Accuracy of Diagnosis of Pediculosis Capitis

Visual Inspection vs Wet Combing

Claudia Jahnke, MD; Eline Bauer, MD; Ulrich R. Hengge, MD, MBA; Hermann Feldmeier, MD, PhD

Objective: To determine the diagnostic accuracy of visual inspection and wet combing in pediculosis capitis (head lice infestation). Visual inspection of 5 predilection sites (temples, behind the ears, and neck) was performed first, followed by wet combing of hair moistened with conditioner. Presence of mobile stages was defined as active infestation, presence of nits alone as historic infestation.

Design: Observer-blinded comparison of 2 diagnostic methods.

Setting: Five primary schools in which head lice infestation was epidemic.

Participants: A total of 304 students aged 6 to 12 years.

Main Outcome Measures: Presence of nymph, adults, and nits; sensitivity, predictive value, and accuracy of both methods.

Results: Visual inspection underestimated the true prevalence of active infestation by a factor of 3.5. The sensitivity of wet combing in diagnosing active infestation was significantly higher than of visual inspection (90.5% vs 28.6%; $P < .001$). The accuracy of the former method was 99.3% and that of the latter method, 95%. In contrast, visual inspection had a higher sensitivity for the diagnosis of historic infestation (86.1% vs 68.4%; $P < .001$).

Conclusions: Wet combing is a very accurate method to diagnose active head lice infestation. Visual inspection is the method of choice, if one aims to determine the frequency of carriers of eggs or nits.

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Author Affiliations: Unit of Child and Adolescent Health, City Health Department, Braunschweig, Germany (Dr Jahnke); Institute of Microbiology und Hygiene, Charité University Medicine, Campus Benjamin Franklin, Berlin, Germany (Drs Bauer and Feldmeier); and Department of Dermatology, Heinrich-Heine-University, Düsseldorf, Germany (Dr Hengge).

PEDICULOSIS CAPITIS (HEAD lice infestation) is one of the most common infections in childhood. In industrialized countries, the point prevalence in children aged 6 to 12 years ranges from 1% to 3%, and the incidence rate has been estimated to be 800 and 2400 new cases per 10 000 children per year.[1] In view of the high frequency of the infestation and the importance attributed to this parasitic skin disease by caregivers, governesses, teachers, and health care providers, it comes as a surprise that the diagnostic accuracy of the techniques currently in use—visual inspection and wet combing—has never been determined appropriately. Lacking data on diagnostic accuracy is a matter of concern because health care professionals and lay personnel frequently overdiagnose pediculosis capitis and fail to discriminate active from extinct infestation.[2]

So far, only 2 studies[3,4] have compared visual inspection and combing, but the authors failed to provide indicators of diagnostic accuracy. In addition, the study by Mumcuoglu et al[4] was performed in selected individuals with a very high intensity of infestation. In view of the facts that (1) the sensitivity of a diagnostic method depends on the intensity of infestation, (2) predictive values are linked to prevalence, and (3) in industrialized countries most children carry only a few head lice, the results of this study cannot be extended to other epidemiological situations.[5,6] A study[7] of Belgium students did not differentiate between active infestation (presence of lice) and historic infestation (presence of nits [dead embryos retained in egg shells] without the presence of lice).

We decided to compare visual inspection with wet combing in a representative group of schoolchildren aged 6 to 12 years and to determine the diagnostic accuracy of both methods. Our data show that wet combing is the optimal method to identify living lice but that visual inspection is preferred if one aims to determine the frequency of nits in a population.

METHODS

SETTING AND PARTICIPANTS

The study was performed in the city of Braunschweig, in northern Germany. Braunschweig is the second largest city in Lower Saxony and has approximately 245 000 inhabitants. It features a university and has a disproportionately high number of citizens with an academic degree.

Schools have to report cases of head lice infestation to the city health department. Usually, the occurrence of head lice comes to notice when several children are infested at the same time. In this case, the staff of the Unit of Child and Adolescent Health gives practical advice on how to control head lice infestations and intervenes if new cases continue to occur.

