Pediculosis

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The 3 major lice that infest humans are *Pediculus humanus capitis* (head louse), *Pthirus pubis* (crab louse), and *Pediculus humanus humanus* (body louse). Patients with louse infestation present with scalp pruritus, excoriations, cervical lymphadenopathy, and conjunctivitis. A hypersensitivity rash, or pediculid, may mimic a viral exanthem. Head lice infestation crosses all economic and social boundaries, whereas body lice infestation preferentially affects the homeless and displaced. Body lice are major vectors of diseases such as typhus, trench fever, and relapsing fever. Pubic lice infestation often is acquired as a sexually transmitted disease and may be a marker to screen for other sexually transmitted diseases. Treatment of louse infestation can be challenging. Mechanical measures, such as combing, are helpful as adjunctive measures, but most studies suggest they are not as effective as chemical agents. Resistance to chemical agents is a growing problem. Major types of resistance include knock-down resistance, glutathione-S-transferase–based resistance, and monooxygenase-based resistance. Research is needed to identify new effective treatments. (J Am Acad Dermatol 2004;50:1-12.)

Learning objective: At the completion of this learning activity, participants should be able to diagnose and manage pediculosis capitis, pediculosis corporis, and pediculosis pubis. Participants should recognize simulators of louse infestation, including hair casts and psocids. They also should know the major vector-borne diseases spread by body lice.

Pediculosis, or louse infestation, remains a worldwide problem. The lice that infest human beings are almost always sucking lice that live in close association with the host and lay their eggs on hair shafts or in the seams of clothing. Chewing lice commonly affect livestock and are of great economic importance, but they rarely affect humans. Free-living psocids, primitive louselike creatures, have been found to infest humans, but such infestation is rare. Almost all of the hundreds of thousands of cases of louse infestation that occur every year are caused by members of only 3 species, the human head louse, the body louse, and the crab louse.

Head louse infestation crosses all social and geographic boundaries, occurring in affluent suburban schools and inner-city schools alike. Treatment failures are common, and patients often seek the advice of a physician only after over-the-counter remedies have failed. Drug resistance is being reported in many parts of the world, and a working knowledge of the mechanisms of resistance is important for the dermatologist in practice.

Body lice preferentially affect the homeless and displaced. They remain major vectors of diseases such as typhus, trench fever, and relapsing fever. In refugee situations, these diseases can kill thousands. Among the homeless in urban areas, louse-borne endocarditis is caused by the trench fever organism.

In this article, we review the taxonomy, epidemiology, and treatment of the 3 major types of lice that infest humans. We present data about the most significant louse-borne disease and discuss simulators of louse infestation, including hair casts and psocid infestation.

Taxonomy

Louse infestation in humans is almost always caused by sucking lice of the phylum Arthropoda, class Insecta, order Phthiraptera, suborder Anoplura, family Pediculidae or family Pthiridae. Three types of lice uniquely infest humans and are generally site-specific: *Pediculus humanus capitis* (the head louse), *Pediculus humanus humanus* (the body louse), and *Pthirus pubis* (the crab louse).[1] Entomologists have debated the correct taxonomy of head and body lice. At this time, it is best to refer to the body louse as *Pediculus humanus humanus* and

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Funding: None.
Conflict of interest: None identified.
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0190-9622/$30.00

doi:10.1016/S0190-9622(03)02729-4

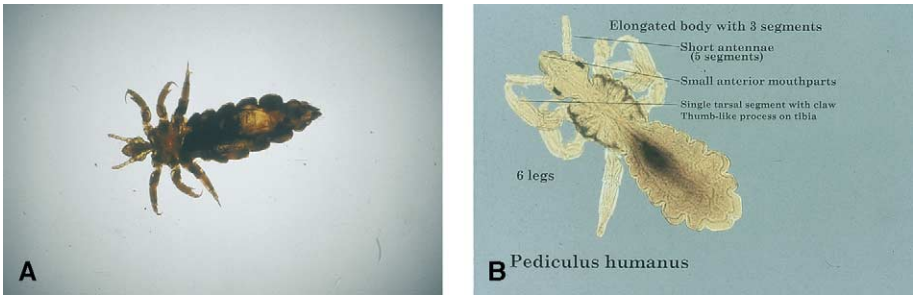

Fig 1. A and **B,** Identifying characteristics of a head louse. (**B** from Elston D. Cutis 1999;63: 259-64. Reprinted with permission. All images in this CME article are in the public domain.)

the head louse as *Pediculus humanus capitis*. They are widely regarded as variants of the same species.[2] *Pthirus pubis* belongs to a separate genus and species in the family Pthiridae.

