

Review articles

Parasites as etiological factors of nosocomial infections

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ABSTRACT. Nosocomial infections represent an increasing threat to public health. In most cases, they concern patients with risk factors such as taken radio- and chemotherapy, those whose immune system might be suppressed and those who might be HIV-positive. Most studies of the incidence of nosocomial infections ignore parasitic infestations. Based on data from 1,265 intensive care units in 75 countries, it was found that the proportion of parasites in nosocomial infections was 0.48% overall, and 0.25% in Western Europe. An analysis of the available literature indicates an increase in the number of hospital parasitoses.

Key words: nosocomial infections, parasites, etiological agents, hospital-acquired parasitosis

Introduction

Nosocomial infections represent an increasing threat to public health. In most cases, they concern patients with risk factors such as taken radio- and chemotherapy, those whose immune system might be suppressed and those who might be HIV-positive.

The Chief Sanitary Inspectorate (Główny Inspektorat Sanitarny) recorded 339 hospital-acquired infections in 2011 [1], and 304 the year before [2]. The number of reported epidemic outbreaks increased threefold from 124 to 339 during the period 2006–2011, which may be associated with a greater awareness of workers and closer observation of regulations. These infections were associated with non-surgical departments (Internal Medicine, Cardiology, Neurology, Nephrology, Rheumatology – 31.3% – figure 1), intensive care units/ICU (13.8%), pediatric departments (13.2%) and surgical units (11.2%). In 2011, 3,195 people were infected: 2,902 patients and 293 employees. The most common cause of nosocomial infections in 2010 were noroviruses (20.4%), and 2011 saw a significant increase in the prevalence of infections caused by *Clostridium difficile*: 11% compared to the 8.2% seen in 2010. A

report of The Program of Hospital Hygiene Promotion [3] notes that *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and other Gram negative bacilli are the most common causes of hospital-acquired infections.

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Intestinal parasites in nosocomial infections

According to the investigators of teams for Control of Hospital-Acquired Infections, one sign of nosocomial infection is diarrhea, most commonly caused by viruses such as rotaviruses and bacteria such as *Clostridium difficile* [1–3]. Parasites have been observed to be etiological agents of diarrhea in 12–17% of nosocomial epidemics and 1% of endemic outbreaks [5]: this figure being higher in surgical wards (19.8%) [6]; most frequently, protozoa such as *Cryptosporidium* sp., *Entamoeba histolytica*, *Giardia lamblia* and *Blastocystis* sp. were detected. Only in isolated cases helminths were noted. Intestinal parasites are frequently

