# Medical Intelligence, Entomology, Tropical and Operational Medicine

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## ABSTRACT

*Medical Intelligence, Entomology and Tropical Medicine are essential for all contingency planning in tropical and subtropical regions. Medical Intelligence is critical for mission success in the sense of a supporting Operational Medicine. The paper gives an update on current threats in ongoing out-of area missions. The countermeasures applied by the German Forces are described, giving an example of actual epidemiological data, including relevant diseases and vectors.*

*Medical expertise and thereby information of operational leaders may be optimally provided, if all aspects of this presentation are linked and applied in an interdisciplinary context.*

## MEDICAL INTELLIGENCE

The new edition of AJP-4.10 „Allied Joint Medical Support Doctrine"(1) defines Medical Intelligence (MedInt) as
"the product of the processing of medical, bio-scientific, epidemiological, environmental and other information related to human or animal health".
This intelligence requires special medical expertise during gathering and processing of the data.
The objective is to provide the commander with medical recommendation about the most appropriate force health protection measures that must be taken to support the deployed forces, including an assessment of adversary health risks and medical capabilities (AJP 4.10.3.).

Medical Intelligence (MedInt) serves at the tactical, strategic and operational level of planning. It must be comprehensive, rapidly available, accurate and up to date by continuous review. In a broader context, MedInt is useful in areas of civil-military cooperation, especially during humanitarian missions.

MedInt provides information about:

- Geographic factors such as effects of climate, topography, flora and fauna
- Epidemic and endemic diseases, their importance and prevalence, local prophylactic measures, resistant strains, treatment etc.
- Veterinary situation
- Special environmental and occupational hazards, pollution, toxic industrial hazards

- Chemical, biological, radiological and nuclear capabilities of involved nations
- Military and civilian medical capabilities and resources available in the Joint Operation Theatre

A number of conventions prohibit the use of biological, chemical or radio nuclear weapons. Nevertheless, particular interest must be drawn to potential terrorist threats, for example food poisoning.
Food terrorism is defined as an act or threat of deliberate contamination of food for human consumption with chemical, biological or radio nuclear agents for the purpose of causing injury or death and/or disrupting social, economic or political stability (2). The chemical agents are man-made or natural toxins, and the biological agents referred to are communicably infectious or non-infectious pathogenic microorganisms, including viruses, bacteria and parasites. Radio nuclear agents are defined in this context as radioactive chemicals capable of causing injury when present at unacceptable levels.
The potential impact on human health by deliberate sabotage of food can be estimated looking at the many documented examples of unintentional outbreaks of food borne diseases. The largest, best-documented incidents include

- outbreak of S. typhimurium in 1985, affecting 170 000 people in the USA,
- outbreak of hepatitis A in China 1991 affected 300 000 people after consumption of clams,
- outbreak of S.enteritidis from contaminated pasteurized ice cream caused illness in 224 000 people in 41 states in the USA and
- 800 people died and 20 000 were injured by chemical agent in oil sold in Spain 1981.
- Thousands of infants in China were intoxicated by artificially produced baby milk in 2008

For example, the causative agent of anthrax, Bacillus anthracis, is a potential biological threat because of its high virulence and stability. The spores can survive in the environment for years and decades, awaiting uptake by the next host. The disease's impact on human and animal health can be devastating. All 3 types of anthrax in humans – cutaneous (95%), gastrointestinal and pulmonary – are potentially fatal if not treated promptly. Disease outbreaks in animals occurred in Africa, but also in China, former Soviet republics and South-East Europe. Vaccination should be confined to high-risk groups, such as occupationally exposed persons or to military personnel (3).

Certain chemical and biological agents and radio nuclear materials can be disseminated as small aerosols or volatile liquid for the purposes of an airborne attack. Purposeful contamination of food might be easier to control to some extent than attacks by air or water, but many developing countries lack basic food safety infrastructures and are vulnerable to deliberate acts of sabotage. Thereby they are also not able to develop activities for preventing and responding quickly to food terrorism.
Training of military epidemiologists is needed to include considerations of food and food borne agents as a core competency in Medical Intelligence.