PEDICULOSIS CAPITIS

Pediculosis capitis is caused by infestation of the scalp with *Pediculus humanus capitis*. It is estimated that in the United States, pediculosis capitis affects 6 to 12 million people per year.[3] Exact numbers are unknown, as it is not a reportable disease. Infestation may be more common during warmer months.[4] Head lice generally affect children, primarily girls, aged 3-12 years.[3,5-7] Transmission is thought to occur through head-to-head close contact, the sharing of headgear, or contact with other fomites (inanimate objects that harbor the disease organism).[3] A recent study of spatial and kinetic factors involved in the transfer of head lice indicated that transfer is optimal to hairs that are parallel and slow-moving relative to the infested hair.[8] This finding suggests that direct head-to-head contact for a prolonged period may be the most important mode of transmission.

Fig 2. Head louse nit attached to hair shaft.

Louse characteristics

The head louse is the size of a sesame seed, 1-2 mm in length. It is wingless, dorsoventrally flattened, and elongated (Fig 1). It has narrow sucking mouthparts hidden inside the structure of the head, short antennae, and three pairs of clawed legs that are adapted to grasp hairs.[1] The eyes and labial palps are greatly reduced in size and appear almost vestigial. Stylets are present, rather than mandibles. The louse inserts its mouthparts and injects saliva with vasodilatory properties. Head lice move by grasping hairs, generally remaining close to the scalp. Head lice can crawl rapidly, traveling up to 23 cm/min.[9] Lice egg cases are referred to as nits, are firmly cemented to human hair, and are thus difficult to remove (Fig 2). It may be possible to differentiate *Pediculus* nits from *Pthirus* nits, as the latter are attached to the hair shaft at a relatively more acute angle.[1]

Except in very humid climates, lice lay nits (ova within a chitinous case) within 1-2 mm of the scalp. The nit cases are firmly cemented to the hair shaft. Young lice hatch within 1 week and pass through 3 nymphal instar stages, growing larger and maturing to adults over a period of 1 week. First and second instar forms are not easily transmitted from one individual to another; most spread is related to third instar forms and adults.[10] One female head louse can lay 50 to 150 ova over an average lifetime of 16 days. Lice must generally eat every 4 to 6 hours. In most climates, they survive only several hours off the scalp, although they may live for up to 4 days in favorable conditions.[1,11]

Fig 3. Hundreds of hair casts presenting as pseudonits in a young girl.

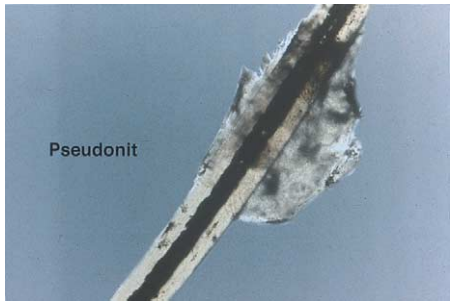

Fig 4. Microscopic mount of amorphous keratin forming the pseudonit.

In the United States, African Americans have a lower incidence of infestation. Factors that contribute to this lower incidence may include the use of hair pomades and characteristics of lice that make them better adapted to grasp the more cylindrical hairs of Caucasians or Asians.[12]

Clinical manifestations

Nits are often in the occipital and retroauricular portions of the scalp and are seen easily in comparison with crawling adult lice. Identification of lice may be easiest by means of combing. Although patients with lice can be asymptomatic,[13] pruritus is common. Bite reactions, excoriations, cervical lymphadenopathy, and conjunctivitis are also common manifestations.[11,14] A hypersensitivity rash, or pediculid, may mimic a viral exanthem. Bite reactions are classified into 4 phases. Phase I has no clinical symptoms, phase II entails papules with moderate pruritus, phase III consists of wheals immediately following a bite with subsequent delayed papules and intense itching, and phase IV is characterized by smaller papules with mild pruritus. The phases presumably are related to evolution of immune sensitivity and tolerance. Notably, new bites may cause reactivation of older, healed bites.[11] An inflammatory reaction to injected louse saliva or anticoagulant has been suggested as the most likely cause of the bite reactions.[15]

Diagnosis and differential diagnosis

The diagnosis of head lice is definitive when crawling lice are seen in the scalp hair or are combed from the scalp. As head lice avoid light and can crawl quickly, visual inspection without combing can be somewhat difficult. The use of louse combs increases the chances of finding live lice and is a useful tool for screening.[16,17] Nits alone are not diagnostic of active infestation, but if the nits are within $\frac{1}{4}$ inch of the scalp, active infestation is likely.[18] In warm climates, viable nits can be found 8 or more inches from the scalp.[19] If the patient presents with a history of nits in the hair, the differential diagnosis includes inner root sheath remnants (hair casts), as well as black and white piedra, caused by *Piedraia hortae* and *Trichosporon beigelii*.[20] Occasionally, hundreds of hair casts will be present on a child's scalp (Fig 3). Hair casts (pseudonits) form when the soft inner root sheath keratin fails to break away from the hair shaft. Instead, it forms a soft ring that encircles the shaft. As keratin may wear asymmetrically, hair casts may closely resemble nits stuck to hair shafts. They are generally noticed by a parent, teacher, or school nurse who mistakes them for nits. In contrast to nits, hair casts are freely movable along the hair shaft. Microscopic examination allows easy distinction of the opaque amorphous hair cast (Fig 4) from a transparent flask-shaped nit firmly attached to one side of the hair shaft.

