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Prevention of Infectious Diseases during Military Deployments: A Review of the UAE Armed Forces Experience

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ABSTRACT **Published Online: 01 May, 2023**

The UAE Armed Forces involved in many missions that range from major combat operations to humanitarian relief efforts. Military medical professional accompanied deployed military troops is responsible for disease prevention, which can be made more difficult in the situation of short preparation times and prolonged deployment duration. The military medical professional must use deployment medicine in protecting military personnel from infectious and tropical diseases in operation theatre. This review emphasizes the importance of preparation, health education, personal protective measures, vaccines, chemoprophylaxis, and surveillance in an attempt to prevent infectious diseases. This review gives a summary of experiences of preventive medicine for UAE Medical Corps during deployment in many countries.

INTRODUCTION

United Arab Emirates Armed Forces participated in many overseas operation including Kuwait liberation 'Operation Desert Storm' (Gulf war, 1990) [1], peacekeeping in Kosovo conflict (1998) [2, 3], support reconstruction in Afghanistan with coalition with US Armed Forces (2003) [4], security enforcing in Bahrain (2011) [5], Yemen Restoring Hope operation (2014) [6]. Also, UAE Armed Forces with the cooperation of UAE Red Crescent participated in humanitarian missions including Pakistan earthquake (2005) [7, 8], and Yemen flood (2008) [4].

UAE soldiers deployed in some countries (e.g. Afghanistan, Yemen) that are characterized by spreading of communicable diseases, broken healthcare system, unsafe water supply, insufficient food supply [9,10,11]. These factors work as stressors in addition to hostile war circumstances. Soldiers are exposed to many infectious diseases through human contact with local population and environment. In this review, the author discusses the primary goal of military professionals which is disease prevention during military deployment especially infectious diseases.

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MILITARY DEPLOYMENT AND INFECTIONS

Military deployment is referred to all activities to move military personals, military vehicles, weapons and material from home installation to specific destination [12]. During Deployment, healthcare professionals in deployed unit aim to provide health care and effectively return patients to full duty as quickly as possible.

Many deployment environmental stressors can be identified, assessed, and control before deployment. These stressors are usually classified to physical (temperature, altitude, noise, and radiation), chemical (food, water, and occupational and environmental contaminants), and biological stressors (food, water, and vector-borne disease) [13].

Communicable diseases are most threatening hazards for deployed military personnel. Historically, infectious diseases affect military troops and can result in cancellation of military operations [14]. For example, at the Battle of the Gravelines in 1588, the Spanish Armada was weakened by outbreaks of dysentery and then typhus, which probably contributed to their defeat against English Navy [15]. Most common infectious disease in deployment troops is diarrhea. Among US military personnel deployed to Iraq and Afghanistan, diarrhea was commonly reported (72.4% of respondents had at least one diarrhea episode during their deployment) [9]. Also, an acute diarrhea-deployment overall incidence of 25.2 episodes per 100 person-months [16]. There is no study about reporting diarrhea among UAE military troops, but many

military physicians had noticed that diarrhea more during first months of deployment.

Vector-borne diseases (malaria, dengue fever, scabies or leishmaniasis) remain a huge problem for military personnel during deployment and post-deployment. UAE military medical corps (public health section) invested in prevention measures and chemoprophylaxis especially malaria. These tropical diseases can affect the military troops capacity and readiness to accomplish their mission in a hostile environment.

In Afghanistan, 56 malaria cases had been diagnosed among US Army soldiers [17]. Another US Army study that had been done on Afghanistan calculates malaria (Plasmodium vivax) attack rate. observed malaria attack rate was 52.4 cases per 1000 soldiers, with the diagnosis made 1–339 days (median, 233 days) post-deployment [18]. Recently, Yemen conflict, UAE Medical Corps help UAE Armed Forces by providing medical care and fighting against cholera, malaria and dengue fever which were widespread in many Yemeni cities. World Health Organization recent malaria report for Yemen (2015) found that the overall prevalence of malaria was 22.2% with Plasmodium falciparum as the predominant species (100%) [19]. Also, we found that number of P. falciparum cases had been decreased from 109504 case (2012) which was before the conflict to 68682 case (2015) which was during the war [19]. This could be for the unrecognized efforts that have been done by UAE Red Crescent and other humanitarian organization in restoring basic needs for Yemeni people.

