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INCIDENCE OF IMPACTED CERUMEN DETECTED BY OTOSCOPY AMONG PRIMARY-SCHOOL CHILDREN IN LAHORE, PAKISTAN: A CROSS-SECTIONAL STUDY

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Abstract

Background: *Cerumen is a normal, protective secretion of the external auditory canal, but when it accumulates and obstructs the canal it becomes one of the commonest causes of reversible conductive hearing loss. In children, even mild hearing loss during the years of speech and language acquisition can impair communication, learning and school performance, yet impacted cerumen is frequently silent and routine ear screening is rarely carried out in schools in Pakistan.*

Objective: *To determine the incidence of impacted cerumen detected by otoscopy among primary-school children in Lahore, and to examine its relationship with age, sex and socioeconomic status.*

Methods: *An observational, descriptive cross-sectional study was carried out from 12 October to 31 December 2015 on 2,016 apparently healthy children (4,032 ears), aged 3–12 years, selected by cluster sampling from four primary schools representing the four educational zones of Lahore. Both ears of every child were examined with a hand-held magnifying otoscope. Canal colour, the translucency and position of the tympanic membrane, and the presence and consistency of cerumen were recorded. Total obstruction of the external auditory canal by cerumen, preventing visualisation of the tympanic membrane, was classified as impaction. Data were analysed in SPSS version 17.*

Results: *Cerumen impaction was identified in 855 children, an overall incidence of 42.4%. The rates in boys (42.7%) and girls (42.0%) did not differ appreciably. The incidence declined steadily with age, from 48.8% in 3–5-year-olds to 37.5% in 9–12-year-olds, and rose sharply as socioeconomic status fell,*

affecting 53.1% of children from lower-income backgrounds versus 29.0% in the upper group. Involvement was bilateral in 60.1% of affected children, and the impacted wax was hard in 58.5%. Most affected children (70.3%) were asymptomatic. Otological findings other than impacted cerumen were present in a further 329 children (16.3%).

Conclusion: *Impacted cerumen is highly prevalent among primary-school children in Lahore, affecting more than four in ten children, is usually bilateral and asymptomatic, and is strongly associated with low socioeconomic status. Routine school-based otoscopic screening is recommended to allow early detection and simple treatment, thereby preventing avoidable hearing impairment and its downstream effect on learning.*

INTRODUCTION

The earwax or cerumen is a natural substance of the external auditory canal, which is a combination of the secretions of the ceruminous and sebaceous glands, along with desquamated epithelial cells. It is NOT a waste product, but a protective product: It lubricates the canal, keeps a protective acidic and antibacterial environment, collects dust and foreign particles, and repels water. The canal is self-cleaning and the passage of cerumen is directed radially away from the center of the ear canal by the flow of the epithelium, and falls off at the meatus under normal circumstances (McCarter et al., 2007; Guest et al., 2004; Michaudet & Malaty, 2018). Cerumen is clinically problematic only when this self-cleaning mechanism is impaired and cerumen builds up until it blocks the canal.

The Definition of Cerumen Impaction by the American Academy of Otolaryngology–Head and Neck Surgery Foundation is defined as the presence of cerumen that is associated with symptoms and/or that prevents necessary evaluation of the ear (Roland et al., 2008; Schwartz et al., 2017). When this definition is applied, impaction is very prevalent. It is estimated that approximately 10% of children, 5% of healthy adults, up to 57% of older people in nursing homes, and about 36% of those with intellectual disability have it, and cerumen removal is one of the most commonly performed procedures by primary health care (PHC) providers (McCarter et al., 2007; Guest et al., 2004). Traditionally, the effects of impaction have been categorized as audiological, primarily as a mild conductive hearing loss, and as a barrier to clinical examination, because a canal which is obstructed by wax cannot be examined and the audiometric and tympanometric procedures are also hampered by wax. Impaction can also be associated with tinnitus, itching, and/or feeling of fullness or blockage in the ear, dizziness and, sometimes, reflex cough.

Earwax is not solid, it is not composed of a single substance. Two phenotypes have been genetically determined, a wet, sticky, yellow-brown one and a dry, flaky, grey one; the secretions of the outer canal are on the order of one to two thousand ceruminous glands, in conjunction with sebum and shed keratin, produce the wax. Impaction occurs when the production and clearance of the material is disregulated. It can be caused by simple over-production by hyperactive ceruminous glands, or more commonly by a defect in the normal canal epithelium's migration to the outside that is sometimes complicated by inability of the keratinocyte to separate, leading to dense, sticky plugs. Habitual use of cotton-tipped swabs, hair-pins, and other objects that push the wax into the drum, is a known factor and anatomical factors like a narrow or tortuous canal, an abundance of canal hair, and hearing aids or ear-plugs also delay clearance. Hard wax plugs are those with a higher amount of keratin and are particularly liable to impactation (Guest et al., 2004; McCarter et al., 2007).