Nits also can be confused with debris on the hair shaft left by hair spray and accumulated flakes of seborrheic dermatitis. Trichodystrophies, such as monilethrix and trichorrhexis nodosa, have also been mistaken for nits at gross examination. Microscopic examination of hair shafts helps to establish the correct diagnosis.

Psocids are louselike insects that rarely can cause human scalp infestation.[21] They belong to the class Insecta, order Psocoptera, and consist of many different species. Their life cycle includes six nymphal instars. The wingless forms found indoors are commonly known as "booklice" despite the fact that they are not true lice. They belong to the family Liposcelidae, genus *Liposcelis*. The winged forms are generally found outdoors and feed on molds, pollen, and dead insects; these psocids are often found hiding on trees and are called "barklice."[1] Psocids are 2 to 3 mm in length, with chewing mouthparts and long antennae (Fig 5). Psocids are readily differentiated from human lice by their larger heads, large mouthparts, large hind legs, and long antennae.

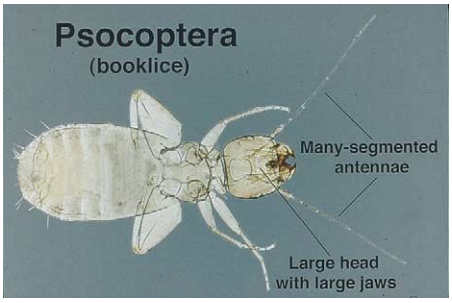

Fig 5. Identifying characteristics of a psocid. (From Elston D. Cutis 1999;63:259-64. Reprinted with permission.)

PEDICULOSIS CORPORIS

Body louse infestation in developed countries is generally seen among the homeless in urban areas. It also is common among refugees and those who live in crowded conditions or cannot launder their clothing. Body lice generally thrive in conditions of poverty, war, and natural disaster. In the setting of the urban poor, the louse acts as a vector for *Bartonella* organisms that may cause fever and endocarditis.[22-24] A study of 57 homeless subjects in Paris indicated that more than half had positive results of serologic testing for *Bartonella quintana,* and positive serologic results were correlated significantly with years of homelessness and the number of previous episodes of pediculosis.[25] Similarly, *Bartonella quintana* was detected in 16.7% of homeless people in Tokyo.[26] There is evidence that the vector influences the disease manifestations of *Bartonella quintana*.[27] When the organism is transmitted by a flea, it is more likely to produce cat-scratch disease or bacillary angiomatosis. When it is transmitted by a louse, it is more likely to produce endocarditis.

Worldwide, body lice are important vectors for louse-borne relapsing fever, trench fever, and epidemic typhus, especially among refugees.[28] Surveillance of body lice for the presence of organisms can be helpful in predicting outbreaks of disease. Louse-borne relapsing fever has been reported in Ethiopian camps for prisoners of war, and in Ethiopian refugee camps in Somalia. Body lice collected from Russia, Peru, France, Burundi, and Zimbabwe have shown evidence of infection with *Rickettsia prowazekii,*[29] the cause of epidemic typhus. There have been no recent reports of this disease in the United States, although outbreaks in Russia[30] and Burundi[31] have been documented. Burundi has had the largest outbreak of typhus since World War II. Coinfection with *Bartonella quintana* has been noted in Burundi, with body lice serving as the vector for both infections.

Typhus remains endemic in areas of the world where American troops travel, such as the former Yugoslavia. Although physicians in North America rarely see typhus, the infection may be imported into the United States from epidemic foci. The United States also has a domestic zoonotic endemic source. North American flying squirrels *(Glaucomys volans* and *sabrinus)* appear to represent a natural endemic reservoir of *R. prowazekii.*[1]

Louse characteristics

The body louse is somewhat larger than the head louse, although it ranges from about 2 mm to 4 mm in length. Other than the larger size, the body louse is indistinguishable from the head louse.

