COLLEGE OF AGRICULTURE & LIFE SCIENCES
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Head Lice: Identification, Biology, and Integrated Pest Management

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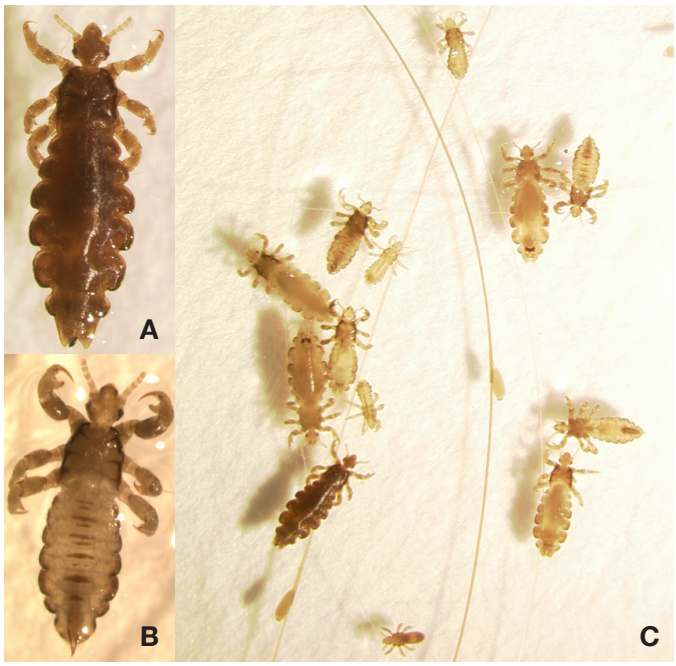

Figure 1. Adult head lice are about the size of a sesame seed (2-3 mm or 1/8 inch long). A. Adult female head louse. B. Adult male head louse. C. Head Lice eggs, nymphs and adults. Images: Shujuan Li

Introduction

The head louse, *Pediculus humanus capitis*, is a tiny insect about the same length as a sesame seed (Fig. 1). It can crawl rapidly across the scalp, but cannot fly or jump. Head lice live on people and cannot survive on pet animals. They feed by piercing the skin to take small blood meals and are generally found associated with hair on the neck and scalp. This human ectoparasite (parasite that lives on the surface of a host) causes scalp itching, and scratching that can lead to secondary skin infections. More noteworthy is the impact of related stress that includes sleepless nights, school days missed by students, and workdays missed by parents and guardians.

Pediculosis, or "lousiness", is one of the most prevalent communicable conditions in the United States. Head lice infestation is very common and it has been estimated that up to one in every 10 children in school acquires head lice at some time during their years in school. Head lice can infest people of all ages, but children are more prone to infestations due to their play activity and close physical contact. Girls acquire head lice more frequently than boys because of hugging and head-to-head "selfie" image capture habits.

The direct health impacts of head lice feeding on the scalp may be negligible, but inappropriate treatments can pose unnecessary health hazards to children and caregivers. According to the Centers for Disease Control and Prevention (CDC) (2010), an estimated 6 million to 12 million infestations occur each year in the U.S. among children 3 to 11 years of

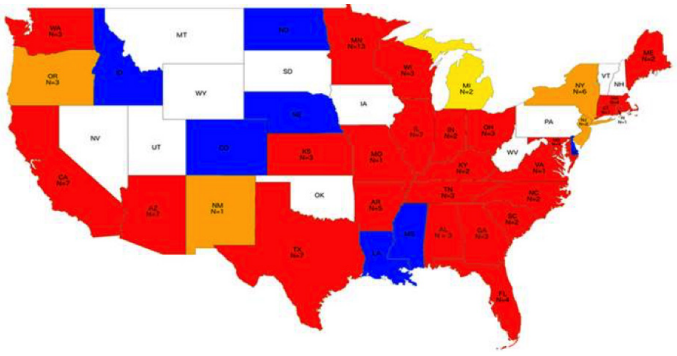

Figure 2. Head lice populations have developed a high level of resistance to some of the most common head lice treatments. Red states: 100% of the tested lice were resistant. Orange states: 50 - 90% of lice were resistant. Yellow states: 1 - 49% were resistant. Blue Sates: Data hasn't been analyzed yet. White states haven't been tested. Image: Kyong Yoon, Southern Illinois University

