

ORIGINAL ARTICLE

First surveillance of malaria among seafarers: evaluation of incidence and identification of risk areas

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Summary. Malaria is a potentially deadly parasitosis. Due to its geographical distribution, seafarers are particularly exposed to it. This study is an epidemiological analysis on the morbidity of malaria onboard commercial ships without a physician, with the purpose of proposing solutions aimed at limiting further infections in this delicate and difficult working environment. *Methods:* We examined 17,212 health records of patients embarked on ships assisted by the CIRM from 2011 to 2015. All the diagnosed diseases have been categorized based on the ICD-10 classification system by the WHO. This study analyzed the cases of suspected malaria and the cases of malaria confirmed by clinical tests. The geographical distribution of infections and the drugs chosen by physicians are also assessed. *Results:* Although a reduction in malaria cases was appreciated during the 5-year period taken into consideration, this disease still covers an important percentage of all infectious diseases that occurred onboard. This proves that it is a major health problem for seafarers. *Conclusions:* In order to protect seafarers' population, strengthen malaria prevention and control programs, as well to improve the availability of antimalarial drugs onboard ships is necessary. This may ensure rapid and efficient health interventions in case of need. (www.actabiomedica.it)

Key words: malaria, prophylaxis, merchant ships, seamen, travel

1. Introduction

Malaria is the deadliest parasitosis in the world; every year it kills about 400,000 people, gaining the second place as a cause of infectious death, after tuberculosis (1).

It is transmitted by the female mosquitoes of the genus *Anopheles*, and caused by a parasite of the genus *Plasmodium*, Phylum *Apicomplexa*. Human malaria is primarily caused by four species of *Plasmodium*: *Plasmodium falciparum*, *Plasmodium malariae*, *Plasmodium ovale* and *Plasmodium vivax*, but also, occasionally, by *Plasmodium knowlesi* (2-4). Among these, the most lethal is *Plasmodium falciparum*, with the highest mortality rate among infested subjects, and mainly widespread in Sub-Saharan Africa (5). Ma-

laria manifests itself as an acute febrile illness, with an incubation period of 7 days or more, and with a symptomatology and clinical evolution whose severity depends on the species that has transmitted the infection (5, 6). Malarial starting symptomatology, which can be rather bland, includes fever, chills, headache, muscular aching and weakness, vomiting, cough, diarrhea, and abdominal pain. Subsequently, very serious complications may arise, such as symptoms related to organ failure, such as acute renal failure, pulmonary edema, generalized convulsions, circulatory collapse, coma and death (6).

About 40% of the world population lives in areas where malaria is endemic, such as in tropical and subtropical areas, and at an altitude of less than 1,800 meters (5, 7-9).

The remarkable geographical distribution of malaria causes travelers (10) and sailors to be particularly exposed to this disease.

In fact, a category of people particularly at risk is that of seafarers, especially those embarked on commercial ships that take long journeys around the world, for relatively long periods of time, and without a physician on board (11-15). These workers sail all over the world, and for work reasons they are often forced to visit malaria risk areas. Moreover, the work on ships is associated with an increased risk of illness and injury (16-21). This would seem to be due to the specific conditions of the sea, to the scarce possibilities of escaping from danger, exposure to extreme climatic conditions, psycho-physical stress and so on. Then, malaria among seafarers can have a double risk: the disease itself, and therefore the malaise and consequent disability of the subject, and the difficulty of diagnosis and therapy on-board ships (22).

Although many studies have shown a significant reduction in morbidity from infectious diseases in recent years, malaria still remains one of the biggest health problems related to sailors (11). Seafarers, by the nature of their job, cannot avoid malarial regions. That's why it emerges that it is essential to act in terms of prevention, avoiding the bite of the mosquito, and especially through chemo-prophylaxis, to be performed and maintained throughout the period in which the subject is potentially exposed to the disease or for the entire period of stay in the malarial area, and at least until 4 weeks after return or departure (2).

According to the World Health Organization's most updated guidelines, in malarial areas with multidrug-resistances, the most effective medicine has turned out to be the Malarone, which comes from the association of 250 mg of Atovaquone and 100 mg of Proguanil in a tablet (23).

Epidemiological investigations in the maritime sector are slightly uncommon in literature; even more rare are the investigations focusing on malaria; as a matter of fact, in this field epidemiology has often focused on small samples of the working population. Similar studies published in the last 10 years are also lacking (11, 13, 24-28).

The aim of this study is to carry out an epidemiological investigation on the morbidity of malaria on

board commercial vessels, on the basis of the electronic health records provided by the International Radio Medical Centre (CIRM), paying particular attention to the geographical distribution of infections, and proposing strategies aimed at preventing further and future infections in this delicate and difficult working environment.