Dengue fever is another challenge for military troops in the endemic area. Moreover, infected military personnel can introduce dengue viruses from endemic countries (e.g. Yemen) to non-endemic areas (UAE). A study had been done in Japan show that dengue viruses can be imported by visitors to Japan with the present of vectors (Aedes. aegypti or Aedes. albopictus mosquitoes) in Japan environment [20]. Even mosquitoes (Aedes. albopictus) can be imported from another country to UAE environment. This scenario happened on California 2001 where vector (Aedes albopictus mosquito) invaded to the environment through imported "lucky bamboo" from Asia and dengue virus had been imported by Mexican immigrants [21, 22]. During Yemen conflict, few cases had been reported on Zayed Military Hospital [23]. If one of these cases can transmit the virus to an eligible vector (Aedes. albopictus), it will spread the infection to the community in UAE. UAE Red Crescent help Yemeni government during Yemen restoring hope operation to fight dengue infection and malaria through mosquito fogging and water management.

Moreover, According to Dr. Albedwawi, few cases of leishmaniasis had been reported on UAE soldiers during Yemen War [23]. Despite the extensive effort by US military in prevention vector-borne diseases, visceral and cutaneous leishmaniasis have been observed during major combat operations (Operation Enduring Freedom in Afghanistan and Operation Iraqi Freedom in Iraq) [24]. US military policy instructs the person who received a diagnosis of any type of leishmaniasis that he/she is not eligible to donate blood [25]. This policy will affect critically military troops because each person had been considered as blood donator during operation.

PREPARATION

During pre-deployment period, a military physician needs to prepare for the expected infectious diseases that likely will affect deployed military personnel [26]. He/she should know about the deployment type, duration, and location, and time available for planning. Sometime, we can't have all of this information due to mission situation, but a deployed medical professional must know the health hazards in operation combat area especially infectious diseases. A number of websites can be used for assessing deployment specific infectious diseases risks, see Table 1.

Table 1.1 Websites used for assessing deployment-specific infectious disease risks.

Site	URL
World Health Organization	http://www.who.int/
Centers for Disease Control and Prevention (CDC)- Travellers' Health	https://wwwnc.cdc.gov/travel
CDC Pink Book: Epidemiology and Prevention of Vaccine-Preventable Diseases	https://www.cdc.gov/vaccines/pubs/pinkbook/index.html

In addition to these online sources of information, the department of public health of the UAE Medical Corps has a written guidelines regarding pre-deployment and health risks during deployment. Unfortunately, UAE medical crops don't have an online medical information database for epidemiology and public health. If we develop an online medical database, it will give up-to-date information for UAE military physicians and nurses and a secured emails. The

military physician applies traditional travel medicine recommendations as a guide to prepare plans for the deployment. Moreover, many tropical diseases having seasonal variations with an increased level of transmission during the rainy season (e.g. malaria and dengue) [19, 27]. Some combat operations had been postponed due to tropical disease outbreaks. Medical preparation for military mission consists of medical fitness, immunization, chemoprophylaxis, DNA testing and health education.

Pre-Deployment Medical Examination

All UAE military personnel undergo a mandatory pre-deployment medical examination which can be done at recruitment health clinics. Unfortunately, the pre-deployment medical fitness standards are much similar to military enlistment medical fitness standards [28]. However, these standards can disqualify many individuals with important experiences who can be necessary for succeeding in the operational theatre. Sometimes, some commanders ignore the pre-deployment medical examination in order to push more experts in the deployment area. Also, some minor conditions are not of such severity as to be likely to interfere with a soldier's ability to perform military duties in the deployment area.

