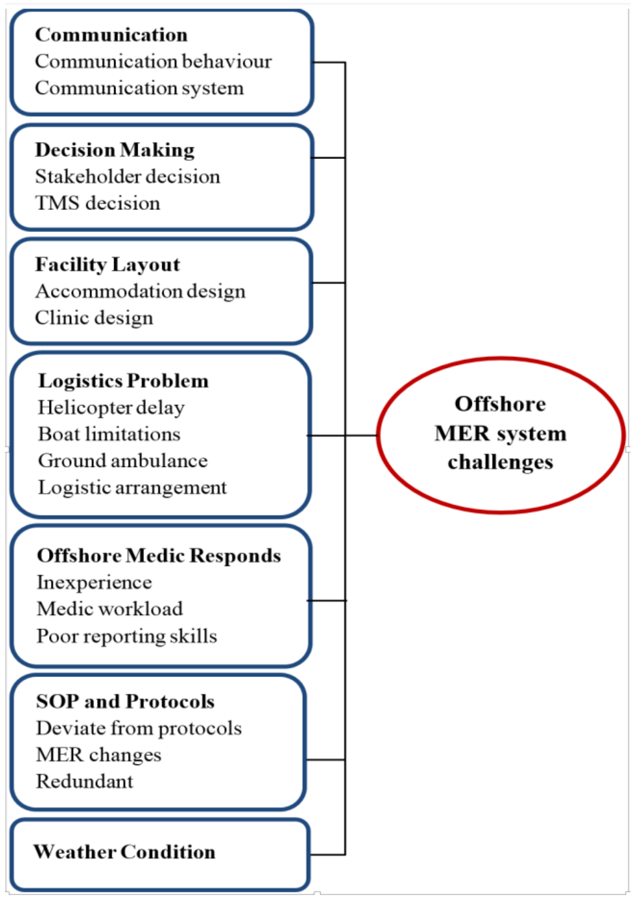

Fig. 2: MER system challenges model

Additionally, there were times when the communication system at the facility failed entirely or the telephone connection was interrupted during conversation with TMS. However, critical incidents involving communication systems in this study only happened on mobile offshore facilities such as drilling rigs and barges. One of the participants reflected:

'*Half way conversation with topside, the line broken…Again the line was unclear and broken*.' (C6)

3.2 Decision making

Decision making forms the major theme in offshore MER system challenges. Critical incidents in this theme were found in all 11 cases (100% case rate). The theme was divided into two main categories; stakeholders' decision and TMS decision.

The stakeholders' decision category emerged from cases that revealed factors such as avoiding recordable cases, bureaucracy, confirmation time and IP employment category; that has delayed the final decision time in activating the emergency medevac. Stakeholders consist of the operator companies, contractor companies and the IP's employer. Especially when the emergency medical event involved workers who were on duty, the stakeholders were careful in making the decision to approve the treatment and emergency medevac decision made by TMS. The bureaucracy was demonstrated when multiple stages of confirmation are required to activate the emergency medevac. For example, in the drilling facility case, once the TMS doctor has made a decision, it needs to be confirmed by the client medical advisor (drilling contractor company), rig manager, OIM and company man.

The stakeholders' decisions were influenced by the IP employment status as well. The status of the IP who are contractor employees or employees in lower positions might negatively affect the stakeholders' decision-making time. According to one of the participating offshore medics:

'*Moreover, he is floor man. Not important position, though. So they took it for granted*.' (C10)

Furthermore, TMS was found uncertain in making decisions for emergency medevacs. The medical information provided by offshore medics was repeatedly requested. Additionally, the TMS doctor asked to provide more information even though it was not essential information needed to determine the emergency status. With the time running, the offshore medic was trying to convince the TMS on the emergency of the situation. On the other hand, the TMS asks the offshore medics to wait for their feedback while the case is discussed with the medical specialist team. One of the participants reflected:

'*The next day early in the morning around 0730H, I update the Topside doctor with all the information required. Heart rate is still high around 130/minutes. I spoke with another doctor again and after waiting for quite sometimes, they only decided at 1120H …. It takes almost 4 hours.*' (C2)

The offshore medics viewed the TMS doctor's decision as not the ultimate decision but one that is influenced by the stakeholders. The TMS needs to inform, discuss and seek agreement with the stakeholders, specifically the client's medical advisor and facility manager for the decision to be made. Therefore, the decision that is made is based on business interests superseding the medical perspective. While the offshore medic is handling the IP at the facility clinic, extensive discussions are going on to reach a final decision.