age (http://www.cdc.gov/parasites/lice/head/gen_info/faqs.html). The economic impact of head lice in the U.S. is estimated at $1 billion dollars annually, which includes direct costs (treatments and tools used to manage lice and nits) and indirect costs (missed school and work days, misdiagnosis, misuse of pediculicides, and unnecessary expenditures) (Hansen and O'Haver 2004).

The number of head lice cases peaks each year at the beginning of the academic year. Head lice are now more difficult to control than ever as documented in a new publication by Yoon and his colleagues (2015). In fact, 25 states have head lice populations that are highly resistant to the most commonly used lice shampoo treatments (Fig. 2), including pyrethrins and the synthetic pyrethroid insecticide, permethrin. The research work is continuing, but in most states, head lice that have been tested are resistant to the over-the-counter lice treatment products (Yoon et al. 2015).

Because of the occurrence of pesticide resistance, it is more important than ever to use an **integrated pest management (IPM) strategy** to battle this "lousy" pest. Using multiple complementary control tactics and paying careful attention to results is critical. Relying on a one-step / one-tactic "fix" generally has little chance of success. Parents, teachers, and childcare professionals should be aware of this insect pest and know how to prevent and manage it.

Identification And Biology

Head lice do not have wings or legs designed for jumping. They can crawl rapidly across the surface of the scalp and move around in hair using specially adapted claw-like structures at the ends of their legs (Fig. 3). Head lice prefer to live on the hair of the head, although they have been known to wander to other parts of the body. Because head lice feed every 4 - 6 hours, they must remain in close contact with the host. They are unable to survive away from a human host for more than about 48 hours. They cannot live on rugs, carpets, furniture, or on the upholstery of vehicles. Head lice are not found on animals or household pets, and are not transmitted from pets to humans.

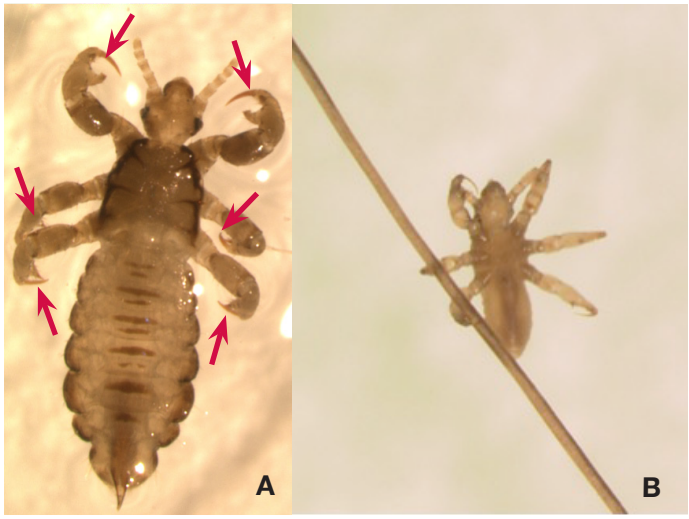

Figure 3. The tarsal claw at the end of each head louse leg. A. Notice the claws on legs of a male head louse; B. A head louse is grasping on a hair. Both images: Shujuan Li