We searched for evidence around how this examination is effective or not effective on the deployment environment. Gubata et al, found no difference in length of deployment of 18,093 U.S. service members medically waived compared to non-waived in length of deployment from 2001 to 2011 [29]. Moreover, Royal Netherlands Army compared between Basic Medical Requirements (BMEKL) fitness test which ranks military personnel to grades according to workload-capability and classical American fitness test (PULHEEMS) which grade military personnel to fit or unfit according to their medical condition. It appeared that members of BMEKL "workload-capability" group had better performances (multiple linear regression analysis and $P<0.01$) [30].

NATO developed a medical deployment guide for 31 specific diseases/conditions using a rational, standardized and algorithmic approach based on a red–yellow–green risk stratification (high risk-moderate risk-low risk).[31] This standard aim to decrease the number of military individuals being deployed with pre-existing medical conditions that have a high likelihood of exacerbation of their chronic diseases. This guideline had been developed by military physicians from all countries in NATO. Also, it had been built by experts opinion instead of evidence-based or observation studies of deployed soldiers.

Ideally, we need to study the outcomes of soldiers deployed with various pre-existing chronic diseases. This will require more field researches for pre-deployment assessments and associations with relevant outcomes such as in-theatre morbidity, medical evacuation, and length of deployment period.

Immunization

All children (local and non-local) are receiving free immunization program in first three years of their life's [32]. These vaccinations are compulsory for all children in UAE before entering kindergarten. Moreover, children during their school's years until grade 11 receive several vaccinations and boosters [33]. Although the UAE preschool and school immunization program are very strict, there are failures in achieving positive serological immunity for some vaccinations. Al-Mekaini and colleagues found that seroprevalence rate of Al-Ain's children for mumps was 82.8%, for varicella was 68.3%, for diphtheria was 86.4%, for tetanus was 89.9%, for Haemophilus influenza type B was 84.1% and pertussis for 39.2%.[34]

Pre-deployment vaccination programs have significantly reduced the incidence of vaccine-preventable infections. Vaccinations are mandatory for UAE military personals before 1-2 month for deployment which can be given in public health sections in Zayed Military Hospital-Abu Dhabi (ZMH) and Zayed Military Hospital-Bateyeh (BMH). The public health professional shouldn't depend only on soldiers' previous school immunization card and investigates them for serological immunity for common vaccine-preventable diseases (hepatitis B, diphtheria, tetanus, polio, pertussis, measles, mumps, and rubella). After that, military personnel must receive vaccinations and boosters according to his/her results of serological immunity. Moreover, soldiers will receive other vaccinations (meningococcal, hepatitis A, typhoid fever, yellow fever) depend on deployment location. In addition, soldiers will receive annual influenza vaccine regardless the deployment location.

Table 1.2

UAE Military Pre-Deployment Vaccinations.*	Schedule
Tetanus	Single dose + every 10 years
Diphtheria	Single dose
Pertussis	Every 10 years
Measles	Single dose**

Mumps	Single dose**
Rubella	Single dose**
Influenza	Annual
Meningococcus	Single dose
Polio	Single dose*
Varicella	Two doses**
Hepatitis A	Two doses
Hepatitis B	Three dose series**
Anthrax	Multi-dose series***
Smallpox	Single dose***
Typhoid	Single dose every 2 years
Yellow fever	Single dose every 10 years***
Cholera	Two doses (1-6 weeks apart)
Rabies	Three dose series***
* Depend on deployment location ** Based on results of serologic screening *** Special forces or risk for biohazards	

Although the mandatory of pre-deployment vaccinations, there is low coverage among military unit due to lack awareness and safety concerns. Al-Khashan and colleagues had found that low vaccination coverage among Saudi military personnel in Riyadh (meningitis 51.7% compared with influenza 17.8%) [35]. Also, US Forces had sub-optimal pre-deployment vaccination coverage (89.3%) due to public attitudes toward immunization programs [36, 37]. Many people afraid of vaccine components and serious side effects. Some of UAE military personnel have same concerns but we didn't find any published study investigated these concerns.