The body louse lives, on average, 18 days. Female body lice lay 270-300 ova in their lifetime, each contained within a translucent chitinous case. The entire unit is commonly referred to as a nit. Nits incubate for 8-10 days, and nymphs mature into adults over about 2 weeks. Body lice live in the seams of clothing and can survive without a blood meal for up to 3 days.[1]

Clinical manifestations

The body louse and nits are generally found in the clothing seams of a parasitized individual, but the louse does grab onto body hairs to feed. Bite reactions are identical to those described above for head lice. With chronic infestation and pruritus, the skin may be thickened and hyperpigmented in a generalized distribution.[32] Clothing may be stained with serum, blood, or louse feces.[10]

Diagnosis and differential

The diagnosis is made by finding body lice or nits in the seams of clothing; preferred locations are in areas of higher body temperature, such as waistbands. The differential diagnosis of pediculosis corporis is broad. Early infestation may mimic atopic dermatitis, allergic contact dermatitis, irritant contact dermatitis, drug reaction, or a viral exanthem. In patients with widespread excoriations, the differential diagnosis includes scabies. Some patients will, in fact, have both scabies and pediculosis. This finding is especially true in refugee populations, where individuals may be infested with lice, scabies mites, and fleas. One study of Ethiopian immigrants showed a 65% rate of head louse infestation, and the prevalence of body louse infestation was 39%. Children were more likely to have head lice, whereas body lice were more common in adults. Ten percent of the immigrants examined had scabies, and roughly 4% were infested with *Pulex irritans* (the human flea), another well-known vector of disease.[33]

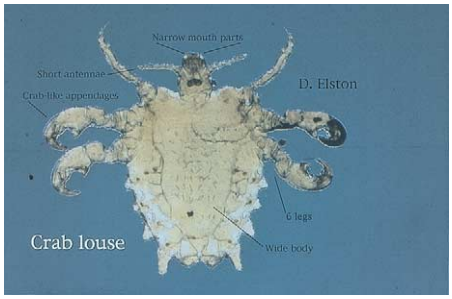

Fig 6. Identifying characteristics of a crab louse.

Fig 7. Crab louse nits at the base of lower abdominal hairs.

PEDICULOSIS PUBIS

Crab louse infestation is commonly spread as a sexually transmitted disease. Furthermore, as human DNA can be extracted from lice, lice have potential to contribute to forensic evidence in cases of rape.[34] Infestation with crab lice may be more common during the colder months.[4] Thirty percent of patients will have another concurrent sexually transmitted disease and therefore should undergo screening for HIV, syphilis, gonorrhea, chlamydial infection, herpes, warts, and trichomoniasis.[10] A retrospective study of 62 adolescents with pubic lice showed that they were twice as likely as uninfested adolescents to have chlamydial and gonorrheal infections.[35]

Louse characteristics

The crab louse is about 0.8-1.2 mm in length. Its legs are clawed, except for the first pair, which are shortened and vestigial. In contrast to the oval shape of head and body lice, the crab louse is almost as wide as it is long, allowing it to grasp widely spaced pubic hairs (Fig 6). Crab lice live for about 2 weeks, and during that time females produce about 25 ova. Nits incubate for 1 week, and nymphs mature into adults over 2 weeks.[1] Adult crab lice can crawl up to 10 cm/day.[10]

Clinical manifestations

The crab louse attaches to pubic hairs and the adjacent hair of the chest, abdomen, legs, and buttocks (Fig 7). Pubic lice occasionally may infest the scalp.[36,37] Nits may also be attached to the eyelashes. A characteristic of established infestation is the finding of maculae ceruleae. These bluish-gray macules on the lower abdomen and thighs are secondary to the bites of the crab louse. The color of the macules presumably is related to deep dermal hemosiderin deposition from the bites. Underwear may be stained with minute droplets of blood and crusts.

Diagnosis and differential

Crab lice can be seen with the naked eye, and diagnosis is generally not difficult if the physician considers the diagnosis and takes time to examine the patient closely. The presence of lice and nits on body hairs establishes the diagnosis of crab louse infestation, as crab lice are generally present in the body hair in great numbers, whereas body lice hide in the seams of clothing where they lay their nits. Nits on the pubic hairs may be mistaken for white piedra or trichomycosis pubis. Extensive excoriations may suggest scabies or contact dermatitis. Some patients will, in fact, have coexisting scabies. Other patients will have tried a variety of home remedies that may have caused an irritant or allergic contact dermatitis. Careful history taking and physical examination are critical.

MANAGEMENT OF LOUSE INFESTATION

Fomite and environmental control

Although there is no proven transmission from fomites (inanimate carriers of an organism), head lice and ova have been found on brushes, hats, combs, linens, and stuffed animals; thus it is probably expedient to eradicate these lice by vacuuming, washing, dry cleaning, or isolating items in sealed plastic bags for 2 weeks.[38,39] Upholstered furniture can be vacuumed. Spraying households and items with insecticides is not necessary. During epidemics in schools, it is best to separate hats and scarves under each child's desk, rather than piling them in a common area. It should be emphasized that all efforts to reduce transmission by fomites are merely adjunctive measures and have not been proved to be necessary to effect a cure. Lice tend to stay in close proximity to the scalp, and the major determinant of effective treatment remains effective killing and removal of scalp lice and ova.