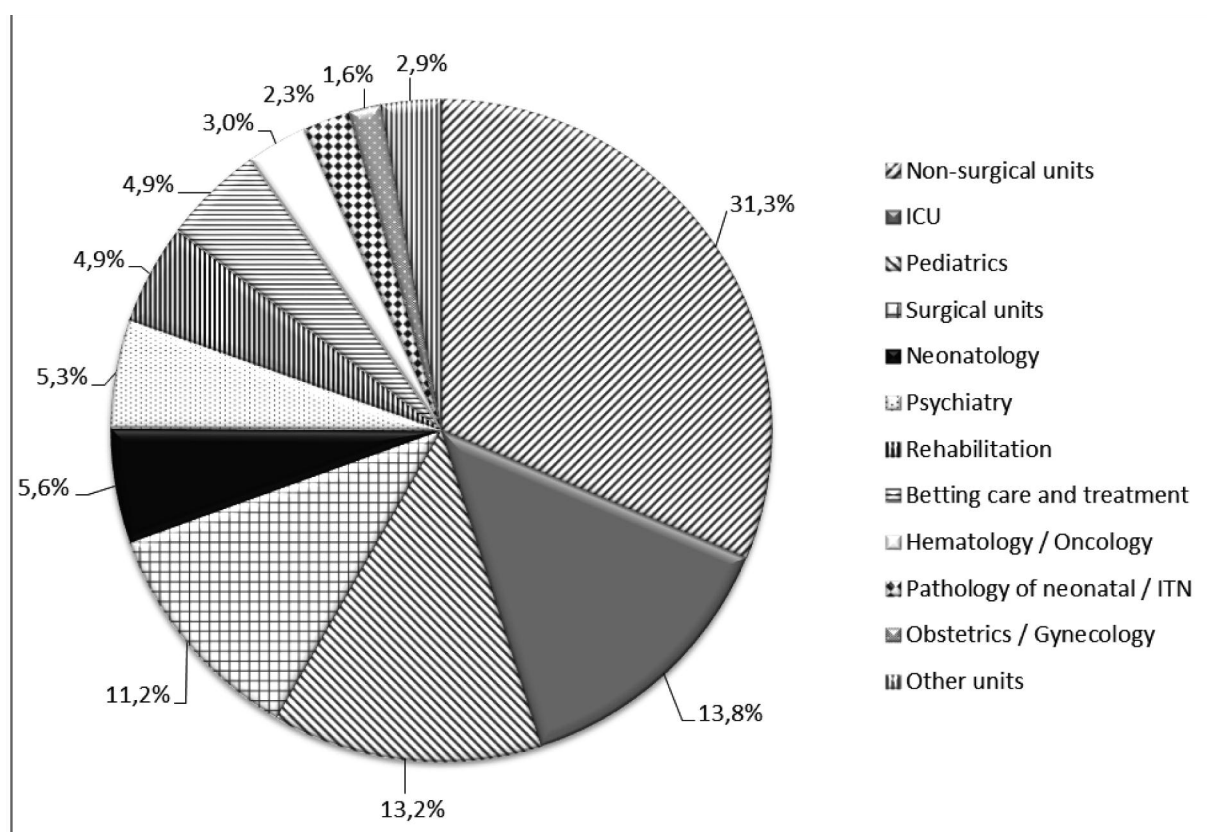


Fig. 1. Occurrence of epidemic outbreaks or hospitals wards on the Report of Chief Sanitary Inspectorate

recorded among patients after chemotherapy, steroid therapy and long-term antibiotic therapy against bacteria, and therefore may affect patients in oncological, intensive care, internal medicine, geriatric and pediatric wards [1,5–7]. In Tunisia, *Cryptosporidium hominis* was found in about 45% of children with a complex immune deficiency, in whom profuse diarrhea was seen [8]. In pediatric wards, although *Enterobius vermicularis* has been seen to spread extremely quickly, their occurrence does not need to be reported, as is the case with nosocomial infections. Lacroix and Sørensen [9] demonstrate that the prevalence of pinworms in children staying in hospital is 22%, reaching as high as 29% in the group of 5- to 12-year-old children. Epidemiological studies carried out in several psychiatric hospitals have revealed the presence of parasites in 8.4% of patients, with two- and three-species invasions in 2.1%: the most common species identified in Internal Medicine ward being *Trichuris trichiura* [10]. Infections were three times more common in those hospitalized for more than three years, which suggests transmission between patients [10,11].

Protozoa causing diarrhea can be transmitted through food and water contaminated with feces,

direct contact with a sick person, or indirectly through the use of shared equipment and through care treatments [5,12,13]. Intestinal protozoa may lead to outbreaks of epidemics just as rotavirus and *Clostridium difficile* [1]. One of the most interesting cases was such an outbreak in a hospital in Copenhagen [14]. As many as 18 HIV-positive patients in a short time were infected with *Cryptosporidium* spp. Epidemiological investigation showed that the source of the parasite was a patient with cryptosporidiosis and a psychotic history, who, through frequent use of the ice machines, contaminated ice cubes with *Cryptosporidium* cysts. These cysts are very resistant to environmental conditions, being able to survive for up to 2 hours, even on a dry surface [15]. Thus, contamination of ice in a very short period of time resulted in the spread of the pathogen among people with impaired immunity. Unfortunately, most of the liquids used for disinfection do not possess antiparasitic activity, or their effectiveness against protozoan cysts or helminth eggs is low; also the cysts of some other protozoans, such as *Giardia lamblia* and *Entamoeba histolytica*, demonstrate significant resistance to biocidal agents [15,16].