The German Armed Forces (Bundeswehr) have established a Medical Intelligence service, which provides specific information for military leaders, but also personal briefings for recreational travelers, belonging to the armed forces. The information is provided by MedIntel specialists. The German MedIntel services include:

1. MedIntel Acute (Priority): It contains brief and actual recommendations for disease prevention and health care in special missions. A good example is the quick response to the humanitarian disaster after the Tsunami in SE Asia.
2. Country or region reports: detailed briefings/documents for long-term contingency planning
3. MedIntel-Hotline: A 24 hrs M.D. service provided by the Bundeswehr Medical Office and the Navy Medical Institute.

The personnel of the MedIntel service are engaged in a broad spectrum of activities. This includes participation in fact finding teams in the pre-deployment phase, continuous multidisciplinary risk evaluation during deployment and data recording and editing post deployed. Close and interdisciplinary liaison and cooperation with civilian experts has been established to guarantee the best level of expertise.

The low malaria incidence among German soldiers deployed into endemic areas is most likely associated with effective preventive medical efforts which have been optimized during recent years to foster Force Health Protection.
From December 2001 to June 2006 no impact of preventable infectious diseases on the military operability of German forces was noticed and there were no reported side effects of recommended pharmacological prophylaxis.

Only 7 Malaria cases (6 ISAF, 1 OEF MOMBASA) and 19 cases of Leishmaniasis (ISAF) occurred since 2002.
From 1st January 2001 until 31st June, 2005, only 6 cases of malaria have been reported among deployed German troops, resulting in an overall incidence of 0.06 cases per 100 soldiers per year. One case of Pl. falciparum malaria has been acquired during Operation Enduring Freedom in Kenya, resulting in a malaria incidence rate of 0.14 per 100 soldiers per year.

## ENTOMOLOGY

One specialized core element, embedded in the field of Medical Intelligence and military preventive medicine, is the military medical entomological service of the German Armed Forces.
Medical Entomology conducts the assessment of local vectors before deployment and updates data during deployment.

Teams of tropical medicine experts carry out onsite surveys in order to evaluate the risks, data and countermeasures in all missions of the Bundeswehr in tropical and subtropical areas.

Multiple possible vector transmitted diseases make entomological surveys necessary.
For example disease relevant species of mosquito are living in different habitats. Species Aedes prefers smallest water reservoirs, e.g. in flowerpots or old tires. Eradicating small water reservoirs prevents infections transmitted by Aedes like Yellow Fever.
Anopheles is not reproducing in this environment. This species needs open, shallow water for breeding. Usally both species are not living in the same habitat.

Another example is the enormous amount of garbage produced in Military camps and the corresponding problem of attracted rats or similar animals. With these animals appear insects like the Sandfly (Phlebotomus) which transmits Leishmaniasis.

The potential risk caused by mosquito should not to be underestimated. In the face of the very short developing cycle of 1 week in tropical regions, the importance of surveillance of these vectors and the appropriate countermeasures are of great relevance (4).

Currently, more than 1700 different human-pathogenic microorganisms are known, of which 50% are defined as zoonoses. Out of the 1700 pathogens known, 156 are currently defined as “emerging infectious diseases”. 73% of these 156 emerging infectious diseases are classified as zoonoses, resp. vector diseases. On average, zoonotic diseases show a more than 3-fold increased epidemic spread when compared with human-to-human transmitted diseases.

This trend clearly underlines the current and future importance of diseases transmitted by arthropod vectors and rodent reservoirs for both, the civilian and the military community.

The following facts demonstrate the military importance of vector-borne diseases.
65-80 % of all hospitalizations during military deployments are due to infectious diseases compared with 5-25 % due to battle injuries and 5-10 % to non-battle injuries (5). Approximately 2/3 of diseases of military importance are vector- borne.
Throughout history, the deadly comrades of war and disease have accounted for a major proportion of human suffering and death. During conflict, human populations are often suddenly displaced, associated with crude mortality rates over 60-times higher than baseline rates. Promoting factors like mass movement of populations, overcrowding, no access to clean water, poor sanitation, lack of shelter, and poor nutritional status directly result in rapid increase of infectious diseases like respiratory and intestinal tract infections as well as vector-borne diseases.