2. Methods

The period considered in this paper is from 1st January 2011 to 31st December 2015; in this time frame, the CIRM has assisted 17.212 patients on board commercial ships; for each case assisted by the Centre, a digitalized medical file, called "electronic record", has been established and updated following every contact with the ship. These files represent the basis of the investigations conducted in this study. Subject of this study are the crew members of commercial ships sailing in international waters. In these vessels there is no medical or health personnel on board, and medical assistance is provided through tele-assistance techniques.

All the diagnosed diseases have been categorized based on the International Statistical Classification of Diseases and Related Health Problems (10th Revision) by the World Health Organization (WHO) (29). Among the different ICD-10 categories, we took into consideration the diagnoses included in the ICD-10 Class "I", called "Certain Infectious and Parasitic Diseases", a category to which malaria belongs, as parasitosis. In this way, we were able to perform a quantitative comparison between cases of malaria and cases of other infectious and parasitic diseases.

In this paper, malaria diagnoses are distinguished in "suspected unconfirmed cases" and "cases confirmed by clinical tests". After a first telemedical contact with a competent CIRM doctor, a pre-diagnosis is proposed depending on the patient's symptoms and on physiological parameters directly measured on board. In the event that the symptomatology is ascribable to malaria, immediate confirmation is requested through clinical analyses, to be carried out at the nearest port. The performance of these laboratory tests has made it possible to distinguish confirmed cases of malaria from those who, despite having a symptomatology attribut-

able to this disease, have not had anything to do with it, and which we have called “suspected unconfirmed cases”. In a second phase, through the identification of every single case of malaria, we were able to analyze the coordinates relating to the call position at the time the assistance request was formulated. This made it possible to analyze the geographic distribution of Plasmodium infections registered by us, and then to compile a cartography highlighting the areas with the highest endemic risk of malaria for seafarers. All data was analyzed with standard statistic methods; Microsoft Excel was the software used for information processing and result analysis. Data are expressed in the text as means \pm SD.

According to informed consent, data were anonymized before being used for research purpose. The survey is a part of the project called Health Protection and Safety on Board Ships (acronym: HEALTHY SHIP). It is a project of disease prevention and health protection on board sailing ships through information campaigns on the major health risks for seafarers and on their prevention (30), approved by Comitato Etico Fondazione Centro Internazionale Radio Medico (C.I.R.M. Foundation ethic, scientific and medic Committee).

3. Results

The results of the epidemiological analysis conducted in this study are summarized in Table 1.

In Table 1 malaria diagnoses are compared with the diagnosis of other infectious and parasitic diseases included in the ICD-10 category I (Certain infectious and parasitic diseases), and also reported in percentages (%). This table therefore allows us to evaluate the morbidity of malaria and compare it with other infectious and parasitic diseases that occur on board. Fortunately, there were no deaths due to malaria among the cases of assistance taken into consideration in this study.

Whenever a request for assistance comes from a patient with malarial symptoms, the assistant doctor also orders to perform an appropriate laboratory test to diagnose malaria. The “confirmed by clinical tests” cases are those whose clinical examination has returned a positive result; on the other hand, we are talking about cases of “suspected unconfirmed” malaria, and then of pathological conditions of different etiology but which showed a symptomatology attributable to malaria.

In most cases, prescribing doctors, pending the results of laboratory tests, prescribed antipyretic drugs for the control of symptoms, especially those of a febrile kind and malaise. In particular, the most administered drug (75% of all cases) was paracetamol, with a dosage of 0.5-1g three times a day, followed by 200 mg ibuprofen tablets (for the remaining 25% of all cases).

Following the confirmation of malaria, made possible by clinical laboratory tests, the pharmacological choices of CIRM physicians, strongly influenced by the availability on antimalarial drugs on board, showed chloroquine as the drug of first choice (107 prescrip-

Table 1. Number of ICD-10 class I diagnoses, and number of malaria cases on board commercial ships assisted by the CIRM in the period 2011-2015

Year	Number of patients on board ships assisted by the CIRM	Number of ICD-10, category I cases	Number of “Suspected unconfirmed” Malaria Cases N(%)	Number of Malaria Cases “Confirmed by clinical tests” N(%)
2011	2561	80	2 (2,50%)	27 (33,75%)
2012	3120	84	3 (3,57%)	35 (41,67%)
2013	3428	152	5 (3,29%)	33 (21,71%)
2014	3908	200	4 (2,00%)	31 (15,50%)
2015	4195	154	2 (1,30%)	20 (12,99%)
Total	17212	670	16 (2,39%)	146 (21,79%)

tions, corresponding to 73,29% of all cases), followed by the artemether (19 prescriptions, 13,01% of all cases) then by the mefloquine (13 prescriptions, 8,90% of all cases), and finally the malarone (7 prescriptions, 4,80% of all cases).