Etiological factors associated with transfusions and transplantations

As one of the risk factors for parasitic nosocomial infections is immunosuppression, infection is more likely in patients undergoing transplantation [17]. According to the literature, while parasitosis affects around 5% of organ recipients, rates of infection with intestinal parasites as high as 33.3% were seen among patients after kidney transplantation [18,19]. *Entamoeba coli* and *Endolimax nana* were detected most frequently, and *Ascaris lumbricoides* only once. The majority of the infections after transplantation are helminths infections and they are associated with water or food contamination. The literature also indicates the possibility of transferring the parasite from the donor to the recipient together with the organ transplant or blood transfusion.

During transfusion, infection most often occurs with protozoa of the genus *Plasmodium*, which causes malaria in humans. The first such case was recorded in 1911, and by 1979, the number of post-transfusion malaria cases had increased to 145 per year [20]. Before 1950, the most commonly identified species was *P. vivax*, in the period 1950 to 1970 it was *P. malariae*, and following this, until 1985, it was again *P. vivax*. Currently, the most common factor of post-transfusion malaria is *P. falciparum*, which is responsible for 25% of cases. However, *P. vivax* can cause 20% of infections after blood transfusion. In endemic areas, the threat posed by contamination of blood products is very high; for example, in Senegal, malaria is the third most common source of post-transfusion

infection, after HBV and syphilis, and ahead of HIV [21]. In most cases, post-transfusion malaria results in the death of the patient [22,23]. It was found that all species of *Plasmodium* can survive and remain potentially invasive for 7 days in preserved blood and up to 2 years in frozen blood. It has been shown that the source of infection may be not only full prepared blood, but also the blood products derived from infected donors, such as concentrated red blood cells, white blood cells, platelets and cryoprecipitate [23–25]. Therefore, blood donors in Europe who have visited or come from areas endemic for malaria, are tested for *Plasmodium* as standard [23]. Unfortunately, donors sometimes forget or deliberately do not provide information about trips abroad. Over a period of 20 years in the United Kingdom, 5 cases of post-transfusion malaria were recorded (Table 1), with at least two donors not giving complete information on stays abroad, and in one case an infected donor was incorrectly classified in the computer system [23]. Talabiska et al. [26] describe a case of malaria development in a liver recipient in whom blood transfusions were also used. Although the protozoa probably arrived together with the transfused blood, the authors do not exclude the implantation of an infected organ as the route of infection.

Blood and transplanted organs may be sources of infection also with other protozoa. Reports about post-transfusion and post-transplant infections with *Toxoplasma gondii* [27], *Trypanosoma cruzi* [28,29] and *Leishmania* sp. [29] can also be found in the literature. Leyva and Cruz [27] describe a case of cutaneous toxoplasmosis in a patient after transplantation, in whom the protozoan was

Table 1. Cases of post-transfusion malaria due to errors in the donor qualifications in the UK 1986-2006

No.	Date	Recipient – preparation type	Donor
1	1986	72 F – platelet concentrate	Male worked 10 years in Africa (from two years in England), suffered from malaria
2	1986	81 F – full blood	Male born in Ghana, incorrectly classified as a donor by the system
3	1994	M – full blood	A woman born in Nigeria, in England from 4 years, visited Ghana in 1993 - did not give this information during blood donation!
4	1997	62 M – full blood, died of cerebral malaria	19 year old woman born in Ghana, in 1994 was in Uganda and during the stay fever appeared
5	2003	51 M – full blood, died despite successful treatment of malaria	38 year old woman born Ghana, last stay in Ghana in 1996

M – male, F – female

transferred along with the bone marrow. In few patients after kidney transplantation, side effects were noted from the implanted organ [30,31]. During repeated operation, the presence of numerous larvae of *Strongyloides stercoralis* in kidney transplant was observed, suggesting that the nematode transmission from donor to recipient took place through the transplanted organ [30].