Head louse infestation should be viewed as a community-wide problem. School administrators and parents must work together to eradicate infestations among school children. All children in the infested class or school should be examined, and the problem should be discussed openly. During screening, particular attention should be paid to

Fig 8. Immersion oil mount of a crab louse. The network of respiratory tubules appears as an array of black lines because of the air-fluid interface.

family members and playmates of infested children. Although all children should be examined, empiric treatment of contacts is not required. Successful eradication of infestation is possible by treating only those individuals with confirmed infestation.[40]

In refugee populations, the use of pyrethroid-impregnated mosquito netting for malaria prevention has been shown to reduce the incidence of head lice.[41] Presumably, the mechanism of action is to prevent the spread of lice between families sleeping in close quarters. In Britain, piperonal has been marketed as a louse repellent. Some in vitro data suggest that it may be effective.[42,43] Although these measures hold some promise in special situations, they are only adjunctive measures. In clinical practice, successful treatment of louse infestation still is dependent on the appropriate use of an effective pediculicide. The safe use and proper storage of prescription agents should be emphasized in discussions with the parents.

As chemical pediculicides remain the mainstay of treatment of head lice, the question of drug resistance has emerged as an important issue in recent years. While past studies have shown that malathion, permethrin, and pyrethrins were similar in efficacy,[44,45] these data may be no longer clinically relevant in communities with resistant lice.[46-48] To slow the emergence of resistance, therapeutic agents can be rotated.[49] Malathion was off the market for many years in the United States. A recent in vitro pediculicidal study of lice in Florida indicated a lack of resistance to malathion.[50] Now that malathion has returned to the American marketplace, resistance is likely to emerge. Patterns of resistance often appear to follow patterns of drug use in different areas of the world.[51-53] Resistance to permethrin may cross over to pyrethrins and other pyrethroids.[54] Lice resistant to both pyrethrin and malathion have been documented in Britain.[55]

Most studies of pediculicides focus on head lice, as families with head louse infestation represent the largest commercial market for pediculicides in industrialized countries. Various methods have been used to assess the efficacy of potential agents, and no single method has been validated as optimal. In vitro studies and studies in closed populations may not be predictive of results in actual clinical use. At present, judgments of the relative efficacy of available agents are based on a variety of in vitro methods and limited field trials. Resistance patterns vary in different geographic locations, and treatment should be tailored to local resistance patterns and availability of agents.

Therapeutic failure may result from continued contact with another infested individual, insensitivity of the ova to the pediculicide, or resistance of both lice and ova to the agent. There are different mechanisms for louse resistance. Surveillance for resistant lice should address knock-down resistance (nerve insensitivity), glutathione-S-transferase–based resistance (a cause of dichlorodiphenyltrichloroethane [DDT] and pyrethroid resistance), and monooxygenase-based resistance (enhanced drug metabolism that may be overcome by synergistic agents such as piperonyl butoxide).[56] Evolving strategies in response to different mechanisms of resistance may involve the choice of an alternate agent or combinations of agents. Oral drugs have the theoretical advantage of direct ingestion by the louse, bypassing the need for absorption through the chitinous body or respiratory tract (accentuated by the air-fluid interface in an oil preparation and visible as a black network in Fig 8).

Many treatment failures are not related to drug resistance. The efficacy of any agent is dependent not only on the active ingredient but also on the vehicle and proper application of the agent. Causes of treatment failure include improper dilution or duration of application, differences in formulation, reinfestation from untreated contacts, and relative lack of ovicidal effect of some agents.[57] Specifically, products are often applied to wet hair, which dilutes the product and protects lice as they reflexively close their respiratory spiracles when exposed to water.[58] Most products should be applied to dry hair. Hair conditioners may coat the hair shafts and prevent pediculicides from binding adequately to the hairs.[55] For practical purposes, it may be best to assume that no product is reliably ovicidal and that patients will not comply fully with instructions. Retreatment in 1 week to 10 days is advisable to kill recently hatched nymphs.[45] Agents currently licensed for the treatment of head lice are listed in Table I. Advice for the clinician faced with a patient with refractory head lice is summarized in Table II.