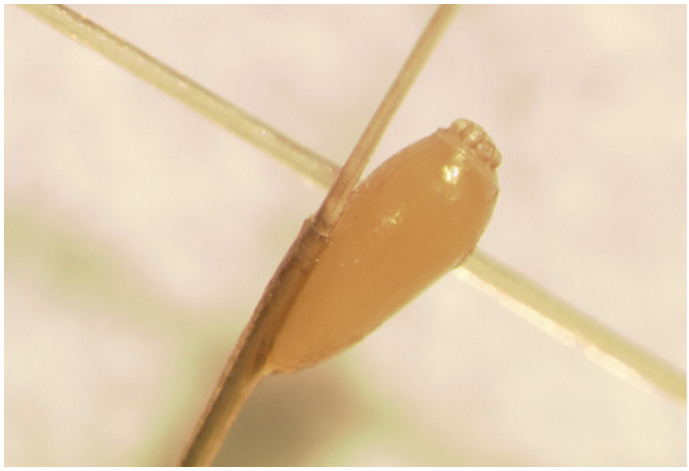

Figure 4. Egg of the head louse on a hair. Image: Shujuan Li

Lice eggs are called nits. Nits are oval in shape. They are very small, about the size of a knot in a sewing thread, and are often camouflaged with the host's own hair pigment. They are usually glued to hairs by female lice on the head near the scalp (Fig. 4). Nits are quite often found on hair around a person's ears and back of the head. Nits will hatch in 7 - 10 days under room temperature. Once a nit hatches, a nymph (immature) leaves the shell casing that then appears white in color. The empty nits are far more obvious to the observer and unless physically removed they can remain attached to the hair and eventually grow out over time.

Both nymphs (immatures) and adults (Fig. 1C) have piercing-sucking mouthparts to pierce the skin for a blood meal. Within an hour of hatching, a nymph will take its first blood meal. Lice pass through three nymphal stages during the next 10 - 12 days before reaching the adult stage (⅛ inch or 2-3 mm long). The female louse can mate and begin to lay eggs soon after becoming an adult. Females can live up to

40 days, laying 3 - 7 eggs per day, up to 50 - 100 eggs during their lifetime! A new generation of head lice can occur every 3 weeks.

The reaction of individuals to louse bites can vary considerably. Most often, people previously unexposed to lice may experience little irritation from their first bites. But many individuals become sensitized to the lice saliva that is injected when they feed, and itching is a common reaction to the constant biting. Reactions include reddening of the skin, itching, and overall inflammation. Broken skin due to constant scratching may lead to further complications and secondary infections, so catching infestations early is important.

Integrated Pest Management

Inspection - Checking for Head Lice

Periodic inspections for early detection of individual lice are far easier than dealing with advanced infestations (Fig. 5). In fact, the problem of head lice can be so rampant among preschool and school-aged students that schools must often work in conjunction with many families to control an infestation. During the early fall months (August to November), children should be inspected weekly by parents or caregivers. Follow these steps to inspect for head lice:

1. Shampoo and condition hair.
2. Remove tangles with a comb or hairbrush.
3. Use good lighting for your inspection. A lamp or good natural light from a window works.
4. Divide the hair in sections and fasten the hair that is not being inspected using clips.
5. Use a hand lens or magnifying glass to help verify what you find are nits or lice. There is often "debris" in hair that can be mistaken for nits and lice. Dandruff, sand and solidified droplets of hairspray are commonly mistaken for nits.
6. Look for nits near the scalp. Nits that are further than ½ inch (or 1 cm) from the scalp are usually hatched, not viable or dead and do not, by themselves, indicate an active infestation or a need for treatment.
7. When adults or lots of nits (more than 5 nits occurring in the area of a dime) are found close to the scalp, this is a call to action.
8. Check for nits and lice on **everyone** in the household, including adult family members.

Figure 5. Check for head lice. Image: Shujuan Li

Environmental Interventions

Remove lice and nits from the household environment. Once an infestation is detected, all clothes worn by an infected person should be laundered or dry-cleaned. Towels, pillowcases, sheets, blankets and other bedding should be washed and placed in the clothes dryer until completely dry. The dryer heat will kill the lice and nits. Any non-washable items should be dry cleaned or sealed in a plastic bag and placed in the freezer at 5 °F or lower over-night (this is a good option for headphones and other non-washable items). Vacuuming the home will remove shed hair that may have nits attached. Remember that lice removed from the body for 48 hours will die, so simply placing things that cannot be laundered (very large stuffed animals, duvets, furniture, etc.) in a plastic bag or "off-limits" for 48 hours will help to eliminate lice. Homes, school or childcare classrooms need not be treated for head lice.