From February through June 2007, 5 primary schools reported emerging or persistent head lice infestation in some classes or in the whole school to the Unit of Child and Adolescent Health. These schools—4 public and 1 private institution—were attended by a total of 1400 children aged 6 to 12 years. Immediately after the notification, meetings were organized with the director and representatives of the parents' council, and the objective of the study was explained. A period was set—usually the coming week—during which all students attending the affected classes would be examined for head lice. A leaflet was distributed to the parents explaining the intended examinations and providing general information on head lice.

SCREENING FOR HEAD LICE

Every child who attended on the day of the study was examined by 2 diagnostic methods. First, the child underwent visual screening, in which 1 investigator (C.J.) systematically parted the hair with the aid of an applicator stick at 5 topographic sites: the temples, behind the ears, and neck. These areas are considered to be predilection sites.[8,9] During the examination, the child sat on a table in a room with good light. If eggs/nits or lice were detected, they were inspected with an illuminated magnifying glass, removed, and destroyed.

After visual screening was completed, a different investigator (E.B.), who was unaware of the results, reexamined every child with a head lice detection comb. First, the hair was wetted with a commercially available conditioner that did not need to be washed out. Then, the hair was brushed or combed with an ordinary comb to disentangle wisps and knots. Finally, wet combing was performed. For diagnostic combing, 2 types of lice combs were used: in the case of long hair, a metal comb with long teeth, and in children with short hair, a plastic comb with short teeth. Both types were high-quality combs with parallel-sided teeth 0.2 mm apart with square-cut edges (NISSKA comb; Metallkammfabriken Fritz B. Mückenhaupt Erben OHG, Schwarzenbruck, Germany; NYDA comb; Pohl-Boskamp GmbH & Co. KG, Hohenlockstedt, Germany). Even the smallest first instar nymphs cannot pass between these teeth.[3]

Combing was performed systematically starting on one side of the head and working around it to the other side. Each section of hair was combed at least 3 to 4 times before moving to the adjacent section. Combing was continued until the entire scalp had been combed or until 1 louse was found. The combing technique involved inserting the comb into wet hair until the tips of the teeth were in contact with the skin and then drawing the comb smoothly through the hair to the end of the tress. After each time the comb was pulled through the hair, the conditioner was wiped on white sanitary paper and each object trapped was investigated with an illuminated magnifying glass. At the end of the investigation the hair was blow-dried. The 3 investigators involved in the examination (C.J., E.B., and a technician) were skilled medical personnel. Every 2 hours, the investigators rotated their job, so that each investigator performed visual inspection and wet combing in a similar number of children examined during that day. Children with positive findings were given a short report for their caregivers with suggestions on how to treat pediculosis capitis.

OUTCOME MEASURES

The primary outcome measure was the sensitivity of visual inspection compared with wet combing in diagnosing active (presence of living lice) and historic infestation (presence of nits without presence of lice). Secondary outcome measures were the accuracy with which each of the tests identified the prevalence of active infestation in the population examined.

STATISTICAL ANALYSIS

Proportions were compared with the χ^2 test. Values of sensitivity, negative predictive value, and accuracy are presented as percentages with 95% confidence intervals. Because the sample size was reasonably large, the sampling distribution of the proportion was considered approximately normal.[10] Data analysis was conducted with SigmaStat statistical software (version 3.1; Systat Software Inc, Point Richmond, California).

The sample size was based on the assumption that the prevalence of active head lice infestation was 5%. Provided that the sensitivity of the 2 techniques differed by 10%, 292 individuals had to be examined to detect a difference with a probability of 95% (power of test, 90%).

The way the study was conceived made it impossible to determine specificity. However, because trophic stages cannot be confounded with artifacts, the specificity for both methods to detect head lice was 100% by definition.

ETHICAL CONSIDERATIONS

The study was approved by the council of teachers and parents in each school in which children were expected to be examined. Children were admitted to the study only when the parents had given informed written consent and the child agreed to have the hair moistened with a conditioner. Before each child left the room in which he or she had been examined, the hair was blow-dried to avoid a common cold. Privacy of results was guaranteed.