The clinical effects of impaction can range. In addition to conductive hearing loss, an obstructed canal can give a feeling of fullness or blockage, otalgia, itching, tinnitus and can even induce a cough reflex, which occurs due to the presence of the auricular branch of the vagus nerve in the supply to the canal. The impaction may also lead to otitis externa, and more importantly, impaction will prevent the clinician from being able to examine the ear drum, making coexisting middle-ear disease undiagnosable and auditometric testing unreliable

(McCarter et al, 2007; Michaudet & Malaty, 2018). A child's effects may not reflect any of these effects, and it's for this reason that objective examination is so important.
These consequences are of particular concern in children. Even a moderate conductive loss in the early years of speech, language and cognitive development can affect the hearing sensitivity of a child in the classroom, and therefore impact on their attainment in language, social and academic skills. Olusanya, Okolo and Ijaduola (2000) reported impacted cerumen in 52.6% of an age representative sample of school entrants in Nigeria and Olusanya (2003) demonstrated, in a matched case–control study of school entrants, that children who had had impacted cerumen removed were more likely to be hearing impaired than the controls and the hearing impairment more likely to be permanent. The ear is not only a concern for the prevention and early detection of impaction but for the child's broader development; particularly in environments where routine systematic hearing screening is not routinely conducted.
This is due to the relevant anatomy. The external auditory canal extends from the concha to the tympanic membrane and is about 2.5-3.5 cm long in a grown-up. The outer third is cartilaginous and is covered with thick skin which contains ceruminous and sebaceous glands that produce wax as well as hair follicles, but the inner two-thirds is bony and lined with thin, hairless skin and narrow at the isthmus, a few millimetres lateral to the drum (Gelfand, 2009; Dhingra & Dhingra, 2010). The canal is shorter, narrower and more horizontal than in adults in young children, making cerumen more likely to accumulate in the canal. A wax plug is located at the point shown in Figure 1.

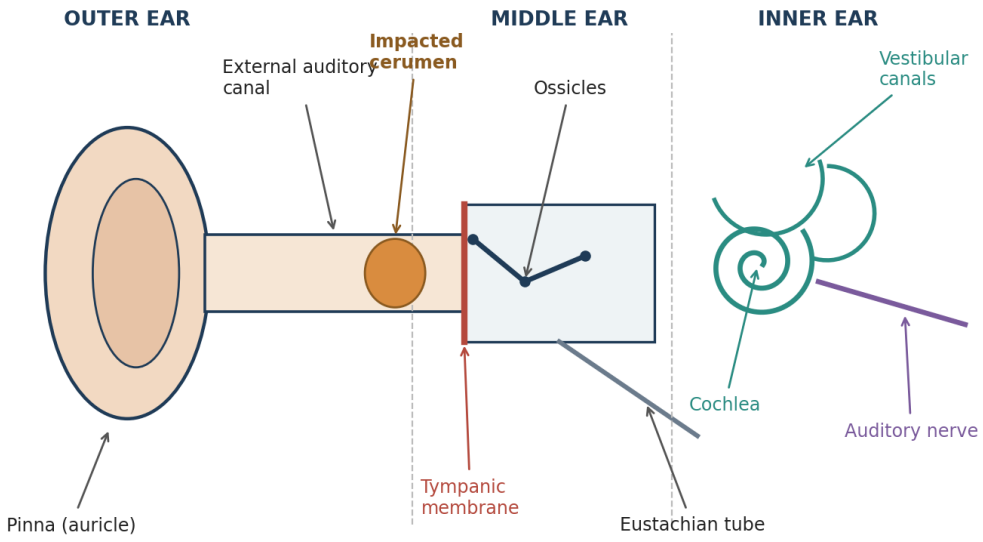


Figure 1. Schematic anatomy of the ear, showing the site of cerumen impaction within the external auditory canal.