Head Lice Treatment

Only initiate a head lice treatment when there is a clear diagnosis or identification of living adult or immature lice present. Parents, childcare professionals, caretakers and pediatricians should use products or methods that are effective, and most importantly, **safe.**

Over-the-counter lice shampoos

Many over-the-counter lice shampoo products (pediculicides) sold in pharmacies and supermarkets contain insecticides, and they can be hazardous if not used exactly according to the label directions (Fig. 6). When using a pediculicide shampoo, minimize body exposure by confining the product to the head hair. Wash the infested person's hair in a basin or sink so the insecticide does **not** contact other parts of the body. **Never apply treatments to children in the bath or shower!**

Figure 6. Follow label directions

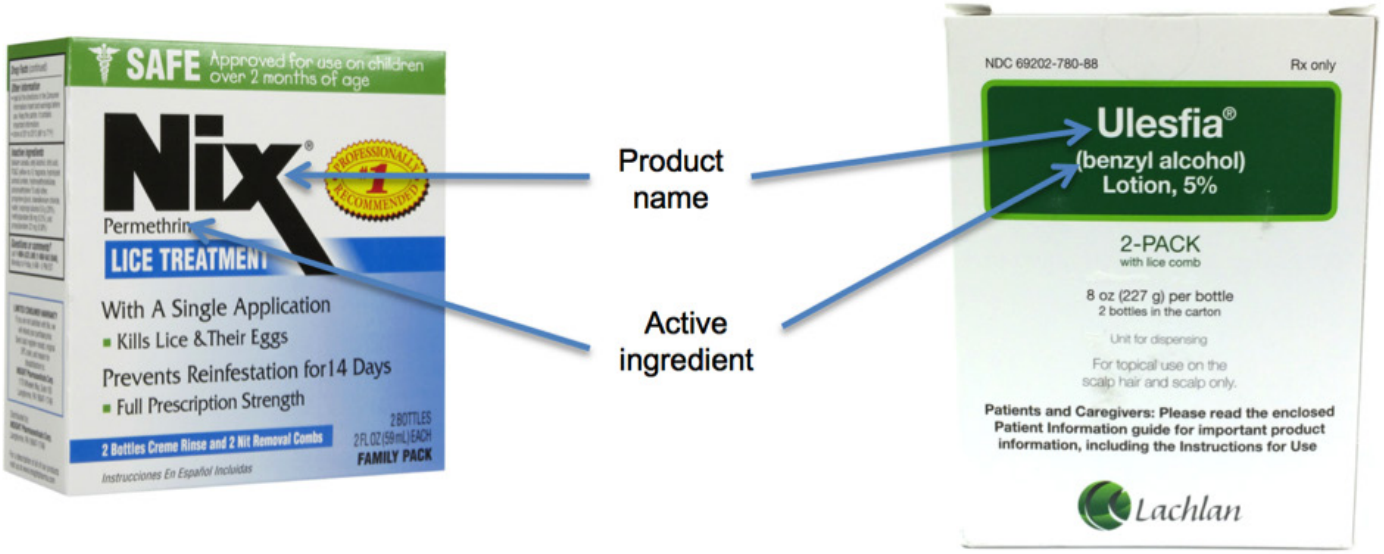

Figure 7. Locate the active ingredient information. Image: Shujuan Li

The person helping to apply the treatment should wear chemical resistant gloves. Never apply an insecticide to anyone who has open cuts, scratches, or inflammations, and never use these materials on infants. Consult a doctor if you have an infested infant. Always read and follow label directions completely and carefully.

As previously discussed, widespread resistance has developed by head lice to the most commonly used over-the-counter pediculicides (pyrethrins and permethrin). If a pediculicide is effective, lice should die within 30 minutes of a treatment. If live lice are found after 30 minutes, discontinue use of that product. Switch to a different kind of product that does not contain the same active ingredient (Fig. 7).

Pediculicidal products are for external use only, and should only be applied to the scalp. These products may be harmful if swallowed or inhaled. If accidental ingestion occurs, contact poison control immediately at (800) 222-1222 (Fig. 8).