According to the geographic coordinates concerning the calls made to the CIRM by the different naval units, we have created a world plan where the positions occupied by the ships are indicated with a special symbol, at the time of the request for assistance (Figure 1).

Considering the incubation times of malaria (7 days or more) (5, 6), and that the request for assistance is performed at the onset of symptoms, we have analyzed the routes travelled by the ships in the 7 days before the request for assistance. Then, thanks to this information, we created a map that highlights the areas at risk of malaria through different colors (Figure 2).

4. Discussion

As shown in Table 1, the malaria cases accounts for a significant proportion of the total, especially in the years 2011 and 2012 where it represents respec-

tively 33,75% and 41,67% of the total cases of all infectious and parasitic diseases diagnosed on board.

This is cause for concern, since the ICD-10 I category also includes relatively less dangerous and rather common pathologies (such as topical fungal infections, bacterial and viral infections) (29), and the fact that malaria represents as overall 21,79% of the total cases of infectious diseases (in the 5 years analyzed) means that this parasitosis still represents a great threat to the health of seafarers.

On the other hand, the reduction of malaria cases, between 2013 and 2015 (Table 1) is encouraging, and suggests that if the correct prevention rules are followed correctly, a significant reduction of malaria cases onboard commercial vessels can definitely become an achievable goal.

According to the results of this report, by observing the geographic areas at risk of malaria in Figure 1 and Figure 2, we can see that the coasts of West Africa represent the area with the highest risk of contracting malaria.

The risk was intermediate nearby the coasts of the Middle East, while it was lower in Central America and South-East Asia. Looking in detail at Figure 2 we also notice a higher risk of contracting malaria in those

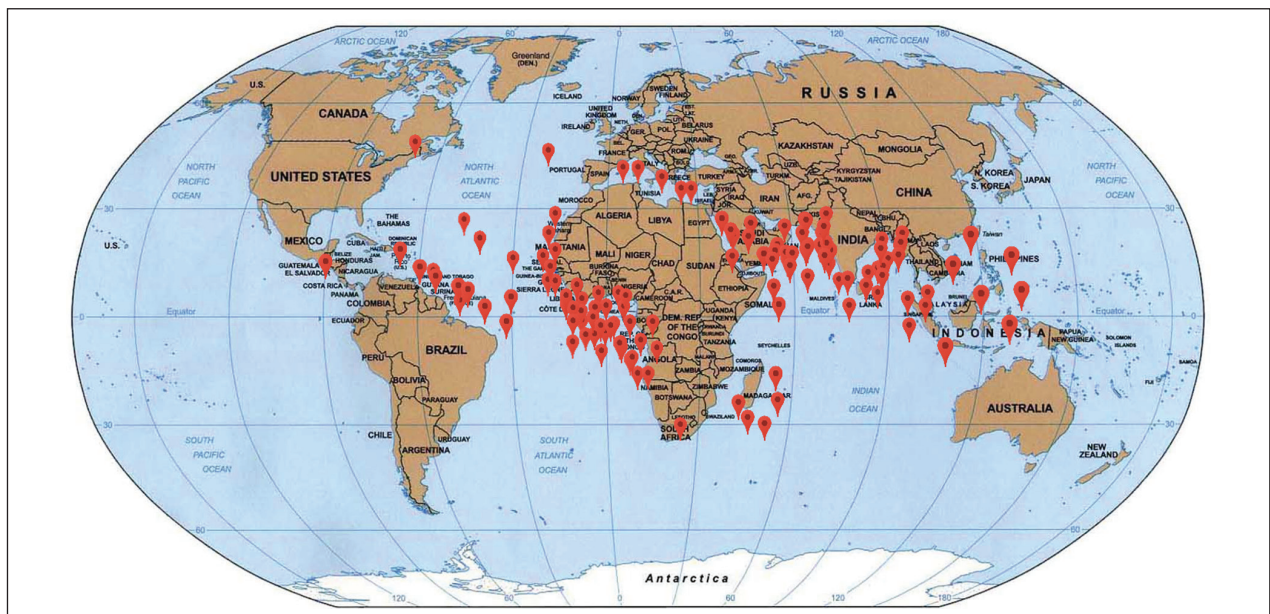


Figure 1. Geographical position of the vessels at the time of request for assistance