In 26 out of 52 retrospectively analyzed wars from 480 B.C. to 2002 A.D., vector-borne diseases like malaria, plague, louse-borne typhus (Napoleon's troops), yellow fever, relapsing fever, scrub typhus, visceral and cutaneous Leishmaniasis prevailed or essentially contributed to overall mortality.

Climate change and climate variability are increasing extreme weather events, food-, water-, vector- and rodent-borne diseases (6). In Western Europe, 35 000 excess deaths were reported following the 2003 heat-wave. During that meteorological summer the temperatures were 3.4 ° C higher than the average from 1961-1990.
It is to be expected, that a rise of the mean temperature of 7°C in July will occur in the Western Mediterranean until 2050 (7).
Increasing air and water temperatures improve the living conditions of viruses, bacteria, and vectors. Changes and variability of the climate and the hereby resulting and unexpected weather situations may also contribute to the creation of clusters of vector-borne diseases due to the imbalance in the biological balance.

## TROPICAL MEDICINE

The following chapters give an overview of typical diseases, their epidemiology and possible countermeasures pointing out their importance for ongoing missions. It is not intended to go into particular details of pathophysiology and clinical aspects, but more to focus on the operational context.

### Malaria

During the last decades, devastating war-related outbreaks of malaria have been reported.
According to the humanitarian claim to protect, or to re-establish, the health of the affected population, essential medical and entomological expertise has been increasingly involved in complex emergency response scenarios in order to analyse and interrupt transmission modes as well as to reduce the epidemiological impact.

A study provided by Snow et al. (8) on the basis of an empirical approach by using a combination of epidemiological, geographical and demographic data estimates that the disease is far more common than it was expected – about half a billion cases in 2002. This is about 50 % more than the number of cases reported by the WHO globally and 200 % higher for areas outside of Africa, showing sloppy reporting procedures in some countries. The new numbers show that Africa still bears the biggest share of the global burden. On the other hand the revision shows that malaria is three times more prevalent in Brazil than previously thought and 1000 times more in Pakistan. In fact, South and Southeast Asia account for most of the newly estimated rise in the malaria prevalence of the globe. The region is now believed to have one-fourth of the world's cases.

The minimum survival temperature for Anopheles and Pl. falciparum is 8-10°C respective 16-19°C. Therefore the risk of infection is also temperature dependant. The change of global temperatures is likely to raise the risk of infection by 1.5 in the mountainous areas of the tropical Africa and South America. Additionally the risk is expected to be doubled in wide regions of Europe, Central Asia and the USA.

The military threat caused by malaria is significant. During WW II Malaria among US troops led to 695.000 cases with 377 deaths and 12, 1 Mio. man-days lost.
Probably the single greatest defeat of the United States Army during World War II was the fall of the Philippines in 1942, where malaria had a key adverse effect on the defense system. In the final stages of the battle, the daily hospital admission rate was 500 to 700 men, caused by malaria alone. At that time, the British 14th Army in Burma experienced malaria incidence rates of 840 cases/1.000 men/year.
The percentage of American soldiers deployed in Vietnam infected with malaria was about 10% in 1965.
During the period 1981-1989, 7683 cases of Pl. vivax malaria were imported into the USSR by soldiers returning from Afghanistan.
In 1993 the percentage of infected American soldiers deployed to Somalia was about 29%.

Among 439 Brazilian army troops deployed to Angola in 1995-1996 there were 78 cases of malaria (18%). Three patients died of cerebral malaria.

It must be kept in mind that during military deployments into hyper endemic areas, malaria as well as the numerous other vector-borne diseases can appear as a so called „war stopper“ or „show stopper“, severely influencing troop health and readiness.

## Leishmaniasis

Leishmaniasis is a parasitic infection which is transmitted by the bite of the infected female phlebotomine sandfly. Leishmaniasis presents itself in humans in four different forms with a broad range of clinical manifestations. All forms can have devastating consequences for the patients.
Visceral Leishmaniasis (VL), also known as Kala Azar, is the most severe form, which, if untreated, has a mortality rate of almost 100 %.
Mucocutaneous Leishmaniasis (MCL) produces lesions, which can lead to extensive and disfiguring destruction of mucous membranes of the nose, mouth and throat cavities.
Cutaneous Leishmaniasis (CL) can produce large numbers of skin ulcers on the exposed part of the body, causing serious disability.
Diffuse cutaneous Leishmaniasis does not heal spontaneously and tends to relapse after treatment.
The cutaneous forms are the most common and represent 50-75 % of all new cases.