There is a wide range of reported prevalence of impaction in schoolchildren from different parts of the world, which is due to actual differences in age, climate and ear cleaning habits, in living conditions, at least in part due to sampling differences, and due to different criteria used to define impaction. In a survey of 46,000 school children in Kuwait, Al-Fadala and Holmquist (1985) reported total canal obstruction due to cerumen in only a small percentage of children and Minja and Machemba (1996) in a survey in Dar es Salaam, Tanzania, reported a prevalence of 15.7% for cerumen impaction. Brkic (2010) found intermediate levels of approximately a quarter in Bosnia and Herzegovina, and similar surveys conducted across Europe and Africa have yielded rates in this general range (Hatcher et al., 1995). On the other extreme, Eziyi et

al. (2011) reported 46.7% in primary schools in Nigeria. An important finding across these studies is that impaction is much more common among low socioeconomic status (Eziyi et al., 2011; Adegbiji et al., 2014) which is mainly attributed to differences in access to health care, hygiene practices and awareness.

Epidemiological data regarding cerumen impaction in Pakistan is limited and screening of the ears is not regular practice in the schools in the country. The present study was, therefore, conducted to find the prevalence of impacted cerumen in primary school children of Lahore and to draw a picture of its distribution according to age, sex and socioeconomic status. It was hoped the results would help to increase awareness of school authorities to the implications of impaction and help promote the use of simple, low cost otoscopic screening for early identification and management.

2. Materials and Methods

This was an observational, descriptive cross sectional study performed in Department of Allied Health Sciences, FMH College of Medicine & Dentistry, Shadman, Lahore. The field work was carried out during three months period after the approval of the study synopsis from 12 October to 31 December 2015. The study population was the apparently healthy children of mainstream primary schools in the city of Lahore.

A cluster-sampling technique was used to recruit participants. Four main schools were selected, one from each of the four educational zones of the city with a deliberate effort to include as much as possible a cross section of the socioeconomic class of Lahore. Children aged 3 to 12 years in the selected clusters, who were all primary school children, were eligible for inclusion and 2016 children (4032 ears) were examined. All children were included and no children were excluded due to an existing ear condition; the aim was to estimate the prevalence of impaction in the general school population and not a clinic-attending or symptomatic group of children.

Children were examined bilaterally using the same examiner who used a battery-powered, hand-held otoscope equipped with a battery light source and a magnifying lens. Pinna was raised upwards and backwards and the speculum was placed before the canal was brought into line with the tympanic membrane (Figure 2). A canal colour (red, white or yellow), translucency of the tympanic membrane (transparent or opaque) and position (retracted, neutral or bulging) were noted for every ear, as were the presence and consistency (hard or soft) of any cerumen.

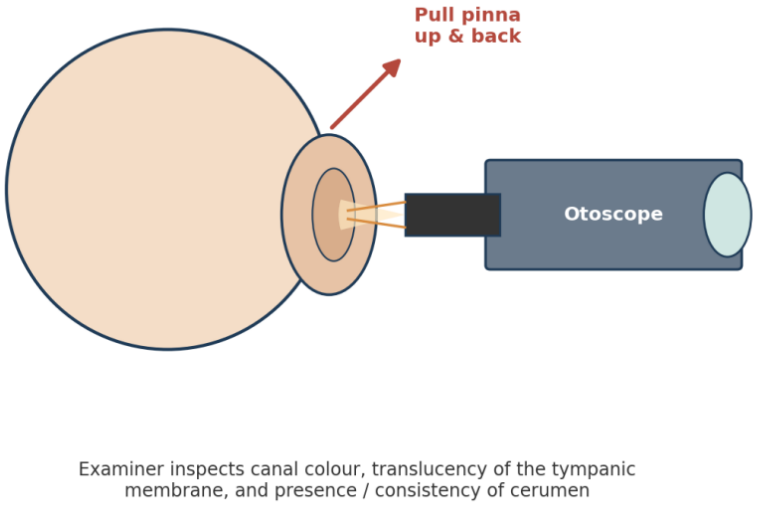


Figure 2. Otoscopic examination technique: the pinna is retracted upward and backward to align the ear canal with the tympanic membrane before the speculum is introduced.

In the context of this study an otoscope was defined as a medical instrument for examining the ear, ear canal and tympanic membrane, cerumen was defined as the natural mixture of glandular secretion and desquamated epithelium found in the outer ear canal and cerumen impaction was defined as an impaction of cerumen such that the tympanic membrane was not visualised at the time of examination, which is the accepted criteria for this condition. Only ears that were fully obstructed by ear wax were counted as impacted, and partial or incidental ear wax, which allowed a view of the drum was not defined as impaction. No effort was made to remove the wax at the time of examination and children identified with impaction or other anomalies were referred for suitable care.

Children were classified into lower, middle and upper socioeconomic levels based on the cluster in which they were enrolled, which was determined by the geographical area served by the schools in the cluster. The administration of each school had given verbal consent for the examination before data collection. As the study was non-interventional (wasn't dealing with removing the wax from the ear or performing any experiment), it was determined that there were no extra concerns with it.