Figure 8. Contact Poison Help

Prescription lice treatment options

Relatively new prescription pediculicides that contain different active ingredients are available. Very effective prescription products are Ulesfia® (benzyl alcohol), and NatrobaTM (spinosad insecticide plus benzyl alcohol). Be informed before you visit your pediatrician, avoid high risk and poorly performing control options.

Ulesfia® (benzyl alcohol) Lotion is a Food and Drug Administration (FDA) approved prescription head lice treatment which is not neurotoxic, but it is a highly effective lotion used for the topical treatment of head lice on patients older than 6 months (it should not be used on newborn babies or infants below the age of 6 months). Ulesfia® Lotion is not ovicidal (does not kill lice eggs), so two treatments are necessary. This effective product is available by prescription-only and no resistance issues have been reported. A minimal side-effect most commonly occurring is mild drying of the scalp.

NatrobaTM Topical Suspension (spinosad 0.9% plus benzyl alcohol) is a FDA approved prescription head lice treatment that does not require nit combing and in clinical trials demonstrated superior efficacy to Nix® (permethrin 1%). Natroba™ Topical Suspension contains benzyl alcohol and is **not recommended** for use on newborn babies and infants below the age of 6 months. Systemic exposure to benzyl alcohol has been associated with serious adverse reactions and death in newborns and low birth-weight infants.

Sklice Lotion (ivermectin 0.5%) is a prescription medication for topical use on the hair and scalp only. It is FDA approved as a 10-minute head lice treatment in people 6 months of age

and older. To prevent accidental ingestion, adult supervision is required for pediatric application. Avoid contact with eyes.

Some FDA approved prescription treatments are significantly more hazardous than others e.g., products that contain the insecticide, malathion and lindane have more health risks associated with their use. Both active ingredients rely on older pesticide chemistry, and may not be as safe or as effective as the newer prescription treatments previously listed.

In general, most head lice treatment products have limited ovicidal activity so **two treatments are commonly needed.** Skipping the second treatment often leads to re-establishment of head lice, thus necessitating an additional two treatments. The second treatment is required to kill lice that hatch **after** the first treatment. Typically, the second treatment should follow 7 - 10 days after the first, depending on the product and its instructions. Do not be tempted to repeat treatments sooner than recommended. Follow instructions for the correct timing of the second treatment. Do not expose children to more treatments than necessary as health hazards increase.

Alternative approaches

In addition to pediculicide treatments, alternative approaches with other products include using petroleum jelly, mayonnaise, margarine, herbal oils, enzyme-based products and olive oil. There has been no conclusive evidence showing that these treatments are effective. But, any time that the hair and scalp are shampooed, some head lice are eliminated in the process.

Suffocants – petroleum jelly, mayonnaise, olive oil, or Cetaphil Gentle Skin Cleanser

Suffocants smother adult lice and to some extent nits by preventing air exchange. These products are massaged on to the entire scalp and hair then covered with a shower cap, and left on for several hours. Usually, the process is followed by nit combing.

Diligent shampooing is usually necessary for at least the next 7 days to remove the residue of suffocants. The combination treatment of applying a suffocant, followed by shampooing, combing and drying can be beneficial in removing lice and nits.

Another alternative approach without the sticky residues is to use soap shampoos that contain coconut or olive oils. Begin with daily shampooing and use of a hair conditioner. Shampoo with 1% coal tar can help to reduce an irritated and itchy scalp and reduce dandruff (which can be mistaken for lice). Hair conditioners (e.g., Fekkai hair conditioners) help with the nit combing process greatly. Each successive shampooing and conditioning eliminates some lice and nits.

Cetaphil Gentle Skin Cleanser can be massaged on to the entire scalp and hair. Comb out any excess product, then dry the hair completely with a hair dryer, and leave the dried product on the hair for 8 hours. The hair can then be washed and the process should be repeated several times over the next couple of weeks. Research (Pearlman 2004) has demonstrated a high success rate of greater than 94% lice reduction even without nit combing. If nit combing is for some reason impossible, this may be a good treatment choice.