Regions where Leishmaniasis is endemic have expanded significantly since 1993. The geographic spread is due to factors related mostly to development and migration.
Now Leishmaniasis is endemic in 88 countries on five continents with a total of 350 million people at risk. It is believed that 12 million people are affected worldwide; this figure includes cases with overt disease and those with no apparent symptoms. Of the 1.5-2 million new cases of Leishmaniasis estimated to occur annually, only 600 000 are officially declared. Of the 500000 new cases of VL annually, 90% are in Bangladesh, Brazil, India, Nepal and Sudan. 90% of all cases of MCL occur in Bolivia, Brazil and Peru and 90 % of all cases of CL occur in Afghanistan, Brazil, Iran, Peru, Saudi Arabia and Syria, with 1-1.5 million new cases reported annually worldwide (9). AIDS and other immunosuppressive conditions increase the risk of Leishmania infected people developing visceral illness. Leishmania/HIV co-infection is emerging as an extremely serious, new disease and it is increasingly frequent.

Co-infections can lead to epidemiological changes, which modify the traditional patterns of VL. Patients harbor a high number of Leishmania in their blood and may become reservoirs for this disease. Experimentally, sandflies can be infected through a blood meal containing a very small quantity of blood from co-infected patients.
Sandflies are very sensitive to temperature and prefer regions with low changes in temperature. While a temperature rise in subtropical and tropical regions will lead to the death of sandflies, better living conditions could be in temperate climates. In European regions sandflies are usually found south of latitude 45° N and less than 800 meters above sea level, but recent findings detected one species in Germany as high as 49° N. Also, the incidence of infection has increased in France and Italy, and new endemic areas have been detected in Northern Croatia and Northern Italy (10).

## Dengue and Dengue Haemorrhagic Fever

Dengue is also a mosquito-borne infection, which in recent years has become a major international public health concern. Since it is found in tropical and sub-tropical regions and predominantly in urban and semi-urban areas, e.g. where household water storage is common and where solid waste disposal services are inadequate, the threat for forces especially deployed in humanitarian missions in these areas may not be ignored. There are four distinct, but closely related, viruses that cause dengue. The most important vector of Dengue viruses with their four serotypes is the predominantly urban species Aedes aegypti. Recovery from infection provides lifelong immunity against that serotype but confers only partial and transient protection against subsequent infection by the other three. There is good evidence that sequential infection increases the risk of more serious disease resulting in dengue haemorrhagic fever (DHF).

The global prevalence of dengue fever has grown dramatically in recent decades. Models have shown that an increase of the global temperature of 2°C until 2100 will lead to a threat in higher latitudes and altitudes. The disease is now endemic in more than 100 countries; Africa, the Americas, the Eastern Mediterranean, South-East Asia and the Western Pacific are most seriously affected. DHF epidemics have increased more than four-fold by 1996. An estimated 500000 cases of DHF require hospitalization each year. At least 2.5% of cases die and DHF case fatality rates can exceed 20% without proper treatment (11).

Three reported possible cases of dengue fever in Afghanistan raised international concerns about an upcoming epidemic of this arboviral disease not. Entomological risk evaluation and vector surveillance quickly made clear, that the urban main vectors, Aedes aeygpti and Aedes albopicta, are not endemic in the affected areas. These results rapidly support the view that dengue fever cannot be endemic at least in the areas of Kabul, Kunduz and Feyzabad, and that the disease was most likely caused by other pathogens.
Subsequent investigations carried out by a British laboratory revealed that the used Dengue dip stick ELISA showed false-positive results due to cross reactivity against antibodies directed to other flavi-viruses (e.g. Tick-borne encephalitis or Yellow Fever vaccination).