The data were analyzed with IBM SPSS 17 (SPSS Inc., Chicago, IL, USA). Continuous variables (e.g. age) are summarized as means and standard deviations while categorical variables (e.g. sex, laterality, impaction status) are summarized as frequencies and proportions. Bar charts and related graphics are used to present results. The sequence of sampling and examination is as shown in a flow diagram in Figure 3.

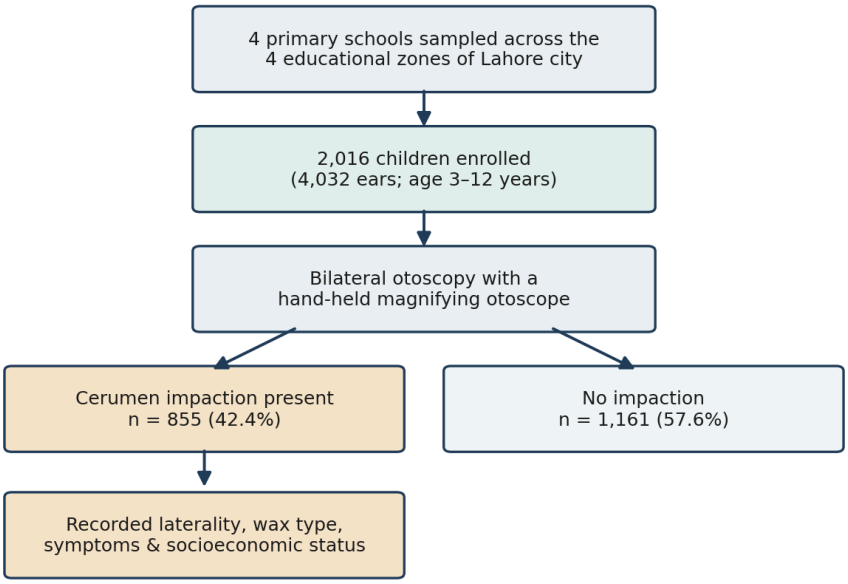


Figure 3. Flow diagram of the sampling and examination process.

3. Results

A total of 2,016 children, representing 4,032 ears, were examined. The sample comprised 1,100 boys (54.6%) and 916 girls (45.4%), and the mean age was 8.41 ± 2.14 years, with individual ages ranging from 3 to 12 years. The distribution of the sample by sex and age group is shown in Table 1.

Table 1. Demographic characteristics of the study population (N = 2,016).

Characteristic	n	%
Boys	1,100	54.6
Girls	916	45.4
Age 3–5 years	430	21.3
Age 6–8 years	760	37.7
Age 9–12 years	826	41.0
Total	**2,016**	**100.0**

Cerumen impaction, defined as total obstruction of the canal preventing a view of the tympanic membrane, was identified in 855 children, giving an overall incidence of 42.4% (Figure 4). Impaction was thus present in almost half of the children screened, confirming that it is a common finding in this population.

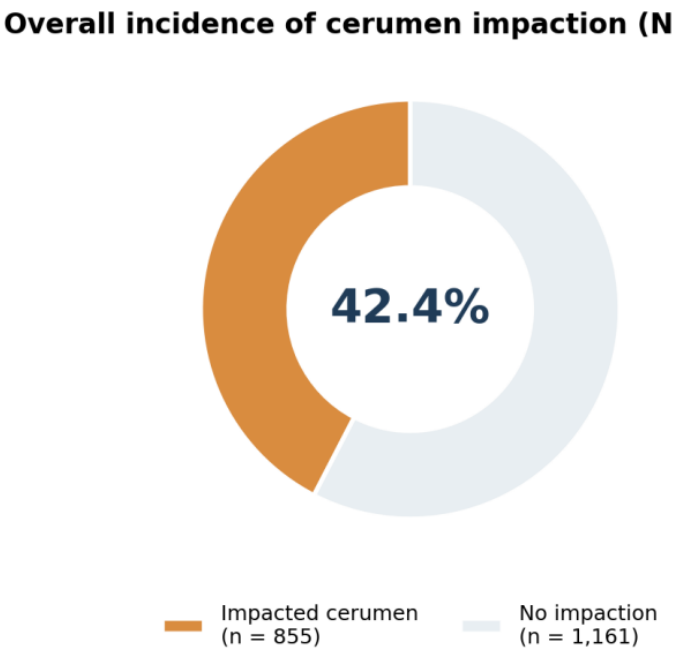


Figure 4. Overall incidence of cerumen impaction among the 2,016 children examined.