Typhoid vaccination plays an important role in preventing enteric infections among military personnel especially in circumstances with lack of clean water and proper sanitation in developing countries. A recent Cochrane review found that both lived and non-lived typhoid vaccination is effective in preventing typhoid and paratyphoid infections (the estimated 2.5–3.0 year cumulative efficacy was 55% for the parenteral Vi polysaccharide vaccine and 48% for the oral Ty21a vaccine) [38]. Usually, UAE military personnel will receive a shot of parental Vi polysaccharide vaccine in pre-deployment phase. We prefer this vaccine because it is a single dose and the oral active vaccine are 4 doses which are administered in 4 doses on alternating days over 1 week [39]. This intramuscular vaccine is practical for military soldiers when the compliance to an oral vaccine is not possible.

UAE military hospitals offer oral inactivated cholera vaccines (Dukoral) for military personnel who are traveling to an area of active cholera transmission (recently Yemen). Dukoral offers incomplete protection. Therefore, vaccination should never take the place of standard prevention and control measures [40]. In the Armed forces and Humanitarian activities subtitle, more discussion about UAE Armed Forces efforts in control cholera in Yemen.

Also, hepatitis A infection is directly related to poor sanitation and hygiene during deployment. It is mandatory for the soldier to receive hepatitis which is a killed vaccine and should be given as two doses (at least 6 months apart) [41]. Within one month pre-deployment it is impossible to follow-up this guideline, therefore, the last dose can be given after soldier finishes his mission.

Rabies immunization is not routinely given but is recommended in case of occupational high risk of exposure (veterinarians or k9 personal dog trainer for example). However, military physician needs to be prepared with rabies vaccine and rabies immunoglobin for an emergency from animal bites (homeless dogs, bats or foxes)

Protective measures and chemoprophylaxis

Military troops place fundamental importance on individual protective measures among military personnel. Usually, deployment had been taken place in countries with high diarrhea rates [42]. When military units deployed for short period, prevention of diarrheal diseases includes standard health education which similar to recommendations for short-term travelers. If they deployed for a longer durations, standard public health military regulations are established, including hand-washing stations, sanitation, and food inspection [43]. Some military units (Special Forces) depend mainly on bottled water and meals ready to eat (MREs) to accomplish their missions. Despite, the food and water hygiene measures in military camps, military personnel had some outbreaks of foodborne or waterborne diseases [9, 44]. Avoidance of vector exposures can be done by personal protective measures which are usually used with mosquitoes.

Military personnel can use topical mosquito repellents, Insecticide-treated bed nets (ITNs), proper wear of clothes (trousers and long sleeve shirts), and uniform treated with permethrin [45, 46, 47]. See Figure.1 (UAE Medical Crops health education for malaria and dengue fever adopted from WHO, Yemen conflict)

Figure 1. Malaria and Dengue poster

Moreover, Group measures must be implemented on deployment which aims to reduce vectors density (mosquitos) in contact with military camps. Three actions are important to reduce vectors density around the field camp. First, selection for the location of field camp and vector (mosquitos) risk around that area. Second, living places on the camp are sealed to vectors (mosquito nets and frequent spraying insecticides). Third, establish a larval source management in the camps and local area surrounding of the camps that had been considered the most important step to fight vector-borne disease [48, 49]. For example, military camps are not living at an isolated location from the local community. During Afghanistan operations, many American soldiers had been infected with malaria from the local community [17, 18]. Manning and colleagues reviewed the role of militaries in controlling malaria in Greater Mekong Sub-region (Cambodia, parts of China, Laos, Myanmar, Thailand, and Vietnam). They recommended that militaries could facilitate malaria elimination efforts to remote and forest areas in Greater Mekong Sub-region. For example, militaries in Thailand and Cambodia provided long-lasting insecticide-treated hammocks (LLIH) to at-risk populations in the forest [50]. UAE through Humanitarian organizations had adopted the same policy in fighting malaria and dengue fever in Yemen [51]. These organizations couldn't enter Yemen during the conflict without a help from UAE and Saudi militaries.