Because the true sensitivity of wet combing was not known and an infestation might have been overlooked by the second investigator, we deliberately decided to remove all head lice and eggs or nits identified during visual inspection.

RESULTS

A total of 304 children participated in the study; data from visual inspection were available from 304 individuals and from wet combing from 300 children (4 children refused to have their hair moistened). They ranged in age from 6 to 12 years; 141 participants were girls and 159 were boys. Using the criteria defined in **Table 1**, pediculosis capitis (presence of eggs/nits) was identified in 79 children (26.3%) and trophic stages were seen in 21 (7%) children. Fifty-eight children(19.3%) had only eggs/nits; 4 (1.4%), only lice; and 19 (6.3%), lice and eggs/nits. Two individuals (0.7%) were classified as positive for infestation by visual inspection for the presence of trophic stages but negative by wet combing (Table 1).

Table 1. Results of the Procedures and Interpretation in 300 Schoolchildren

Visual Inspection	Wet Combing	Diagnosis	Children, No. (%)	Interpretation
Presence of eggs/nits				
Negative	Negative	No	221 (73.7)	TN inspection/TN combing
Negative	Positive	Yes	11 (3.7)	FN inspection/TP combing
Positive	Negative	Yes	25 (8.3)	TP inspection/FN combing
Positive	Positive	Yes	43 (14.3)	TP inspection/TP combing
Presence of mobile stages				
Negative	Negative	No	279 (93.0)	TN inspection/TN combing
Negative	Positive	Yes	15 (5.0)	FN inspection/TP combing
Positive	Negative	Yes	2 (0.7)	TP inspection/FN combing
Positive	Positive	Yes	4 (1.3)	TP inspection/TP combing

Abbreviations: FN, false negative; TN, true negative; TP, true positive.

The diagnostic characteristics of both methods are shown in **Table 2**. The sensitivity of visual inspection in the diagnosis of presence of eggs/nits was significantly better than wet combing (86.1% vs 68.4%; $P<.001$). The negative predictive value of visual inspection was 95.3% and that of wet combing, 89.8%. However, the accuracy of both tests was rather similar (96.3% vs 92.0%).

In contrast, wet combing largely outperformed visual inspection in the diagnosis of trophic stages: sensitivity was 90.5% vs 28.6%, respectively ($P<.001$). The accuracy of wet combing was 99.3%, that of visual inspection, 95.0% ($P<.01$). If only visual inspection was used, the true prevalence of trophic stages would have been underestimated by a factor of 3.5 (**Table 3**). The difference in prevalence of trophic stages determined by wet combing and visual inspection was significant (6.3% vs 2.0%; $P<.001$). The prevalence of eggs/nits determined by visual inspection was similar to that found by wet combing (22.4% vs 18.0%; $P=.18$).

Age- and sex-specific prevalences are shown in the **Figure**. Prevalence was consistently higher in girls than in boys and peaked in 9- to 10-year-old children.

Table 2. Diagnostic Value of Visual Inspection vs Wet Combing

	Percentage (95% CI)	
Diagnostic Parameter	Visual Inspection	Wet Combing
Presence of eggs/nits		
Sensitivity (TP/TP + FN)	86.1 (82.2-90.0)	68.4 (63.1-73.7)
Positive predictive value (TP/TP + FP)	100	100
Negative predictive value (TN/TN + FN)	95.3 (92.9-97.7)	89.8 (86.5-93.1)
Accuracy (TN + TP/ TN + TP + FN + FP)	96.3 (94.1-98.5)	92.0 (88.9-95.1)
Presence of mobile stages		
Sensitivity (TP/TP + FN)	28.6 (23.5-33.7)	90.5 (87.2-93.8)
Positive predictive value (TP/TP + FP)	100	100
Negative predictive value (TN/TN + FN)	94.9 (92.4-97.4)	99.3 (98.3-100)
Accuracy (TN + TP/ TN + TP + FN + FP)	95.0 (92.5-97.5)	99.3 (98.3-100)

Abbreviations: CI, confidence interval; FN, false negative; TN, true negative; TP, true positive.