The incidence of impaction was very similar in the two sexes. It was found in 470 of 1,100 boys (42.7%) and in 385 of 916 girls (42.0%), a difference that is negligible and of no statistical or clinical importance (Table 2). Impaction in this population therefore showed no meaningful sex predilection.

Table 2. Incidence of cerumen impaction by sex.

Sex	Examined (n)	Impacted (n)	Rate (%)
Boys	1,100	470	42.7
Girls	916	385	42.0
Total	**2,016**	**855**	**42.4**

A clear relationship with age was observed. Impaction was most frequent in the youngest children and became progressively less common in the older age bands, falling from 48.8% among 3–5-year-olds to 44.1% among 6–8-year-olds and 37.5% among 9–12-year-olds (Figure 5, Table 3). The trend is consistent with the narrower, shorter and more horizontal ear canal of younger children, which hinders the natural outward migration of cerumen.

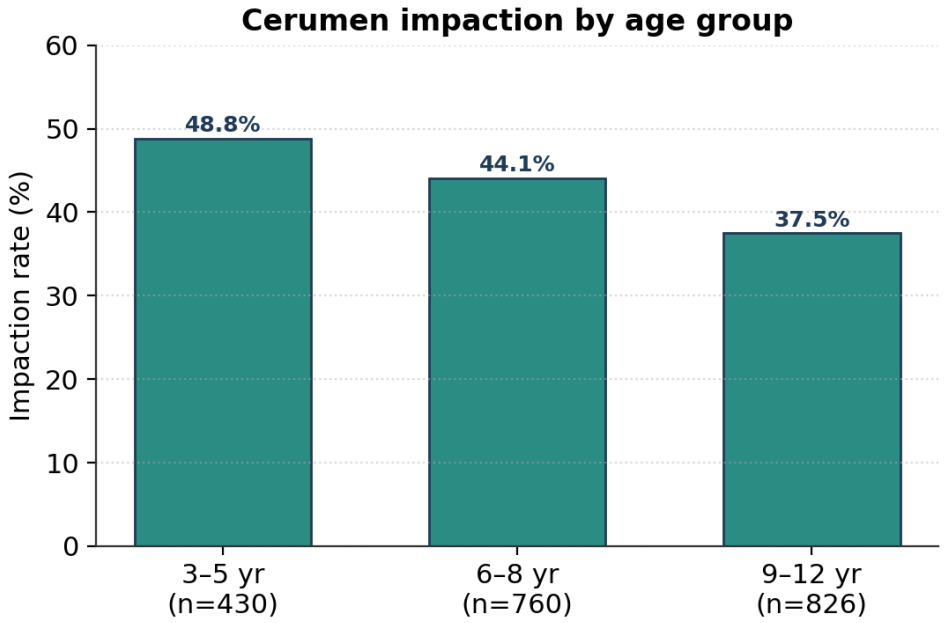


Figure 5. Incidence of cerumen impaction by age group.

Table 3. Incidence of cerumen impaction by age group.

Age group	Examined (n)	Impacted (n)	Rate (%)
3–5 years	430	210	48.8
6–8 years	760	335	44.1
9–12 years	826	310	37.5
Total	**2,016**	**855**	**42.4**

The strongest association in the study was with socioeconomic status. A clear gradient was seen across the three groups: impaction affected 430 of 810 children (53.1%) from lower socioeconomic backgrounds, 280 of 706 (39.7%) from middle-income backgrounds, and 145 of 500 (29.0%) from the upper group (Figure 6, Table 4). Children from lower-income backgrounds were thus almost twice as likely to have impacted cerumen as those from the most affluent group.