During deployment, soldiers are given malaria chemoprophylaxis. Among UAE military personnel, the present first line drug to be prescribed is mefloquine at the weekly dose of 250 mg. Soldier must start it at least 2 weeks before deployment which we can't predict when the time of deployment for security reasons. Also, a soldier needs to take it for four weeks after leave deployment area [52]. US military troops usually take atovaquone/proguanil for long-term malaria prevention [53]. In another hand, French Armed Forces mainly depend on doxycycline 100 mg daily dose as chemoprophylaxis [54]. Even, Centers for Disease control and prevention recommend that mefloquine is recommended as a third-line recommendation for those unable to receive either atovaquone-proguanil or doxycycline [55]. Many types of research had been published regarding the safety and side

effects of mefloquine especially neuropsychiatric side effects [56, 57, 58].

Chemoprophylaxis compliance is very low among UAE soldiers during and after deployment from our discussion with Dr. Albedwawi (infectious diseases specialist) [23]. Even, 60% of US soldiers respond that they were compliant with their chemoprophylaxis as prescribed [59]. US marine adopted directly observed therapy (DOT) where a trained person monitors the military personnel for taking each dose of malaria chemoprophylaxis [53].

For infections such as schistosomiasis and leptospirosis that involve exposure to non-drinking water, the most effective prevention measure is avoidance of exposure to contaminated water. This measure is very difficult to apply during deployment [60, 61]. Limited studies have shown that doxycycline (200 mg orally, weekly), could be used as chemoprophylaxis in preventing leptospirosis [62, 63].

Prevention of sexually transmitted diseases is challenging issue for UAE Armed forces. Among US Army, condoms are provided free of charge to the personnel at all military treatment facilities, whatever the location (US or Abroad) [64]. Some of UAE military Units refused the condoms distribution system due to cultural conflict. Also, prevention of diseases associated with blood and body fluid exposure is another challenge. All UAE soldiers are vaccinated against hepatitis B. This policy is mandatory to prevent transmission of hepatitis B infection during field blood transfusion. Blood transfusion is necessary for many emergencies during the medical care on the battlefield [65]. UAE Medical Crops has issued specific guidelines for transfusion war casualties by blood unit from the blood bank in Zayed Military Hospital. However, fresh whole blood (FWB) is still not been approved where blood units were taken from not injured soldiers, tested for HIV with rapid diagnostic tests, and then delivered to injured soldiers.

Any trauma during deployment must be treated to prevent wound infection. So that, during the medical evacuation, military professional focuses on antibiotics therapy and tetanus prophylaxis [66, 67]. Ceftriaxone 1g IV should be used as antibiotics choice depend on UAE Medical Crops guidelines to prevent wound infections.

DNA testing

National DNA Database is a project started in Ministry of Interior from 2011 to collect and store reference specimens of DNA from all people in UAE. With cooperation between UAE Armed Forces and National DNA Database, UAE Medical Crops began to collect and store reference specimens of DNA from all military personnel especially before a military mission. Any soldier can't leave to mission without giving a saliva swab for obtaining DNA profile. DNA identification was used by US Army in the first Gulf war [68, 69, and 70]. This database is very important for investigation of deaths during the war. UAE Medical Crops had used DNA for identification of remains during Yemen conflict. However, many researchers raise the ethical issues about DNA bank because it contains a unique code for each individual. Even, two members of the United States Marine Corps refused to give DNA samples before being deployed to the Pacific in January 1995 [71]. In UAE situation, DNA database is controlled by Ministry of Interior that could be a benefit that the DNA data can't be released until permission from the court.

Deployment health education and training

Soldiers usually receive health education on combat first aid and preventive health before deployment to the mission area. During pre-deployment, trainers from UAE Medical Crops focus more on training soldiers on combat first aid than on preventive health measures. During deployment, health professionals, who accompanied the deployed military unit, educate military personnel through briefing and posters. Deployed UAE military physician enforces more about personal protective measures, personal hygiene, and chemoprophylaxis for malaria. Despite the extensive health education and health recommendations, compliance with these recommendations is suboptimal [72].