COMMENT

Hitherto, no scientific consensus existed on how to control head lice infestation in children, and various policies have been advocated, implemented, and discarded.[8,11] There is similar uncertainty about how to diagnose this parasitic skin disease effectively. Accurate diagnosis, however, is the key to the successful identification of the infestation, irrespective of whether the purpose of the examiner is the identification of individual cases, such as in clinical practice, or the determination of prevalence in epidemiological surveys.[12]

Usually, diagnosis of head lice infestation is made by the visual inspection of the hair and the scalp. This method is easy, rapid, and does not require additional resources. The alternative is the use of a detection comb, either directly on dry hair or after the hair has been moistened with a conditioner. In both cases, the hair is systematically combed from the scalp to the ends. This method is time consuming, requires trained personnel, and is resource intensive.[7] Several authors[7,13] consider it as the gold standard for head lice diagnosis but fail to substantiate this assumption with appropriate data. Mumcuoglu et al[4] found a 4-fold higher prevalence of active infestation after dry combing compared with visual inspection in children with a high intensity of infestation. Similarly, in Turkish schoolchildren, Balcioglu et al[3] determined a 3-fold higher prevalence after dry combing compared with visual inspection.

In clinical practice, the most important question is to diagnose active head lice infestation in order to prescribe appropriate treatment. Pollack et al[2] showed that physicians in the United States err in the diagnosis of active head lice infestation in about 75% of the cases and concluded that potentially hazardous antilouse formulations are overapplied. Our study shows that the sensitivity of visual inspection in the diagnosis of active pediculosis is only 29%. In contrast, wet combing had a high sensitivity (91%) and an extremely high accuracy (99%; Table 2). Possibly the sensitivity of this method is even higher because the 2 cases in which head lice were identified by visual inspection, but not by wet combing, probably had only been "missed" because all head lice found

Table 3. Prevalence of Head Lice Infestation According to Diagnostic Method

Method	No. Examined	Children, No. (%)				
		Results of Procedures			Prevalence of	
		Only Eggs/Nits	Only Lice	Lice and Eggs/Nits	Head Lice Infestation[a]	Active Head Lice Infestation[b]
Visual inspection	304	62 (20.4)	0	6 (2.0)	68 (22.4)	6 (2.0)
Wet combing	300	35 (11.7)	6 (2.0)	13 (4.3)	54 (18.0)	19 (6.3)
Both methods combined	300	58 (19.3)	2 (0.7)	19 (6.3)	79 (26.3)	21 (7.0)

[a] Presence of eggs/nits without or with lice.
[b] Presence of mobile stages.

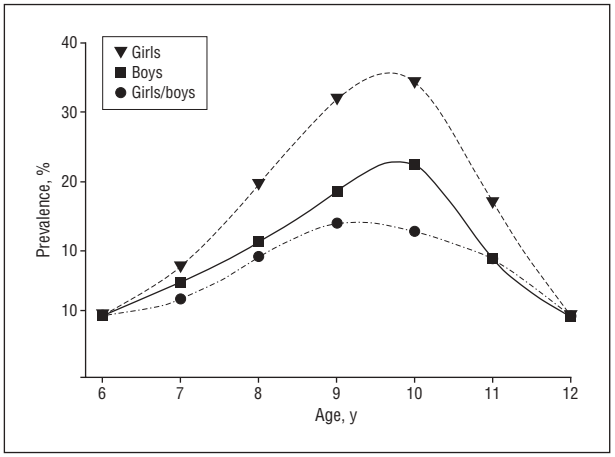

Figure. Smoothed age-specific prevalences in girls and boys (n=304).

by visual inspection were eliminated owing to ethical reasons before the child was examined a second time.