Figure 9. The machine uses hot air to desiccate lice and eggs. Image: AirAllé™

Enzymes - LiceLogic, Lice B Gone, Lice R Gone

Treatment products containing enzymes dissolve or soften the glue that attaches the nit to the hair shaft, promoting nit removal during combing. Some head lice may also be eliminated by the treatment.

Desiccation (heat treatment) – AirAllé™ (formerly known as LouseBuster™) and hair dryer

The AirAllé™ (formerly known as LouseBuster™) is a machine that uses hot air to desiccate lice and eggs (Fig. 9). Research showed that the heat treatment caused high mortality of eggs and hatched lice (Bush et al. 2011). The device is used primarily by professionals in schools, clinics, and places where head lice are commonly treated.

A home hair dryer may not be as effective as the AirAllé™; however, hair drying will desiccate some lice and nits each time it is used. A hair dryer on warm heat setting and hair-brushing or combing are effective ways of eliminating lice mechanically.

Manual removal

An IPM strategy that uses multiple tactics is critical to controlling head lice because 20 to 30% of the lice can still be alive after shampoo treatments. Lice survival can be much higher if pesticide resistant lice are on the scalp and hair. Nits, especially those within a ½- inch of the scalp, should be removed manually after treatment with any product. Manual removal of nits can be difficult and tedious, but it will help to diminish the social stigma and isolation a child can experience in school, enhance the relationship between a parent and child, and decrease diagnostic confusion.

Special combs are needed and can be effective for nit removal when used diligently each day. It is recommended

Figure 10. An example of a great nit comb.

that frequent combing continue for 10-14 days. Nit combs (Fig. 10) come in many forms and all are helpful to remove nits. The LiceMeister® or Nit Free Terminator combs are effective choices. Some useful tips follow.

- Use nit comb on wet hair.
- Conditioners help the comb move through the hair easier.
- Metal combs with stiff tines (teeth) and narrow slots between tines are the best (e.g., Nit Free Terminator Stainless Steel Lice Comb).
- Short-tined combs work best on short hair, long-tined combs work best on long hair.
- Use electrocution combs e.g., RobiComb® on dry hair.
- Use a magnifying glass and good lighting.
- Be gentle. If the comb gets tangled in the hair, it will be less effective at destroying and removing lice and nits.

The thickness and curliness of the hair of the infected child and the experience of the caregivers may determine the length of time required to comb out lice and nits. A set of effective tools is shown in Fig. 11. To remove head lice and nits from the head use the following steps:

1. Have your child wash and condition their hair. An over-the-counter coal tar shampoo will help to sooth the scalp, and reduce dandruff and flakes of skin that can generate confusion. A heavy detangling conditioner will help the nit comb move through the hair easier.
2. Have your child sit comfortably under good light. A movie or good book should keep them entertained.
3. After gently removing tangles, comb hair from the scalp to the ends, dividing hair into manageable sections. Infested heads can be extra sensitive so take the extra time to be gentle and thorough.
4. Dip the nit comb in a container of warm water, then place the tip of the tines on the surface of the scalp. Holding the comb at a 45° angle to the scalp (Fig. 12), slowly pull the comb from the scalp to the ends of the hair, and re-dip the comb in the water. Wipe the comb with tissue to remove lice and nits. When done, discard the tissue.

Figure 11. A set of effective nit combing tools.

Figure 12. Comb hair at a 45° angle to the scalp. Image: Al Fournier.

5. Look through that same section of hair for remaining nits and lice. Repeat if necessary.
6. Systematically comb through all hair.
7. Clean the nit removal comb with hot soapy water. An old toothbrush can help dislodge nits and lice that get caught in the teeth of the comb. If you are still concerned that you may have missed something, place the nit comb in the freezer until the following day.

Daily head checks and nit removal are advisable until the infestation is gone. Follow with weekly head checks for the whole family to detect any reestablishing lice.

Policies And Control Measures In Schools

When parents of elementary school-aged children are surveyed as to what childhood health issues concern them most, head lice usually rank higher than more serious conditions (http://www.health.mo.gov/living/families/schoolhealth/pdf/HEADLICE.pdf). In reality head lice can be easily taken care of if you use effective strategies and take the right management steps.