Table I. Pediculicidal agents currently approved for the treatment of head lice in the United States

Name	Pregnancy category	Instructions for use	Precautions
Permethrin 1%	B	Apply topically to body or dry scalp for 5-10 minutes; then rinse off; repeat in 1 week	Allergic/irritant dermatitis
Lindane	B	Apply topically to body or dry scalp for 5-10 minutes, then rinse off; repeating in 1 week is probably necessary, but risk of toxicity increases	Risk of seizures; allergic/ irritant dermatitis
Pyrethrins	B	Apply topically to body or dry scalp for 5-10 minutes; then rinse off, repeat in 1 week	Allergic/irritant dermatitis
Malathion	B	Apply topically to body or dry scalp for 8-12 hours; then rinse off, repeat in 1 week	Respiratory depression

Table II. Advice for the clinician faced with refractory head lice

1. Positively identify the lice or nits to distinguish them from simulators.
2. Establish what agents have been used and how they were used.
3. Decide if drug resistance is likely, or if improper use or reinfestation is the likely cause of failure.
4. Enlist the help of parents and school officials to identify untreated contacts.
5. Use cream rinse, vinegar, or a commercial nit removal system to help with mechanical removal.
6. Combine mechanical removal with a chemical agent.
7. Choose a chemical agent on the basis of what agents the patient has already used and local patterns of resistance.
8. When resistance is prevalent, consider using agents sequentially.
9. Occlusive hair gels are imperfect but may be of some benefit when added as an adjunctive measure.
10. Be prepared to discuss alternative agents. Your patients will often have found them on the internet and will ask about them. You can prevent toxicity and maintain credibility by being knowledgeable about these agents.

Some schools have adopted a "no nit" policy, and children may not return to school until all nits, as well as crawling head lice, are eradicated. These policies may do more harm than good, as many children with nonviable nits are excluded from the classroom. Nit removal can be problematic, and in dryer climates, nits more than ¼ inch from the scalp should not be considered a sign of active infestation. One study of 50 children with nits alone and no evidence of crawling lice showed that children with nits within ¼ inch of the scalp were more likely to have conversion to active infestation with crawling lice, while most of the remaining children did not have such conversion.[16] Thus the presence of nits alone probably should not be the basis for excluding children from school.[35,59] It would be better to base an assessment of continued infestation on the location of the nits and the presence of crawling lice found during combing.

Specific treatments for head lice

Mechanical removal. Although shaving of parasitized hair on the scalp or the body eradicates head lice, this treatment is not cosmetically acceptable for most patients.[60] Wet combing is popular in the United Kingdom, where there has been documented increasing resistance to pyrethroids and malathion. In a small study, investigators compared wet combing by nurses against treatment with a topical pediculicide and found that while both modalities were less than 30% effective in achieving a cure, wet combing was superior.[61] Wet combing involves combing wet hair with a specially designed comb every 3-4 days. The hair is wetted because, when exposed to water, lice are temporarily immobile and therefore easier to comb out. The duration of this treatment is 2 weeks or more. This treatment is time-consuming for parents. Another study indicated that wet combing was half as effective as malathion in eradicating head lice.[62] Similarly, a study of wet combing in Belgium showed that the cure rate for this modality was low.[63] Combing alone without wetting the hair is also unreliable.[64] Application of diluted vinegar or commercial preparations of 8% formic acid may aid in the removal of nits and

may improve compliance by making combing easier.[65] A variety of enzymatic nit removal systems has also been marketed to aid in combing.

Plastic nit combs may break, especially with heavy nit infestation in thick hair.[66] Some parents complain that it is difficult to move the combs through thick hair. Sturdier metal nit combs are available through the Internet. The use of ample water, conditioner, vinegar, or a commercial nit removal system may help with the combing process.

Chemical agents. Given the drawbacks of mechanical removal, the majority of patients will undergo treatment with a chemical agent. These agents are summarized in Table I. The ideal agent would be inexpensive, readily available, easy to use and to remove from hair, nontoxic to humans, without negative environmental impact, and without potential for development of resistance. Such an agent remains elusive. Most agents currently marketed are reliant on neurotoxicity to kill lice. There is a need for a water-soluble agent that will effectively occlude the respiratory openings of lice and nits or occlude the digestive system so effectively that it kills lice without relying on neurotoxicity. The agent would have to be cosmetically elegant to appeal to the consumer. Until such agents are developed, we rely on a relatively small array of chemical agents that have proved effective in controlling lice. The appropriate choice of an agent is dependent on local resistance patterns, and these patterns continue to change. In general, agents that already have been used by the patient are less likely to be effective, although improper dilution and reinfestation may simulate drug resistance. Web sites of credible sources such as the Food and Drug Administration may be useful to clinicians in the planning of therapy.[67-69]

DDT. The first pediculicide widely available was DDT, which was the main agent used in the treatment of body lice infestations during World War II. This agent has not been available for some time because of its toxic environmental effects.[36]

Permethrin. Permethrin 1% (Nix) is widely used as a treatment for head lice and is available over the counter in the United States. Evidence suggests resistance has been increasing.[61] Permethrin is a synthetic pyrethroid. It is retained on the hair after the initial application and thereby has a "residual effect" for 2-3 weeks, although retreatment at 1 week is still widely recommended. The mechanism of action is interference with sodium transport in the arthropod, subsequent depolarization of neuromembranes, and resultant respiratory paralysis.[70] Permethrin 5% (Elimite) is marketed as a treatment for scabies. It has been used in an effort to overcome relative resistance to permethrin 1%.[71] Unfortunately, permethrin-resistant lice may be resistant over a wide range of doses. Still, as permethrin products have a favorable safety profile with low toxicity, they are still widely used.[72]