It is frequently overlooked that the sensitivity of diagnostic methods—as with other parasitic diseases—depends on the intensity of infestation.[5] In contrast to settings in the developing world in which a high intensity of infestation is the rule, in industrialized countries most children carry only a few lice.[6,12,13] In consequence, the optimal detection method should identify even a single louse and should have a high negative predictive value to exclude the possibility that individuals classified as negative for lice are actually false negative with the potential to spread the parasite. In this regard, wet combing is the only useful method if active infestation has to be ruled out.

With regard to the detection of eggs/nits, visual inspection is superior compared with wet combing (sensitivity, 86.1% vs 68.4%). However, because in 11 cases the presence of eggs/nits was overlooked by visual inspection but confirmed by wet combing, the accuracy of both methods was rather similar. Because visual inspection is rapidly performed, requires no additional resources other than a reusable applicator stick, and is more sensitive, this technique is the method of choice if the frequency of historic pediculosis capitis is to be determined.

It has been a matter of debate whether the presence of eggs is a putative diagnostic of active infestation. However, there are several lines of evidence arguing against this assumption. First, the differentiation between viable eggs, nits, and empty nits is difficult even for experienced investigators.[2,3] Second, measuring the proximity of the eggs to the scalp as an indication of having been recently laid—hence, a proxy of viability—is uncertain.[14] Third, Balcioglu et al[3] found that of 138 students with eggs attached to their hair during a survey, only 10 (7%) converted to carriers of trophic stages 2 weeks later. Hence, the presence of eggs is no longer considered adequate evidence for active pediculosis in the absence of living mobile stages and therefore in many European countries is not a sufficient criterion to prescribe a pediculocide.[12] Finally, untrained physicians and laymen confound eggs/nits with artifacts in about one-third of cases.[2] Taking these findings into account, there are only a few situations in which the identification of individuals carrying eggs/nits is meaningful. For instance, if the determination of period prevalence rather than point prevalence is the goal, the number of individuals with eggs/nits, together with their distance from the scalp, could give an indication about the number of individuals having carried adult lice during a defined period of time.

We are aware that the interpretation of the diagnostic performance of both methods is hampered by the fact that the study design did not allow us to determine their specificity. For ethical reasons, we deliberately decided to remove all lice and eggs/nits identified by visual inspection. Because a comparison of both methods can only be performed in the sequence described herein (ie, visual inspection first and wet combing second), the specificity of visual inspection is difficult to assess. By definition, wet combing is a therapeutic intervention, and if this method is performed first, the specificity of visual inspection might be determined but not its sensitivity. Because adult head lice cannot be confounded with artifacts and nymphs appear as small adults, trained personnel will not confound trophic stages or eggs/nymphs with other parasites or artifacts, respectively. Similar to the situation in scabies, one can therefore assume that irrespective whether mobile stages or eggs/nits are looked for, the specificity of both methods is identical or near to 100%.[15]

An ancillary finding of our study is that visual inspection of 5 predilection sites underestimates the true prevalence of head lice infestation by a factor of 3.5 (Table 3). Balcioglu et al[3] and Mumcuoglu et al[4] came to a similar

conclusion. This is another argument for the use of combing instead of visual inspection.

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Correspondence: Hermann Feldmeier, MD, PhD, Institute of Microbiology and Hygiene, Charité University Medicine, Campus Benjamin Franklin, Hindenburgdamm 27, 12207 Berlin, Germany (hermann.feldmeier@charite.de).
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Section Editor's Note

The authors convincingly demonstrate that visible inspection is more sensitive in detecting eggs/nits and that wet combing is more sensitive in detecting trophic stages. Equating the presence of trophic stages with active infestation and eggs/nits with historic infestation is an inference drawn by the authors that may provoke healthy debate.

The criteria to critically appraise the validity of a diagnostic study include blind comparison with a criterion ("gold") standard, evaluation in an appropriate spectrum of patients, and consistent application of the criterion standard.[1] Few studies in dermatology meet this standard.

The absence of a criterion standard as in this study is common in dermatologic diagnostic studies, but it does not preclude evaluating the sensitivity and specificity using the tests under study. The technique involves using a Bayesian approach.[2]

Michael Bigby, MD

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