Protozoa developing in human blood and tissues can also be transmitted in the course of routine hospital activities and care of patients [32,33]. To save time and equipment, it happens that staff have been known to prepare a batch of doses in one syringe which are then given to several patients, although the hospital procedures do not allow for such practices. In Korea, Brazil, Colombia and Taiwan, *Plasmodium falciparum* transmission has been reported during the intravenous administration of antibiotics or catheter use [22,34–36]. Although the transmission path has not been established, epidemiological investigations have revealed that those patients shared a room, and were subject to the same medical treatment, performed by the same staff. Piro et al. [37] describe the case of *Plasmodium falciparum* infection in two patients by contamination of gloves used by staff. Infection has also been recorded via contamination of the syringe used for saline rinses of catheters of patients in the same room [38], the contamination of multi-dose vials of heparin [39] or even as a result of irregularities in the use of glucose meters [32]. The risk of malaria infection also concerns hospital workers. A case in which a nurse was accidentally pricked by the angiocatheter stylet during care of a patient with malaria [33]. After several days the nurse displayed symptoms of increased temperature, chills and vomiting, and tests showed that 7% of erythrocytes had become infected by *Plasmodium falciparum*. Unfortunately, before the onset of the disease in the nurse, another patient under her care had been accidentally infected.

Scabies

Scabies is a disease usually associated only with a lack of basic hygiene and low socio-economic status, although this typical profile only fits 55% of the examples [40]. In more than 30% of cases, scabies affects people who arguably care too much about hygiene; this atypical scabies with almost imperceptible symptoms which are often not recognized can be a source of infection for others.

Another 15% of cases of scabies are impetigo-like, eczema-like and Norwegian scabies, which are characterized by very severe symptoms and concern people with strongly weakened immune systems. So far, Norwegian scabies has been reported in patients with AIDS, and those who are exhausted physically and mentally retarded.

The combination of the high degree of hygiene, the presence of people with weakened immune systems, and the potential sources represented by patients with AIDS, the homeless, nursing home residents or those being treated with steroids, favors the transmission of *Sarcoptes scabiei* in the hospital environment [1,40]. A literature review reveals 23 nosocomial epidemic outbreaks of scabies worldwide between the years 1985 and 2012 [40–42]. The average duration of the outbreak was approximately 14.5 weeks with 3 to 82 patients and from 6 to 278 hospital workers and their families being infected [41]. The source of infection was often a patient with Norwegian scabies [43,44]. In one outbreak in 2007, 19 people were infected, including as many as 9 family members of staff, of whom 6 were children aged from 7 months to 6 years [44]. In 2005, at one of the geriatric units, epidemic scabies appeared double times and affected a total of 51 people [45]. Another outbreak of scabies in a Teaching Hospital in Baltimore in 1996 affected 82 patients and 113 employees [46].

Unfortunately, not all cases of nosocomial outbreaks of scabies are made public. The report of Chief Sanitary Inspectorate reveals that in 2001–2010, scabies accounted for approximately 5% of hospital-acquired infections. In only 2010, 15 outbreaks of human scabies were recorded in Polish hospitals [2].

Animals staying at hospitals for animal facilities or animalotherapy, or those who are simply pests, can be a source of mites which are unusual for humans. In 1987, a series of infections with bird scabies, *Dermanyssus gallinae*, were recorded, in which two patients, two nurses and a physician suffered an itchy erythematous papular rash. The source of the mites were pigeons perching on the ledges outside the hospital, and around the ventilation ducts [47].