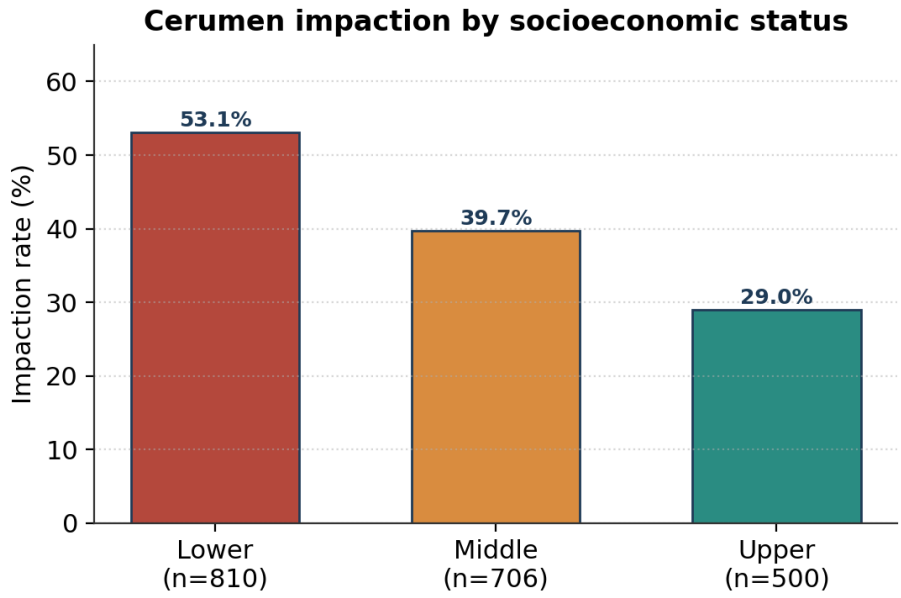


Figure 6. Incidence of cerumen impaction by socioeconomic status.

Table 4. Incidence of cerumen impaction by socioeconomic status.

Socioeconomic status	Examined (n)	Impacted (n)	Rate (%)
Lower	810	430	53.1
Middle	706	280	39.7
Upper	500	145	29.0
Total	**2,016**	**855**	**42.4**

Among the 855 children with impaction, the condition was more often bilateral than unilateral: both ears were affected in 514 children (60.1%) and a single ear in 341 (39.9%). The impacted wax was hard in 500 children (58.5%) and soft in the remaining 355 (41.5%) (Figure 7). The predominance of bilateral, hard impaction is consistent with a process of gradual accumulation rather than an acute event.

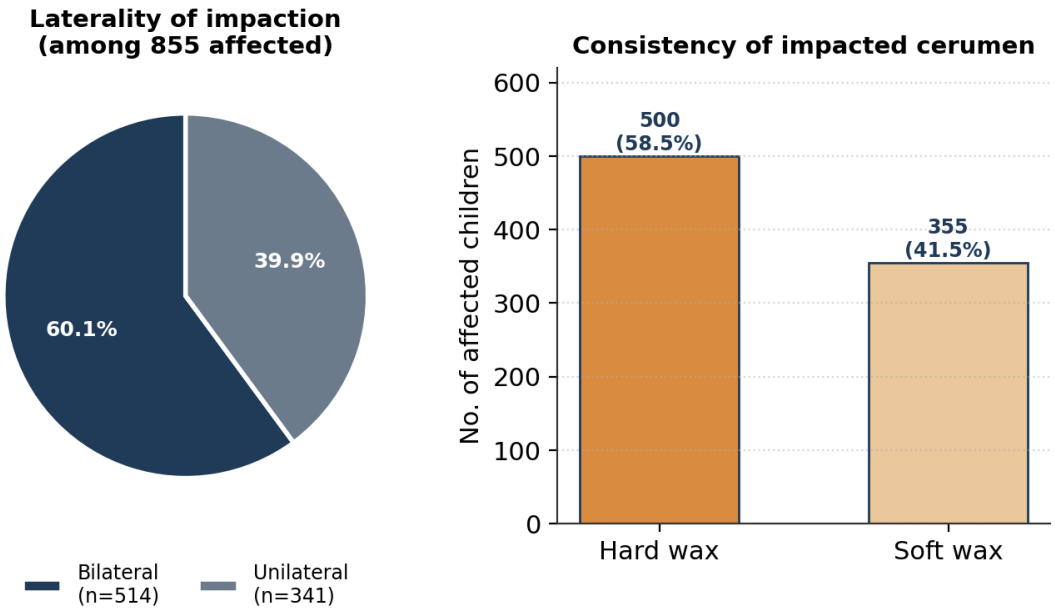


Figure 7. Laterality (left) and consistency (right) of impacted cerumen among the 855 affected children.

A striking feature of the findings was that most affected children had no complaints. Of the 855 children with impaction, 601 (70.3%) were entirely asymptomatic and had not previously sought any medical attention for their ears, while 254 (29.7%) reported one or more symptoms. Among the symptomatic children the commonest complaint was a sensation of a blocked ear or reduced hearing, followed by itching, earache and, less often, tinnitus and dizziness (Table 6). The largely silent nature of the condition underlines the value of active screening, since the great majority of affected children would not otherwise have come to attention.

Table 6. Pattern of complaints among the 254 children with symptomatic impaction.