## Rickettsia induced diseases

Howard Taylor Ricketts and Stanislaus von Prowazek were infected during their research on these pathogens and died. To honour both persons, the causative organisms of "Rocky Mountain Spotted Fever" and Typhus exanthematicus (epidemic typhus) were classified as "Rickettsia rickettsii" and "Rickettsia prowazekii".

Rikketsia-borne diseases are very important in the differential diagnosis of febrile diseases in people returning from deployment or travel into tropical regions. An infected tic can also be imported to Northern regions e.g. by a pet after a stay in southern Europe.

Rickettsia are also known as a potential biological weapon, because of their high pathogenic potential and stability through aerogen transmission (12).

The most important clinical signs are eschar, exanthema, fever and lymphadenopathy. Exanthema, leucocytopenia and thrombocytopenia may result in a misjudgment that the patient suffers from a virus infection, with the consequence of delayed sufficient treatment with antibiotics.

Rocky Mountain Spotted Fever, Epidemic Typhus and Scrub Typhus are serious diseases. Without proper treatment, the fatality rate can reach 35%. Specific treatment includes Doxycycline 2x100 mg per diem and Chloramphenicol in severe cases associated with encephalitis.

## Defense against Malaria / Vector-borne Diseases (VBD) in Military

Up-to-date preventive medical countermeasures against vector-borne diseases are rather complicated and complex, but achievable even under field conditions. Vaccination principally is the first line of defense, but unfortunately available for just a few vector-borne diseases and not yet for malaria. Overall, personal protection procedures usually represent the second line of defense. Nowadays, personal protection measures are the first line of defense against malaria.

Chemoprophylactic regimens are – depending on the regional quantitative threat – usually the third line of defense. Vector monitoring and surveillance as the 4th line of defense is essential in order to precisely quantify the threat of a certain vector-borne disease. It provides basic information for the need of further preventive measures. Integrated vector control serves as the fifth line of defense and the key strategy for the professional use of least toxic but most effective control methods aiming at interruption of the transmission chain of VBDs according to national and international health regulations.

Personal protection measures are most effective against arthropod bites when used altogether simultaneously. Depending on the special vector behavior as a day-time, night-time, indoor, or outdoor biter, one single method can increase or decrease its value.
Simultaneous use of

- insecticide impregnated clothing (e.g. Permethrin),
- effective skin repellent,
- reduction of exposed skin as well as
- insecticide impregnated bed nets, curtains and tents

usually result in an arthropod bite protection exceeding 95%.

Even today, Permethrin, an ester pyrethroid more than 30 years old, is the best choice to treat clothing in order to protect against arthropod bite. Permethrin itself provides an excellent efficacy and stability as insecticide and acaricide (acaricide = effective against ticks and mites). Unlike all the other commercially available pyrethroids, Permethrin reveals a simultaneously occurring repellent effect, hot-feet effect, knock-down effect and kill effect at concentrations above 200 mg/m$^2$ of fabric.
Facing the known disadvantages of impregnating clothing by spraying or dipping, problems like limited residual activity (low laundering resistance, cross contamination), no homogeneously treated surfaces (differing surface concentrations of active ingredient), necessity of frequent re-treatment, necessity of individual treatment documentation and high product costs define the need for factory-treated, highly laundering resistant clothing.

In the year 2002, the German Armed Forces first implemented factory-treated, ready-to-wear deployment clothing for wet and dry tropical areas. Factory-treated fabrics show a specific "vector protection" label. Laboratory investigations showed that the new „polymer-coating" method, which binds Permethrin to a polymer layer on the surface of the fiber, is highly laundering resistant while significantly reducing cross contamination when compared with the spraying or dipping methods. Even after 100 launderings under laboratory conditions the remaining Permethrin concentration was 280 $mg/m^2$ of this fabric.

While the use of insecticide-treated bed nets is essential against malaria, the additional implementation of impregnated curtains as well as the partial treatment of tents was experienced to be beneficial. Insecticide-impregnated mosquito curtains as well as impregnated tents may accomplish bite reduction rates of up to 60%. Besides Permethrin, α-cyano-pyrethroids like Deltamethrin, Cyfluthrin, and λ-Cyhalothrin in various concentrations are often used.