The role of insects in nosocomial infections

The sanitary condition of hospitals is of great importance in the prevention of nosocomial infections. Unfortunately, the Chief Sanitary

Inspectorate report shows that cases of neglect can still be found; although all the 614 hospitals on Polish territory in 2010 had their own central sterilization units, only 141 of these facilities (only 23%) used sterilization procedures up to the standard of Ministry of Health regulations dated 10 December 2006 concerning requirements that must be met in rooms in health care facilities in terms of technical and sanitary (currently valid Regulation of 2 February 2011) [2,48,49].

Poor sanitation procedures encourage the occurrence of a range of pests, such as insects, in hospitals. In a Swiss hospital, about 30 cockroaches, *Ectobius vittiventris*, were observed hiding in oxygen masks, moving on raster under ceiling and falling at night onto intubated patients in the intensive care unit in a single day [50]. A 2000–2002 study by the Polish National Institute of Hygiene evaluated the occurrence of insects in hospital rooms: *Blattella germanica* were found in 79.2% of units, *Blatta orientalis* in 33.3%, and Pharaoh ants, *Monomorium pharaonis*, in 20.8% [51]. In addition, flies were typically found in up to 29.2% of the hospitals, mosquitoes in 12.5%, fleas in 8.3% and wasps in 8.3%. However, despite the procedures being tightened, the overall level of hygiene has not appeared to improve. On the contrary, in 2004, the National Institute of Hygiene noted the existence of flies in 35%, Pharaoh ants in 22% and fleas in 12% of Polish hospitals. Cockroaches were detected in the kitchens, warehouses and laundries of most of the hospitals, in 10% of patient rooms, in 12% of corridors, in 4.3% of sterilization facilities, and even in – 2% of surgical units or in treatment rooms [52]. The emergence of lice or fleas on the ward could result in the outbreak of an epidemic. Head lice epidemics have occurred specifically in children's wards, internal medicine, geriatric, hospital emergency departments and psychiatric hospitals. Studies conducted in Seoul in a psychiatric hospital showed infestation of both body lice and head lice (*Pediculus humanus*) in 33.3% of female patients and 15.4% of male patients [53]. In the Training Materials for Epidemiological Nurses from 2006, *Pediculus humanus capitis* was recognized as the most common, and *Pthirus pubis* the least common [54].

The presence of animals, in form of „therapists” or as potential pests such as rats, promotes the spread of fleas in health care. An outbreak of *Ctenocephalides felis* in a Malayan hospital affected

both the patients and the employees [55]. A paucity of information exists regarding the presence of lice and fleas in hospitals. Such cases appear to be underestimated by both the staff and the management of hospitals. Besides transferring *Rickettsiae* of epidemic typhus or endemic typhus, these insects can cause severe allergic reactions. In cases of serious *Pulex irritans* infestation, melanoderma can occur – the transformation of haemoglobin in melanin, resulting in hyperpigmentation and spots on the skin [56].

As well as polluting facilities with faeces or giving painful stings with possible allergic reactions, insects are also the source of many pathogenic microorganisms. Numerous viruses can be carried on the legs, mouth apparatus or in the gastrointestinal tract along with a large number of bacterial cells and spores, fungal spores, protozoa cysts and invasive forms of helminths. Literature data indicates that transmission of different species of *Plasmodium* between patients staying in the same room is possible [34].