Prior to post-deployment, military personnel are asked to take their malaria chemoprophylaxis during the four weeks following their return to UAE. A study using SMS system for improving compliance with malaria chemoprophylaxis during the post-deployment period had been done among French soldiers, but this strategy didn't show any improvement in compliance between them [73].

Health professionals training in UAE Medical Crops focuses more on evacuating injured soldiers during the combat operation. However, there are less training sessions about preventive health measures, malaria control, dengue control, and outbreak investigation.

Health Surveillance

Health surveillance is very important for deployed military troops. It can monitor any risk of infectious disease during deployment and post-deployment. Physician accompanied military troops in deployment area must submit a daily or a weekly report about all diseases affected the unit. Also, he/she must report any infectious disease cases to theatre commander and public health department in the base hospital (e.g. Zayed Military Hospital). This procedure is critical for deployment to monitor any outbreak between military units and to control it before spread.

In French Armed Forces, military units' physician must notify every week by email the malaria cases happened in the

previous week among soldiers in deployment and post-deployment period [73].

US military troops had more experience from Gulf war and recent operations in Iraq and Afghanistan. Even, US defense had Armed Forces Health Surveillance Branch (AFHSB) which is an epidemiological resource for US Armed Forces. It covers over 90 countries worldwide to serve deployed military units [74]. Also, AFHSB had Medical Surveillance Monthly Report (MSMR) that provides monthly evidence-based estimates of the incidence and distribution of health-related conditions among US military personnel. In addition, MSMR is available online and can be searched through PubMed [75, 76]. UAE medical crops can benefit from AFHSB for medical intelligence and prepare the deployed troops for possible health hazards and infections in a new combat operation theatre.

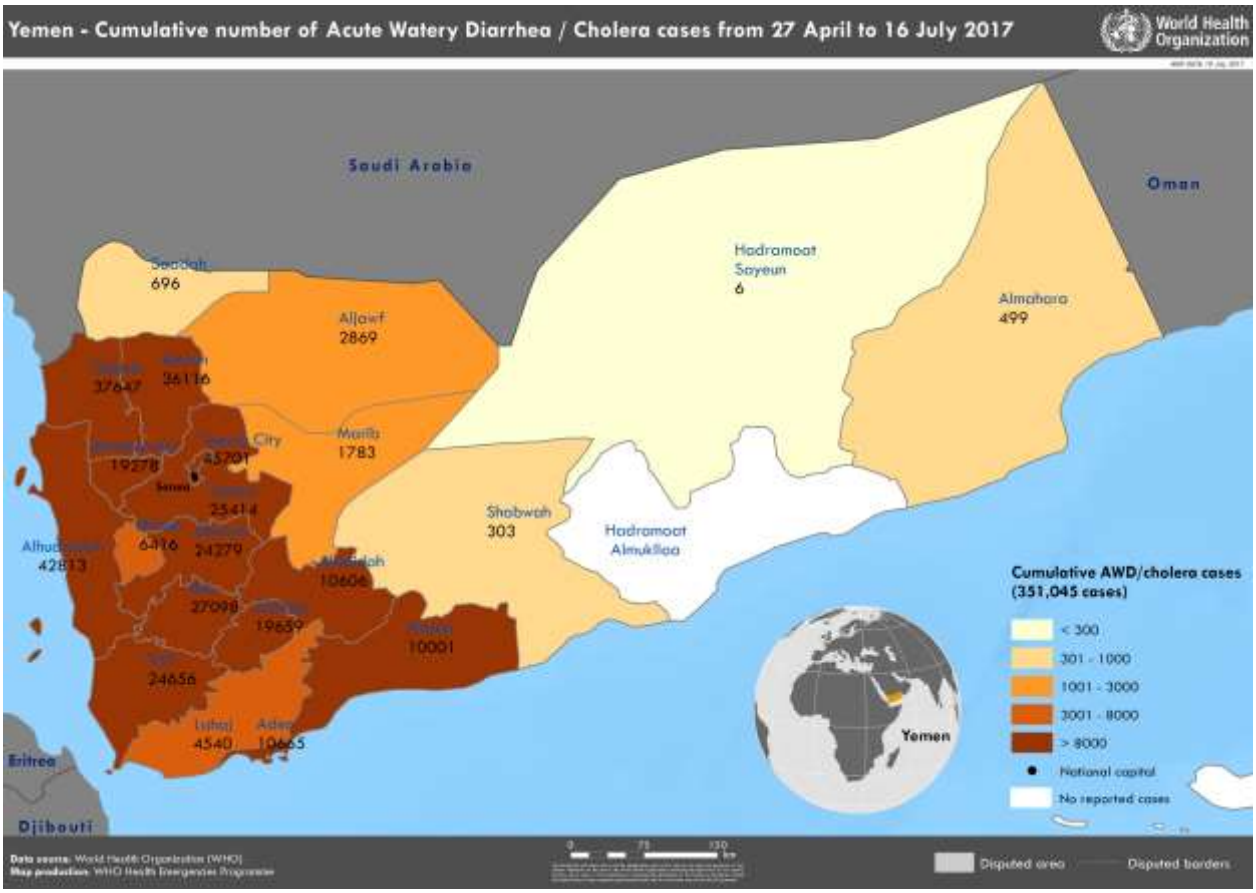
Moreover, US military personnel had been monitored for any infections (tuberculosis and HIV screening) during the post-deployment period under the Army policy of Force Health Protection [53, 77]. UAE military personnel didn't receive a proper post-deployment surveillance because many of them didn't follow-up with their military physician. Also, many Emirati soldiers didn't receive a proper health promotion about infections that could affect them even during the post-deployment period. Also, military personnel receive only pre-deployment health education, but they usually didn't receive the same amount of health education after deployment. Brisson had done a survey for compliance with antimalarial chemoprophylaxis for US military personnel after return from Afghanistan. Forgetfulness (31%), and low perception of risk (24%) were common reasons for non-compliance because of lack of health education during deployment [59].