Lindane. Lindane 1% (formerly Kwell) is an organochloride that kills lice by causing respiratory paralysis. While lindane has been taken off the market in California due to reports of central nervous system toxicity,[73] the actual neurotoxic potential is quite low when the product is used according to the manufacturer's instructions.[74,75] As it is absorbed into the blood stream and is slowly metabolized, it should not be used repeatedly. Ingestion or frequently repeated applications increase the risk of toxicity. It may not be the best choice for young children, patients with an impaired cutaneous barrier, or patients with seizure disorders.[64] Some would argue that this agent is seldom an appropriate choice, as other agents are available and the ovicidal effects of lindane appear to be inferior to that of other agents.

Pyrethrin and piperonyl butoxide. Pyrethrins, derived from an extract of chrysanthemums, appeal to some patients who like natural products. Individuals sensitive to *Compositae* plants should avoid these products. Pyrethrins have the same mechanism of action as permethrin.[64] Piperonyl butoxide is added to potentiate the effect of the pyrethrin and may decrease the development of resistance.[47] There are several different formulations of pyrethrin and piperonyl butoxide (RID Mousse, RID Shampoo, A-200, R and C, Pronto, Clear Lice System). These formulations are not equal in effectiveness, as the vehicle contributes to the pediculicidal activity of the product.[45] For example, A-200 shampoo contains benzyl alcohol, which is synergistic with the pyrethrin,[47] and some studies have shown A-200 to be more effective than RID.[45]

Malathion. Malathion 0.5% (Ovide) was unavailable in the United States for several years. Because of this absence, there is likely to be little resistance to the agent in its early years of reintroduction to the marketplace. Malathion is a relatively weak organophosphate cholinesterase inhibitor that causes respiratory paralysis in arthropods.[64] It has a good margin of safety for mammalian species. It does require an 8- to 12-hour treatment period and has an unappealing odor. Furthermore, the vehicle is 78% isopropanol and is flammable. The vehicle contributes significantly to the efficacy of the agent. Specifically, the dipentene terpineol and 78% isopropanol in the vehicle appear to increase the effectiveness of malathion.[47] Malathion is highly pediculicidal,[45] and pharmaceutical-grade malathion does

not cause urticaria and has a low incidence of irritant or allergic contact dermatitis.[76]

Alternative and unconventional treatments. Alternative topical treatments abound, but most have not been scientifically evaluated. Greasy ointments, petroleum jelly, pomades, oils, kerosene, and mayonnaise have been advocated as being pediculicidal.[54,57] Some of these products are cosmetically inelegant, may be toxic or flammable, and may be difficult to rinse out. The true effectiveness of many of these treatments is unknown. Anecdotal reports are difficult to evaluate, as lice can appear dead but resurrect in several hours.[77] Although we do not advocate the use of most of these agents, patients commonly find them on the Internet and ask about them. For this reason, we believe it is appropriate to present some data regarding these agents. The only alternative agents that we sometimes recommend are those that have well-established risks and are licensed for sale in the United States (such as trimethroprim-sulfa) and products such as hair styling gels that may provide some benefit with minimal identifiable risk.

In several small studies, trimethoprim-sulfamethoxazole has been shown to be effective in eradicating head lice, and the combination of permethrin and trimethoprim-sulfamethoxazole was more effective than either agent alone.[78,79] The mechanism of action is postulated to be ingestion of the antibiotic by the louse as it takes its blood meal; subsequently the antibiotic kills the gut flora of the louse, with death ensuing from a deficiency of B vitamins. The drug and its side effects are generally familiar to most providers. The potential for adverse reactions, including Stevens-Johnson syndrome must be weighed carefully before a clinician considers such off-label use.

Crotamiton (Eurax) is an antiscabietic agent that does not enjoy a tremendous market share in the treatment of scabies. It has some efficacy as an antipruritic and may have some efficacy in the treatment of lice. In one study, it eradicated head lice in 47 of 49 patients.[80] In our opinion, there currently are not enough data to support the use of this agent unless other reasonable options have been exhausted.

Kerosene and *Lippia multiflora* essential oil have shown pediculicidal activity in vitro, but their safety and efficacy remain to be evaluated.[81] We currently would not recommend either of these agents. Several products available by means of the Internet contain coconut oil, anise oil, and ylang-ylang oil. In one study, 119 children underwent treatment with either 3 applications of such a preparation or 2 applications of a spray containing permethrin, malathion, piperonyl butoxide, isododecane, and propellant. Treatment was successful in more than 90% of children in both treatment groups, and no serious side effects were reported.[82] Ylang-ylang oil is a potential contact allergen and is used as a screening agent in our patch test series. The risk of an adulterated product must also be part of a discussion with a patient about agents not regulated as drugs. We do not currently advocate the use of essential oils.