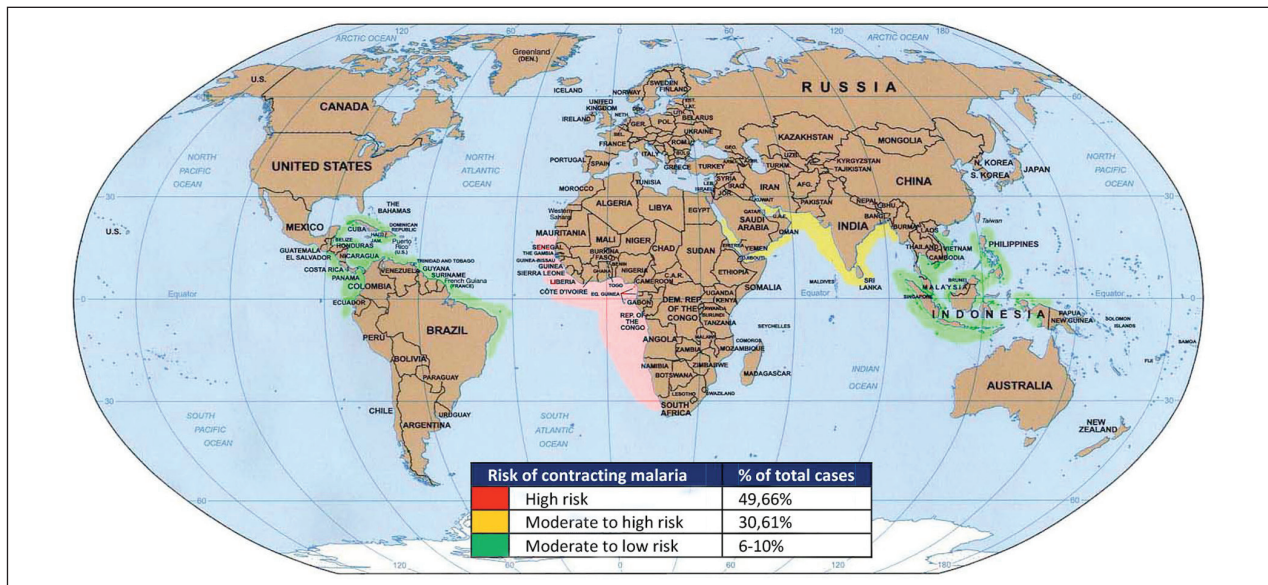


Figure 2. Geographic areas at risk of malaria infection for seafarers (based on the number of reported malaria cases)

where the risk of *P. falciparum* is just as serious (31).

From an analysis of the scientific literature and the international guidelines, it emerges that Malarone is the most effective drug against *P. falciparum*, but also the most efficient medicine against multidrug-resistant Plasmodium (23).

Despite this, it was the least administered among all antimalarial drugs (4.88%), as reported in the results. The choice of drugs considered as non-first choice for a given kind of Plasmodium is probably a consequence of the lack of a multiple choice possibility between different antimalarial drugs in many national medical chests (23, 24). The minimum amount of drugs that each ship should have on board is indicated in two publications: The International Medical Guide for Ships (32), and the Medical First Aid Guide for use in Accidents Involving Dangerous Goods (33), both by The World Health Organization (WHO). According to these two important documents, the main nations have regulated their on-board pharmacies (34).

The existing lack of homogeneity in terms of drugs in the medicine chest can seriously compromise the quality of assistance given to seafarers, and exposes patients to an absolutely non-negligible risk, as malaria is a deadly disease, especially if not properly treated.

5. Conclusions

For work reasons seafarers may not avoid malaria risk areas. That's why the right prevention and surveillance must be considered mandatory onboard ships navigating in endemic zones. These procedures can consist of the identification of samples tested in laboratories, the analysis of suspected infections, and the identification of subjects at risk. The accurate reports that follow will ensure that all cases of infection are reported and documented, with the purpose of performing notification and epidemiological analysis. The results of this analysis showed a reduction in the number of cases of malaria among seafarers over the years of study, highlighting the fact that reducing the cases of infection by this disease is an achievable goal. Therefore, strengthening prevention and creating control programs, along with a standardization in terms of quality and quantity of drugs that commercial vessels must have on board (in particular for more recent and effective medicines), is necessary to ensure a rapid and efficient health intervention in case of need, and reduce the spread of this parasitosis, especially in the delicate maritime sector.

Acknowledgements

This original paper has been written thanks to a collaboration between the Centro di Telemedicina e Telefarmacia of the University of Camerino and CIRM (Centro Internazionale Radio Medico) located in Rome.

Authors' contributions: Graziano Pallotta and Giulio Nittari designed the research, collected and analysed data, wrote the manuscript and conducted statistical analyses. Marzio Di Canio and Stefania Scuri contributed to research execution, collected and analysed data. Francesco Amenta contributed to research execution and results interpretation. All authors read and approved the final manuscript.

Ethical approval and consent to participate: C.I.R.M. Foundation ethic, scientific and medic Committee.

Availability of Data and Materials: The data that support the findings of this study are available from C.I.R.M. (Centro Internazionale Radio Medico) but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of C.I.R.M. (Centro Internazionale Radio Medico).

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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Received: 20 June 2019

Accepted: 6 September 2019

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