Symptom	n	%*
Blocked ear / reduced hearing	149	58.7
Itching (pruritus)	95	37.4
Earache (otalgia)	68	26.8
Tinnitus	39	15.4
Dizziness	18	7.1

* Percentage of the 254 symptomatic children; some children reported more than one symptom, so figures overlap and do not sum to 100.

Finally, otological findings other than impacted cerumen were noted in 329 children (16.3% of the whole sample). The commonest of these was a dull or retracted tympanic membrane suggestive of middle-ear effusion, followed by otitis externa, tympanic-membrane perforation and, less frequently, aural foreign bodies and other abnormalities (Table 5). The presence of these additional findings in roughly one in six children reinforces the broader value of routine ear examination in this age group.

Table 5. Other otological findings among the children examined (n = 329).

Finding	n	%*
Dull / retracted tympanic membrane (?effusion)	120	36.5
Otitis externa	85	25.8
Tympanic-membrane perforation	46	14.0
Foreign body	33	10.0
Other abnormalities	45	13.7
Total	**329**	**100.0**

* Percentage of the 329 children with findings other than impacted cerumen.

Taken together, these results describe a condition that is common, unequally distributed and largely hidden: impaction was present in 42.4% of children overall, was concentrated in the youngest and the poorest, was bilateral and hard in most affected children, and was asymptomatic in roughly seven of every ten.

4. Discussion

In this study, impacted cerumen was present in 42.4% of primary school children of Lahore which implies that over 4 out of 10 primary school children demonstrated complete blocking of their canal by wax. Comparable to international standards, this is a high rate and indicates that impaction is a significant, predominantly unsymptomatic otological disease in this population. This rate of prevalence has implications for child health and hearing as well as for the provision of school health services since a blocked canal results in a conductive hearing loss and at the same time, makes it difficult to examine the ear.

The present value is at the high end of the reported range, considering the broader literature. It is higher than the rate of canal obstruction reported by Al-Fadala and Holmquist (1985) in Kuwait (low) and higher than the rate of canal obstruction reported by Brkic (2010) in Bosnia and Herzegovina (24.4%) but lower than that of Minja and Machemba (1996) in Dar es Salaam (15.7%) school children. However, it falls very close to the rate of 46.7% recorded by Eziyi et al (2011) in the Nigerian primary schools and 52.6% recorded by Olusanya et al (2000) among school entrants in Nigeria. This variation is real, and due to genuine differences in the age of the children studied, climate, and the habits of ear cleaning and hygiene; some of this variation is methodological, and stems from the different definitions of impaction used (such as counting total obstruction versus any visible wax), and the sampling frame (higher rates from clinic-based series than from community screening). This criterion of complete obstruction is, relative to other populations, especially stringent, indicating that the actual incidence of wax with any significant degree of obstruction may be even higher than what was reflected here.

It is difficult to make direct comparisons with other data available from Pakistan and the immediate region, due to the lack of published school-based surveys, which is, in fact, one of the reasons for the present survey. The reported rate is nevertheless well higher than the 10% prevalence estimate for children in the general population that is frequently reported in Western primary care data (McCarter et al., 2007; Schwartz et al., 2017), which may be due to a difference in sampling methods (community versus clinic) as well as environmental and socioeconomic differences between settings. The fact that it is a socioeconomic gradient, and that the same socioeconomic gradient was found in this study and other studies indicates that it may be broadly applicable; the factors driving the socioeconomic gradient (hygiene, awareness and access to care) are the same; and screening methods that have proven successful in other contexts are likely to be effective in Lahore.

The clear public health message from the most consistent finding of this study is the high level of association between low socioeconomic status and impaction. The incidence was consistently lower across each quartile, with children from the poorest 25% being nearly double the incidence of those from the most affluent 25%. This gradient corresponds to that reported by Eziyi et al. (2011) and Adegbiji et al. (2014) and is most likely attributed to the differences in the availability of health care, awareness of ear health and in living conditions/hygiene practices between the different socio-economic groups. It designates low-income children as a priority group to be targeted by any screening programme.

The incidence decreases with age and matches the anatomy of a growing ear. The shorter narrower and more horizontal ear canal in younger children (as compared with older children and adults) also means there is a greater risk of outer-ear pathology occurring, as the ear canal is a smaller surface for the outward epithelial migration that occurs naturally in the ear, favouring cerumen accumulation (Brkic 2010). The rate of impaction was 42.7% in boys and 42.0% in girls, suggesting that there is no significant sex predilection in this population, which is consistent with Brkic (2010) who also showed no significant sex difference, but differs from some clinic based series which reported a slight male predominance (Eziyi et al., 2011; Adegbiji et al., 2014) which was likely to reflect differential care-seeking rather than a true biological influence.