3.3 Facility layout

The offshore facility clinic is located at a distance from the helideck. Whilst the clinic is commonly located at the deck (lower) level, the helideck is located on the top (3 to 4 levels from the clinic) of the accommodation. Critical incidents were considered to have occurred when time was consumed when deciding on the best way of transporting the IP from the clinic to helideck. The risks of carrying the IP on a stretcher while climbing the multi-level narrow stairways up to the helideck were deliberated. When a decision was made to use a crane to transport the IP, a work permit needed be issued with a careful plan to execute the task safely.

The limited facilities at the offshore clinic impose challenges for offshore medics to respond to medical emergencies in an efficient manner. Described as congested with clinic items and equipment, the medics had trouble moving and allocating equipment even at the best-organized clinics. Some of the clinics were set up by separating the sick bay with the clinic's administrative facilities. In this situation, the medic needed to leave the IP to complete paperwork in the room next door which surely consumed time. One of the participants described:

'*The sickbay and office is separate. After attending to the patient, I have to leave for paperwork in the next room. Definitely not in the same room. That's the problem*.' (C1)

3.4 Logistics problems

Logistics problems form the second largest theme (81.8% case rate). The logistic coordination is outsourced to agent companies and therefore, it depends on the capacity of the agent company to respond to emergency medevac cases. There were delays in logistics arrangements which were considered as critical incidents. This was determined by the timeline provided from participants' accounts or directly mentioned by the participants. One of the participants reflected on the case:

'*At around 1630 hours, which is ETD [expected time departure] on earlier plan, received call from medevac team. They update new ETD time around 1730 hours*.' (C4)

In this theme, helicopter delays are the most frequent critical incidents identified (n=13). It means that the helicopter did not arrive to the offshore facility according to its expected time of arrival. The delays ranged from several hours to almost 24 hours. Additionally, when the helicopter transporting the IP arrived at the helibase, there were occasions when there was no ground transportation arranged to transport the IP to the hospital. Conversely, boat limitations in high wave conditions delayed the arrangement of emergency medevac for facilities that use boats as primary transportation. This is because the IP was unable to be transferred from the facility onto the boat safely.

3.5 Offshore medic response

The critical incidents in this theme were categorized into inexperience, workload and poor reporting skills. Offshore medics were inexperienced in managing emergency cases in an offshore environment. This had hindered prompt decision making and lead to discussions with the facility supervisor on the best action appropriate for handling the IP. One of the participants reflected:

'*I discussed with OIM on how to transport the IP from clinic to helideck. At last, we decided to transport the IP using crane to helideck, using transfer basket with stretcher.*' (C5)

Next, offshore medics have a heavy workload to complete within a short period and thus fail to achieve tier 2 response times. One of the participants described:

'I took 2 hours before I called topside because I need to take full history. I need to do ECG as well and the documentation took quite sometimes. There were forms to fill up before I get it scanned and emailed it to topside.' (C2)

The critical incidents did not only happen when the targeted response time was not achieved, but were also considered to have happened when unnecessary tasks or interferences were introduced from the start of the medical event until the IP left the facility. This is because if the offshore medic delays in providing ongoing feedback to the TMS doctor, there will be delays in other responses. For example, the helibase personnel will call the medic to provide updates on logistic arrangements. In this situation, they should be aware that communications on logistics should occur between the helibase personnel and the facility's radio operator.

Another issue is that offshore medics demonstrate poor reporting skills when escalating the case to TMS especially when the photos provided to topside did not represent the actual IP's condition. It leads to arguments and finally, the medic needs to repeat the same process (taking photos, transferring it onto computer and email) to allow the TMS to make the right decision.

3.6 SOP and protocols

There were three issues emerging from the data regarding SOP and protocols. Firstly, there is a redundancy in SOP. This became apparent when offshore medics needed to carry out the same flow of procedure or part of the procedure repetitively, involving separate SOPs being used by the operator company and the main contractor company. This situation creates a dilemma for the offshore medic to either attend to the IP's medical emergency needs or to carry out repetitive tasks to satisfy both companies requirement within a limited period of time. One of the participants expressed it as follows:

'*I am managing the heart case and suddenly I have to inform another party. I took time to call the operator company… seems like repeating the same task. What Ihave reported to topside, needs to be reported to operator company doctor too. Meaning it wasted of time at this point*.' (C7)

Secondly, there were recent changes in the MER procedures prior to the medical event occurring. It was revealed that the changes were either not documented yet or all key personnel were in the process of understanding the new written changes when the emergency medical event happened. Lastly, when the management decided to deviate from protocol, the alternative decision was contemplated from every aspect. It shows that a deviation from protocol would consume more time in coming to a final decision.