Studies concerning the biota inhabiting *Blattella germanica* present in rooms of the Public Hospital of Hamadan in Iran indicates significant contamination of these insects by microorganisms potentially pathogenic to humans [57]. The presence of fungi of the genus *Candida* was noted in as many as 48.9% of cockroaches. In individual cases, the presence of eggs of the human pinworm and roundworms of the genus *Ascaris* was also found. Similar studies were conducted as part of the 2003–2006 Polish National Institute of Health Project 3 P05D 10624: „Synanthropic cockroaches as a possible source of infection in the hospital environment. Estimation of the risk to patients”. Eighty bacterial strains were found on the exoskeletons of randomly selected cockroaches caught in Warsaw hospitals: 34 strains of Gram + cocci, 15 Gram + bacilli and 31 Gram – bacilli [58]. Half of the cocci isolated were bacteria from the genus *Enterococcus*, which are one of the common etiological agents of nosocomial infections. Among the isolated bacteria, a significant proportion of strains resistant to antimicrobial agents were recorded.

Similar studies have been carried out in other countries. A study in Ethiopia identified a significant presence of multidrug-resistance in bacteria causing gastrointestinal infections such as *Salmonella* sp., *Shigella* sp., *Escherichia coli*, *Bacillus cereus*, which were isolated from the

surface of the body and in the gut of cockroaches [59]. In addition, another study identified 45 species of bacteria, including *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Bacillus cereus*, *Klebsiella pneumoniae*, *Escherichia coli*, *Stenotrophomonas maltophilia* and *Yersinia frederiksenii* on the body surface of *Clogmia albipunctata* moths, commonly occurring in German hospitals [60]. In these studies a significant multidrug-resistance of isolated strains was also recorded. Both the wealth of microbiota found in the analyzed cockroaches and moths, as well as the significant resistance to antibiotics and chemotherapeutics possessed by these microorganisms indicates a potential risk to patients, and suggests that insects can be a reservoir of resistance genes for common pathogens in the hospital environment [58].

The presence of flies in hospitals also offers a high risk for patients. In its life cycle, flies undergo a maggot stage. That is a larvae developing in dead organic matter, such as a carcass. In a few cases, egg laying and larval growth can occur in a living animal body, in the intestine or necrotic tissue, resulting in the myiasis. In the literature, few cases of laying eggs by flies in the bodies of hospital patients are reported [61,62]. Patients exposed to eggs laid by flies and the subsequent development of myiasis are often immobilized persons, with extensive damage to the skin and soft tissues, especially in the case of tissue necrosis due to accidents, burns or surgery, those with neuropathic complications such as diabetic foot, and those with a mental illness such as schizophrenia or those with autism [63–67]. The species most commonly causing hospital myiasis include *Phaenicia sericata*, *Lucilia sericata*, *Cochliomyia macellaria*, *Cochliomyia hominivorax* and *Sarcophaga peregrina* [61,65–69]. In mentioned cases, the deposit of insect eggs was found to have taken place during the patient's stay in hospital. A particularly clear example is the case of a girl who was born prematurely, at whom myiasis developed in the vagina aperture during the stay in the incubator [70]. Joo and Kim [61] note the commonness of fly maggot invasion and its probable underreporting by the administration of hospitals and health departments for economic reasons and hospital policy.

Summation

The most recent health legislation of 23 December 2011 regarding the list of emergency

factors, registers and emergency factors of nosocomial infections and hospital reports regarding the current epidemiological situation, ignores parasites [71]. The report of the Polish National Institute of Public Health of the period 1.01–31.12.2012 shows that the number of reported parasitic infections, such as echinococcosis, malaria, cryptosporidiosis and toxoplasmosis, rose compared to the comparable period in 2011 [72]. An analysis of the available literature also indicates an increase in the number of hospital parasitoses. More travel is taking place to areas endemic for many species of parasites and consequently, symptoms of infection are reported upon returning, sometimes even years later. As these patients are admitted to hospital where in many cases, they can be a source of infection to others, it seems reasonable to extend the list of emergency factors to include parasites such as *Plasmodium* and *Trypanosoma*. Also noteworthy are the mites and insects that can live on the human skin and inhabit the hospital environment. Their activity, and the microorganisms that colonize them, can pose a threat to people weakened or immunosuppressed with chemotherapy or long-term antibiotic therapy.

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