Armed forces and Humanitarian activities

Many armies had changed their doctrinal instruction and mission aims. Commanders had been ordered to help host nation to restore their government and basic infrastructure. US Army engaged in recent operations (Afghanistan and Iraq) by training and planning for stability, security, transition, and reconstruction (SSTR). This can't be done unless the deployed military forces provide the local population with security, restore essential services, and meet humanitarian needs [1]. This new military approach can positively help us get a clear picture of local diseases epidemiology and infections outbreaks.

UAE Armed Forces had adopted the same approach in Kosovo conflict and Yemen conflict. During, Kosovo war, UAE deployed military troops provided local populations regardless their religion medical services, food, water, and shelter. Moreover, UAE field hospital had been opened during the mission to serve local people.

During Yemen conflict, many Yemeni cities are without proper infrastructures. Safe water and medical services were not available in remote villages. Health situation varies significantly from area to area due to government corruption. UAE Armed forces under these situations had supported the official Yemeni government and the local population with basic life needs, health support, and safe water. Also, UAE military troops helped humanitarian organizations for reaching and helping people during the Yemen conflict. For example, UAE Red Crescent had dug many water well rigs in Hardramoat, Al Mahara, and Shabwah provinces to supply local populations with safe water. This effort accomplished by WHO help in adding chlorine to public water. UAE Medical Crops emphasized the importance of safe water to protect from cholera not even deployed soldiers but also local population. According to recent WHO report (April-July 2017) about Yemen, acute watery diarrhea/cholera cases were less in Hadramoat, Al Mahara and Shabwah provinces comparing to other Yemeni provinces [78]. See Figure.2



CONCLUSION

This review aims to give a clear picture about UAE Armed Forces experience regarding prevention of infectious diseases. The approach to prevention of infectious diseases during military deployments has developed over many years for UAE Armed Forces. The UAE Medical Corps recommendations for preventing infectious diseases adopted from the international recommendation for travel medicine and experiences of other Armed Forces (e.g. US, French and British Armies). More research is needed to know what suitable for UAE Armed Forces during deployment period.

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