3.7 Weather conditions

Weather conditions only appeared in two cases thus it is not a significant theme based on case rates (18.2%). Bad weather was mentioned when medical emergency events happened and it affected the emergency medevac response. Because of bad weather, there were changes in the logistics arrangements for evacuation transportation. For example, the helicopter was activated when the boat was not appropriate and vice versa. Moreover, communication systems failed in bad weather but the medics claim that it seldom happened.

4 Discussion

This study explores the MER system challenges from the offshore medic perspective through their experiences in handling delayed emergency medevac cases. The model of MER system challenges in Fig 2 was developed to enhance our understanding of the phenomena under study.

The strengths and limitations of this study should be considered. This study was conducted through independent academic research from the university without preserving any company's interest, which could have been a source of bias. Next, this study explores the challenges of the MER system from the offshore medic's perspectives which have never been investigated before. Thus, it brings a new understanding to the complex phenomena of which little is known. Moreover, the fact that this study was conducted by experienced researchers in the field who are familiar with the nature of offshore medical services helped in the analysis of data that required a deeper understanding of the participant accounts.

Even though researcher familiarity in the field helps in data analysis, the familiarity may also have introduced bias in data analysis as the researchers may have preconceived ideas. This might affect the credibility of the findings. However, the second round of interviews that were conducted to get the participants' confirmation may have reduced the elements of researcher bias. Also, the small sample size in this study may affect the trustworthiness of the findings. Therefore, the MER system challenges model developed in this study is immature. Further study is required to confirm the findings using a larger sample size with a comprehensive list of critical incidents to achieve data saturation. However, it can be argued that having more critical incidents is not likely to add new important themes to the current themes about MER system challenges in this study.

Whilst Ponsonby et al. [6] found personnel skills and competency to be the major MER system challenges, our study found decision making to be the major challenge. This difference may be caused by continuous improvements of the system over time. The results of this study regarding decision making are similar to Singh's [8] report. However, the report is only limited to the topside decision, which were delayed and not always conclusive. Even though aspects of the TMS doctor's decision making were identified in our study, the stakeholders' decision making is the major challenge identified.

In oil and gas industry, companies are competing based on performance indicators that aims for zero recordable injury/illness for their operations [19]. Although the management of occupational injury/illness today is more advanced and comprehensive than before [20], the negative effects of having zero recorded injury/illness as a goal cannot be denied when recordable injury/illness are under reported to maintain the clean records of companies [21]. Therefore, it is logical in the current context for this study to find that stakeholders delay decision making to avoid recordable cases.

The communication challenges identified in this study were consistent with the reported literature. The similar aspects of our findings were on communication system interruptions and failure during emergency medevac arrangement [3,5]. However, this study uncovered the communication behaviour category as a new aspect of communication challenges that consists of inappropriate instructions and ineffective communicating changes.

Although logistics problems found in this study are consistent with the previous studies, all studies address different aspects of the problem. The early studies highlighted the ineffective logistics coordination specifically on helicopter activations [7] and the later studies revealed the inappropriate ground transportation used [6]. Unexpectedly, this study uncovered a wide range of logistics problem not only pertaining to coordination but also including air, sea, and ground transportation. Another unexpected finding is the MER challenge about facility layout that involves clinic design and accommodation design which have not been reported in previous literature.

The findings of this study on medic response are similar to the personnel skills and competencies issues in previous studies. However, previous studies merely revealed the inadequacy of personnel's medical skills and competencies both to meet the basic requirements and increasing demands of advanced treatment [6, 7]. Conversely, the offshore medic response theme in our study was developed from the inexperience, reporting skills and workload categories.

The SOP and protocols theme found in this study is similar with the Sande [7] report but involves a different aspect. In the Sande report [7], the challenges mainly involved SOP and protocols that were unclear and no standardized across the company operations facility. Conversely, the findings of our study uncovered the redundancy of SOP and protocols, deviation from protocols and MER system changes. Surprisingly, MER system challenges about equipment and clinic facilities did not emerge from the data analysed in our study. It may be possible that the challenges have been adequately addressed following the maturity of the MER system currently practiced.

In brief, most the findings in this study are supported by previous literature even though there are certain differences in the aspects of MER system challenges within the same factors. Nevertheless, this study has added facility layout as a new factor for MER system challenges. Finally, the findings that lack literature support indicate that our study has discovered new aspects of the challenges in the MER system as a result of using different research approaches and contexts.