Aliphatic alcohols show promise as pediculicides. The effect of these agents appears to be independent of permethrin resistance.[83] These alcohols have potential for further study.

An uncontrolled pilot study of 28 girls with pediculosis capitis indicated that levamisole, an anthelmintic and biologic immune response modifier, administered at a dose of 3.5 mg/kg/day, cleared lice from 85% of the subjects with no adverse effects.[84] In the United States, levamisole is approved by the Food and Drug Administration for the treatment of certain cancers only. We do not currently recommend this agent for treatment of lice.

Long available as over-the-counter treatments in Britain, sales of carbaryl-containing pediculicides recently were restricted. The change was prompted in part by evidence that carbaryl may be carcinogenic.[85] In England, where resistance to over-the-counter treatments such as permethrin, phenothrin, and malathion are present, there is also evidence of resistance to carbaryl.[86] We do not recommend that patients use the forms of carbaryl available in the United States, as they are not licensed for human use.

Ivermectin also has been suggested as a potential therapy for pediculosis.[87-91] Topical ivermectin holds some promise, but oral ivermectin is the only form licensed for human use in the United States, where it is marketed for strongyloidiasis. In the setting of pediculosis, it has generally been given as a single 200 μg/kg dose.[92-96] A second dose has been advocated by some to kill emerging nymphs. One report has suggested the possibility of neurotoxicity from ivermectin in a population of nursing home patients who underwent treatment for scabies. Some of these patients had also undergone treatment with other potentially neurotoxic agents, such as lindane. Still, as the drug appears to have some potential for neurotoxicity and the safety and efficacy of the product in the treatment of pediculosis remains to be established, we hesitate to recommend it. The senior author (D. M. E.) once acted as a consultant to Merck, the manufacturer of ivermectin. To date, he has not recommended the use of the drug for pediculosis outside the setting of mass infestation in a

refugee camp. In the case of the refugee camp, topical permethrin proved adequate to treat the infestation, and ivermectin was never used.

TREATMENT OF BODY AND PUBIC LICE

Body lice are eradicated by means of proper hygiene and laundering of or insecticide application to clothing. A pediculicide may be helpful to treat any lice adherent to body hairs and to treat concurrent infestation with head lice, pubic lice, or scabies. Most pediculicides are labeled for the treatment of head lice only, however. Permethrin tick repellent, used to treat clothing, may help prevent infestation by body lice.[97]

Pubic lice vary in sensitivity but are commonly susceptible to agents used for head lice, such as malathion, permethrin, pyrethrins, and even lindane.[98] In vitro studies also have shown crotamiton to be pediculicidal against *Pthirus pubis*,[99] although clinical data to support the efficacy of this agent are lacking. Resistance to pyrethrins by pubic lice has been documented, with eradication being achieved with the use of permethrin 5%.[100] We typically use a 5% permethrin cream in the treatment of pubic lice, as the preparation is generally acceptable to patients. Patients with pubic lice may be instructed to launder clothing and bedding and to avoid sexual contact until their infestations are cured. Infestation of eyelashes with pubic lice may be treated with an occlusive agent such as Vaseline petroleum jelly.[101] Fluorescein dye strips also have been used in this setting, although controlled studies are lacking. Yellow oxide of mercury ointment has been used, but systemic mercury toxicity is possible with this agent.

CONCLUSION

Pediculosis remains a prevalent disease. While head lice have not been established as disease vectors, body lice remain important vectors of typhus, trench fever, and relapsing fever. Surveillance for body lice carrying *Rickettsia prowazekii* and *Bartonella quintana* is useful in the epidemiologic study of these diseases and in predicting outbreaks of disease. Pediculosis pubis is a marker for other sexually transmitted diseases, and patients should undergo screening accordingly.

The "no nit" policies of many schools create substantial financial difficulties for parents and exclude many children from school needlessly. Such policies should be reevaluated. Treatment of louse infestation is difficult and is complicated by shifting patterns of resistance to currently available agents.

Lice have been in existence for thousands of years. Their extinction seems no more likely than our own. For the foreseeable future, they will continue to be medically significant, and the treatment of pediculosis will remain challenging.

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Answers to CME examination

Identification No. 804-101

January 2004 issue of the Journal of the American Academy of Dermatology

Questions 1-30, Ko CJ, Elston DM. J Am Acad Dermatol 2004;50:1-12.

1. d	7. e	13. b	19. d	25. a
2. b	8. e	14. b	20. c	26. a
3. a	9. c	15. c	21. a	27. b
4. e	10. a	16. c	22. a	28. c
5. b	11. c	17. a	23. c	29. a
6. c	12. d	18. b	24. e	30. b