The most significant practical implication of the study was the fact that many of the children with affected ears in the end were completely asymptomatic and had never complained about their ears. In other words, impacted cerumen is, for the most part, a silent condition in this age group, and if not screened actively, most of the time, it would not be detected. This is important because the conductive loss even arising from mild impactation can worsen a child's hearing in the classroom setting and during the most crucial language development phase of childhood, affect communication, learning and school performance (Olusanya, 2003; Olusanya et al., 2000). The 16.3% of children with other otological abnormalities found, most commonly a dull or retracted drum indicative of middle-ear effusion, is consistent with an argument that a simple examination of the ear at school entry might be of greater benefit than simply looking for ear wax.

Bilateral impaction (60.1%) and the predominance of hard wax (58.5%) in this series is consistent with a slow, constitutional process of accumulation and not with an acute and one-sided event. An equal number of plugs on both ears is indicative of a systemic tendency (either overproduction or failure of epithelial migration or shedding) which affects both ears, whereas the presence of more hard and adherent plugs suggests a higher content of keratin and explains why impaction often fails to resolve spontaneously, and requires intervention (Guest et al., 2004; McCarter et al., 2007).

Fortunately, from the management viewpoint, the condition is simple and cheap to treat once it is diagnosed, and is relatively easy to manage. Potential techniques include softening the wax with a cerumenolytic agent, irrigating the canal with or without cerumenolytic pre-treatment and manual removal under direct vision depending on the clinical situation and operator skill and equipment (Michaudet & Malaty, 2018; Schwartz et al., 2017; Roland et al., 2008). Consultation and education about ear hygiene is also important—families should be reminded that the ear is self-cleaning and that anything pushed into the ear canal, such as cotton swabs, may cause trauma to the ear drum and/or push the earwax more deeply in the ear canal, which will not help. Kids who have a very full canal, an unusual ear canal shape, a history of ear surgery or perforation of the ear drum, or who have trouble hearing when the ear drum is taken out, should be referred to a doctor, or otolaryngologist, not the point of screening, for treatment. The evidence that comes from these findings is compelling to support screening in schools. However, otoscopy is quick, non-invasive, inexpensive, requires minimal training and a hand-held instrument and — as this study demonstrates — can detect a considerable proportion of affected children who would be unrecognised without the use of a hand-held instrument. A pragmatic programme may include an abbreviated otoscopic screening at school entry and periodically afterwards, management of simple impaction in the school setting, clear referral pathways for complicated cases and other otological abnormalities, and health education for children and parents regarding ear hygiene. Schools that were in low-income areas, in which the burden was found to be the highest, could be considered a priority. This screening is likely to be very cost-effective as the potential benefit is the prevention of avoidable hearing loss over the years when the loss is most likely to be affecting learning, and the intervention is very cheap; however, this remains to be confirmed with a formal economic evaluation along with measured hearing and educational outcomes.

These results should be interpreted with the following limitations in mind. The diagnosis was based only on otoscopy and no audiometry or tympanometry were performed, so the degree of hearing loss associated with the impaction could not be quantitated and otological findings were not objectively confirmed. Second, socioeconomic status was determined at the school cluster level (not at the child level), and this approach may have resulted in some misclassification. Thirdly, there was a limitation that the findings of the study were restricted to the students of a single city and those who attend school. Lastly, it was a screening study with no wax removal or follow-up, therefore, the effect of the treatment on hearing was not measured. Further studies are recommended to include audiometry and tympanometry as well as otoscopy, individual socioeconomic status, rural and pre-school populations and to assess the effects of the screening and treatment programme on measured hearing and educational outcomes.

5. Conclusion

More than 4 out of every 10 children examined in primary schools of Lahore had impacted cerumen. It is typically bilateral, most commonly hard wax, and — crucially — silent in the vast majority of instances, and thus would not be detected if not actively screened. Incidence is greatest in the youngest children and increases sharply with decreasing socio-economic status, making identification of young children from lower income groups the group most in need. Impaction causes only a mild conductive hearing loss but the time it occurs during the crucial period of speech and language development can have an disproportionate impact on communication, learning and school performance, and in one in six children a further otological abnormality was discovered. Regular screening of school children with a hand-held otoscope for ear disease – which is simple and inexpensive – and a clear pathway for referral – is strongly recommended as a low cost prevention of avoidable hearing impairment and a way to protect children's education potential. The first step in the process of developing such screening is to raise awareness of school staff of the magnitude and the quiet nature of the problem.

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