4.1 Implications for practice

The findings of this study in the form of MER system challenges model offers implications that can be categorized into two parts. There are implications for the oil and gas industry managers and Health, Safety & Environment (HSE) personnel; as well as implications on industrial guidelines on tier response time. Firstly, it is important for industry managers and HSE personnel to understand the nature of MER system challenges found in our study. Obviously, all the six significant factors of MER system challenges that were found are controllable. Furthermore, the delays in emergency medevac cases investigated in our study were caused by multiple factors that are interrelated. Therefore, it suggests that the managers and HSE personnel need to revise the existing MER system and take the necessary actions for system improvement (refer Table 4). On the other hand, the MER system challenges factors identified can be included for consideration to develop a MER system for a new project. This can ensure that the MER system in place is effective in reducing health and safety risks.

The second implication for practice is on the industrial guidelines regarding tier response times. Table 5 compares the tier response times reported across oils and gas industry. Generally, the tier response time was set from the start of medical event until the IP reached the tertiary medical facility. However, when applying this tier response time to the MER system, there is a gap in the time for decision making.

Table 4: Implications to oil and gas industry managers and HSE personnel

MER system challenges	Implication to managers and HSE personnel
Communication	Assess communication system reliability to find the root causes and best solutions that balance the cost-benefits of the operations. Consider the potential to use advanced telemedicine technology system with cost-benefit assessment.
Decision making Communication behaviour SOP and protocols	Managers and HSE personnel should incorporate the management of change (MOC) when managing the MER system that incorporate points below: ▪ Reduce numbers of decision maker personnel for medevac ▪ Reduce bureaucracy ▪ Ensure effective & efficient communication of changes ▪ Manage changes in MER system effectively
Logistics problems	Need to assess the current logistics resources, capability and coordination system that may cause delays in medevac. Consider area based cooperation [20]
Facility design	Revise risks assessment on accommodation design Consider to redesign the facility if appropriate to meet the industry standard: ▪ Clinic size >5x7m for POB >100, [23] ▪ Escape route width for stretcher 48in.[24]
Offshore medic responds	Ensure the effectiveness of the existing system such as continuous learning, offshore induction programme and onsite specific facility orientation. Need to revise paperwork required for medevac that may contribute to workload and delaying response. However, any efforts to reduce or simplify the paperwork should not jeopardise the legislation requirements.

Table 5: Tier response time comparison

Tier Response Description	OGP Guideline [26]	Shell International[6]	BP Company [25]
Bystander	-	Tier 0 (immediate)	-
First Aider/ Responder	Tier 1 (4min)	Tier 1 (4min)	Tier 0 (4min)
Advanced First Aider	Tier 2 (20min)	-	Tier 1 (10min)
Offshore Medic, Site clinic, Medevac preparation	Tier 3 (1hour)	Tier 2 (1hour)	Tier 2 (1hour)
Evacuation to shore/ admission to local hospital	Tier 4 (6hour), secondary and tertiary	Tier 3 (4hour)	Tier 3 (6hour)
Specialist medical care/ Tertiary medical facility	Tier 4	Tier 4 (varied)	Tier 3

While the results of our study indicate that decision making is the major challenge of an effective MER system implementation, it also gives a sense that the existing tier response times need to be revised. Indeed, it was suggested that another tier response time needs to be added for decision making. Referring to the Oil and Gas Producer (OGP) guidelines [26], the tier response time for decision making should be added between Tier 3 and 4. Fig 3 illustrates the proposed additional tier response times when it is applied to the MER system practiced in the Malaysian offshore. However, it is beyond the scope of our study to determine the duration of decision making tier response times. Further study should be conducted to address the appropriate maximum decision making time in the MER system.