Three things everyone should know

1) In any school classroom 1% head lice incidence is normal.
2) If classrooms report >20% infestation levels, it is likely to be a misdiagnosed head lice infestation.
3) No pesticide treatment of a classroom, school bus or home is ever necessary or beneficial.

Currently, many school districts have "no nit" policies that exclude students from school because of the presence of nits whether or not live lice are present. Such a policy has not been supported by research and is not recommended by experts, because:

1. Nits do not transfer between heads (CDC 2010). (http://health.mo.gov/living/families/schoolhealth/pdf/HeadliceGuidelines.pdf).
2. The over-reaction to nits leads to unproductive use of time by school staff and parents, school days missed by students, and workdays missed by parents and guardians. (National Association of School Nurses 2011; Devore et al. 2015).
3. Nits more than a ½ inch from the scalp are not viable. They are likely dead, empty shells or unlikely to hatch.
4. The misdiagnosis of nits is common during nit checks conducted by nonmedical personnel (CDC 2010), and even some medical personnel.
5. Misdiagnosis may lead to unnecessary use of pediculicides and inappropriate exclusion from school (CDC 2010).

"No nit" policies contribute greatly to the social stigma of lice infestations and have absolutely no impact on preventing additional infestations in the community.

Schools are advised to create a head lice management plan and promote an IPM strategy to battle this pest. Screening for nits alone is not an accurate way of predicting which children will become infested. Children having 5 nits or more within 1 cm^2 of the scalp are significantly more likely to develop an infestation, but even then only ⅓ of these higher-risk children convert to having an active infestation. Providing information to families on the diagnosis, treatment, and prevention of head lice is a helpful and useful plan. Parents and guardians should be encouraged to check their children's heads for lice if the children are symptomatic.

Important Do's:

- Do take an integrated pest management approach (monitor, vacuum home furniture, launder bedding, towels and clothes, treat the head, nit-comb, and evaluate results).
- Do follow pediculicide product directions exactly as written.
- Do second pediculicide treatments as directed on product labels.
- Do use gloves when applying treatments if the label directions indicate their use.
- Do invest time in manual nit removal and infestations will be resolved faster.
- Do try to relax and relax your child, head lice can be dispatched completely.

Important Do not's:

- Do not treat with a pediculicide if there is no evidence of live nymphs or adult head lice.
- Do not use a pediculicide shampoo as a routine shampoo, the products do not prevent a person from getting head lice.
- Do not assume a one-step treatment will be 100% effective at killing lice and nits.
- Do not have a child rinse out treatments in the shower or a bathtub, aim to prevent any other part of the child from exposure to the pesticide.
- Do not leave products on the head for longer than directed.
- Do not re-treat sooner than directed.
- Do not resort to dangerous practices such as aerosol insecticide sprays or total release foggers (bug bombs), or highly flammable materials such as kerosene or gasoline!

In Summary, implement an IPM strategy:

1. Conduct on-going head lice monitoring of family members.
2. Launder bedding, towels, clothing and stuffed animals and throw-pillows.
3. Vacuum couches and carpeted floor areas where children lay down.
4. Wash hair accessories, brushes, combs, etc. Items that cannot be washed can be placed in the freezer or placed "off-limits" for 48 hours.
5. Regular washing, conditioning, drying, and wet or dry-hair brushing.
6. Use the most effective and least-hazardous prescription treatments and nit removal when necessary.

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Resources

More information regarding head lice management:

Head Lice http://pediatrics.aappublications.org/content/135/5/e1355.full.pdf

Head Lice (Sep. 2005) http://cals.arizona.edu/urbanipm/pest_press/index.html

The National Pediculosis Association,® Inc.: http://www.headlice.org/

IPM Action Plan for Head Lice http://www.extension.org/pages/20989/school-ipm-action-plan-for-head-lice#.Uh4-YBYSMy5

Head Lice Pest Press http://cals.arizona.edu/apmc/westernschoolIPM.html#newsletter

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USDA United States Department of Agriculture National Institute of Food and Agriculture

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