Chemoprophylaxis is only available and recommended for the use against malaria. Depending upon quantitative malaria risk, regional resistance situation, and individual exposure behavior, chemoprophylaxis may not be necessary, especially in hypo-endemic areas, or under limited exposure to anopheline mosquitoes. Military leaders have to ensure that all basic procedures (impregnation of clothing, impregnation of mosquito-nets repellents, protection barriers at doors and windows) are applied. Key disadvantages of malaria chemoprophylaxis are the decreasing efficacy due to continuous geographical spread of resistant strains worldwide, difficulties in treatment of complicated or multiresistent malaria and the occurrence of severe side effects, especially when drugs like Mefloquin are taken over longer periods of time or when inappropriately used (13).

Disease risk evaluation and verification teams are essential to define the real threat in a defined geographical region including seasonal changes of disease incidence. These teams usually consist of 2-3 specialists in preventive medicine, tropical medicine and medical entomology and assess the complete risk pattern of communicable diseases of military importance.

Standardized vector monitoring, e.g. using CDC-Light traps, as well as mosquito larvae surveillance is continually carried out during deployment by specialized Preventive Medicine Technicians.

Integrated Vector Control is a basic element for the interruption of the chain of transmission and must address the whole spectrum of vector species. Entomological surveillance data and reported diseases associated with endemic vectors are necessary in order to completely define the strategy of measures suitable for vector control under the given conditions.

The purpose of the NATO guideline AMedP-3 “Chemical Methods of Insect and Rodent Control” (14) is to provide basic information about the use of pesticides to control disease vectors and pests during field situations worldwide. This does also include the professional use and the rapid availability of pesticides in emergencies or outbreak situations during contingency operations, especially in case of NATO Joint Deployment Operations.

Integrated vector management principles will be applied whenever the tactical situation permits, and only pesticides and application techniques proven to be effective are going to be used in order to rapidly

- interrupt the transmission cycle of naturally occurring, or intentionally spread vector-borne diseases,
- prevent further geographical spread of diseases,
- minimize the remaining epidemic potential at least within the camp site areas by reducing infected vector populations.

## OPERATIONAL MEDICINE

Protection against environmental and toxicological threats that impair health and performance of military members requires identification of risks and methods to assess exposure.
During the deployment phase not only sound, temperature, humidity, ionizing and non-ionizing radiation, exposure to sun light and toxins are of importance but also the altitude of the deployment area compared to the altitudes at home. Additionally, fatigue management is a field of great concern, especially looking at highly specialized personnel in the modern operational scenarios.

Physical adaptation to higher altitudes takes weeks. Personnel deployed to areas of higher altitude will show reduced human performance. For mission planning leaders have to be aware of human performance limitations. An interesting field of research is to investigate the benefit of controlled hypoxic exposure prior to deployment. The hypoxic environment might induce full adaptation to high altitudes, although low altitude pressure is not present.

One example for toxic exposure may be the use of Permethrin as explained in the previous chapter. Permethrin belongs to the family of pyrethroids and functions as a neurotoxin, affecting neuron membranes. When sprayed on military clothing, Permethrin might be inhaled. While wearing treated clothing the dermal exposure might lead to some absorption. The urinary excretion rate of metabolites in exposed personnel is a valuable tool for surveillance.

A RTO expert team is looking at neurotoxicological threats in an occupational medicine context. Interactions with physical factors (e.g. heat, dust, work or exercise), psychological stress, and other chemical exposures were evaluated. Research gaps in health risk communication strategies to mitigate risk and achieve optimal compliance with protective measures were also discussed. Recommendations were made for further development of efficient processes for early predeployment consideration of potential threats, assessment and monitoring of neurochemical hazards, and lifecycle health monitoring of exposed individuals (15).
Health and medical care during operations have increasingly become a responsibility of operational commanders and may even become the commander’s main concern. The influence of medical factors on the operational decisions leads to increasing requirements for a professional medical staff to generate interdisciplinary and multi-national solutions. Medical support planning is an integral part of the operational planning process and has to be performed in close co-operation with all other general staff divisions.
The combination of Occupational Medicine, Tropical Medicine and Entomology favors a high level of competency, which is an essential precondition to advise both medical personnel and military leaders and to initiate necessary action.

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