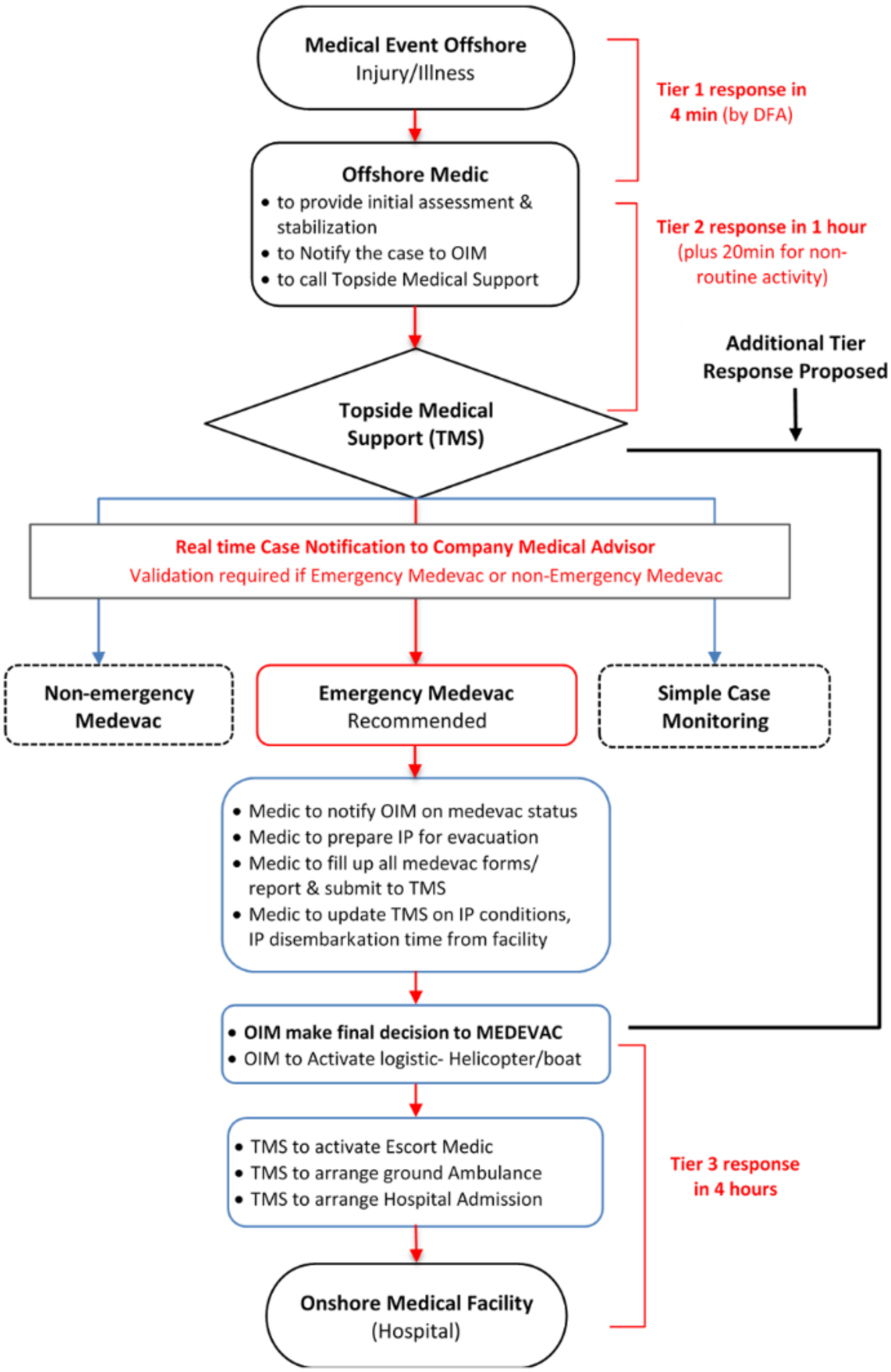

Fig. 3: Proposed offshore MER system revision

Although some might argue that the need to add a tier response time for decision making is trivial, we justified its practicality on the basis of the MER system challenges revealed by first-hand experiences in the field. By having tier response time for decision making, the gap in the MER system that was previously unmeasured can now be monitored. The principle is clear as what has been emphasized is that "you cannot manage what you cannot measure" [27]. Moreover, the key personnel in the MER system who are involved in decision making will take responsibility to act promptly according to what is appropriate to the situations need. Thus, the proposition to add another tier response time in industry guidelines has a strong basis and it should be seriously considered by the industry.

5 Conclusion

In short, we have identified the MER system challenges from the offshore medic perspective in this study. Six significant challenges are identified including decision making, communication, facility layout, logistics problems, offshore medic response as well as SOP and protocols. Yet, decision making is the major MER system challenge that was identified. We developed the MER system challenges model to facilitate a better understanding of the phenomena under study. Considered as a modest theoretical contribution to the field, further study is required to validate the model. The findings of our study imply that it is important for oil and gas industry managers and HSE personnel to revise their MER systems that are in place and make necessary improvement to ensure that the health and safety risks are controlled as low as reasonably practicable. Additionally, we proposed to revise the MER system industrial guidelines specifically on the existing tier response times and added a new tier response time for decision making. Finally, this study has added a new understanding of MER system challenges from a different perspective that was previously unexplored. It also demonstrated that using CIT, we are able to uncover practical problems in complex systems for the purposes of improvement.

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Ethical issue

Authors are aware of, and comply with, best practice in publication ethics specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that submitted work is original and has not been published elsewhere in any language.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses and manuscript writing

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