Introduction
CHAPTER - I
INTRODUCTION

1.1 MEANING AND DEFINITION OF OTITIS MEDIA (OM)

Otitis media may be defined as the infection or the inflammation of the middle ear. The middle ear includes the ossicles, middle ear cleft and the eustachian tube. Otitis media is the infection which is most frequently diagnosed by the physicians among the infants and children who visit the hospital because of illness. Otitis media prevails due to the bacterial or viral infection which is often secondary to any respiratory tract infection, sore throat, cold or breathing problems spread to middle ear.

Otitis media is more common among the infants and children than in adults. Various reasons can be attributed as to why children are more susceptible to the disease than adults. Firstly, the immune systems are still developing in children, hence they have more trouble fighting infections. Secondly, the eustachian tube which is the small passage way that connects the upper part of the throat to the middle ear, is shorter and straighter in children than in adults (See. Fig.1.5). Hence any infection of the upper respiratory tract spreads easily to the middle ear via. eustachian tube. Thirdly, adenoids in children are larger than in adults. They are largely composed of cells (lymphocytes) which help to fight infections. These adenoids are present in the back of the upper part of the throat, near the eustachian tube. Since they are larger in children, because of their size, may interfere with the opening of the eustachian
tube. Eustachian tube opens regularly to ventilate the air in the middle ear, blockage of the eustachian tube prevents the ventilation of the middle ear causing the fluid from the tissue that lines the middle ear to accumulate in the normally air filled middle ear. Thus, anything that interferes with the normal functioning of the eustachian tube predisposes to middle ear infection. It could be recurrent attacks of common cold, upper respiratory tract infection (URTI), exanthematous fevers like measles, diaptheria, whooping cough, infections of tonsils and adenoids, chronic rhinitis and sinusitis, nasal allergy, tumors of nasopharynx, packing of nose or nasophyrynx for epistaxis and cleft palate.

The infection in the middle ear causes swelling of the lining of the middle ear which blocks the eustachian tube and the migration of the white cells from the blood stream which helps to fight infection. Thus, the white cells get accumulated in the middle ear and kill the bacteria, dying themselves leading to the formation of pus, a thick yellowish white fluid. Significant increase of the fluid in the middle ear bulges the cardium leading to its perforation. The discharge of the pus from the middle ear may have foul smell indicating the underlying bone destruction which shows the severity of the disease.

The presence of fluid in the middle ear predisposes a child to some degree of hearing loss. It may be mild, moderate or severe which is of conductive type. We hear because the sound waves enter the ear canal which allows the ear drum to vibrate due to the presence of air in the middle ear but the presence of fluid in the middle ear makes the cardium
and middle ear bones unable to move as freely as they should, leading to hearing loss. The children also experience pain in the ear as the pressure in the air builds, from a dull ache to a sharp stabbing pain. The pain is worse at night. The pressure in the middle ear is relieved intermittently, so the pain comes in waves.

Since the onset of the disease is more frequent from birth to 3 years of age, the hearing loss caused by the presence of fluid in the middle ear makes the child unable to abstract words of speech and language which is their critical period of language acquisition. Thus, the child gets confused while attempting to abstract words, meanings, and grammatical regularities leading to the disability of the same. This reduces the interest of the child in social interaction which in turn leads to social isolation and frustration. It is noted that the hearing loss caused by otitis media is usually temporary but if the disease is left untreated it may lead to permanent hearing impairment.

Normally the parents of the child find it difficult to know what is bothering their child because their children have yet not developed sufficient speech and language skills to tell their parents. Hence, if we notice the common signs like unusual irritability, difficulty in sleeping, tugging or pulling at one or both ear (otalgia), fever, fluid discharges from the ear and hearing difficulty we may take the child to a doctor for further clarification. Even among the adults, the primary symptoms include pain, discharge and some degree of hearing loss which is again of conductive type.
Otitis media is a curable disease but if it is left untreated it may lead to serious complications like mastoiditis, facial paralysis, labyrinthitis, meningitis, brain abscess etc. Thus untreated otitis media may spread to the nearby parts of the head, including the brain. Complications may occur due to various factors like high virulence of organisms, poor resistance of the patient, inadequate antibiotic treatment, presence of systemic diseases like diabetes mellitus, tuberculosis, nephritis, leukemia etc. and resistance of organisms to antibiotics.

Thus, otitis media has long term adverse effects on the children like audiological, physiological, educational and behavioural.

1.2 CLASSIFICATION OF OTITIS MEDIA

1.2.1 Suppurative otitis media

Acute suppurative otitis media (ASOM)

ASOM also known as purulent otitis media is characterized by sudden onset and short duration. Normally acute otitis media is preceded by upper respiratory tract infections as the nasal membranes and the eustachian tube become swollen and congested. Acute otitis media is a common childhood ailment but it can also occur in adults.

80 to 85 per cent of the cases of acute otitis media are due to the bacterial invasion. The most common bacterial offenders are Streptococcus pneumonia, Hemophilus influenza, Escherichia coli, Bacillus proteus, Staphylococcus aureus and Moraxella catarrhalis. Viruses can be found in about 15 per cent of the cases.
In acute otitis media, pus gets collected in the middle ear and due to this the affected individual experiences some degree of hearing loss. This is a very dangerous stage because there are possibilities of central nervous system complications like meningitis, brain abscess, sinus thromboses etc. The duration of acute otitis media is normally up to 3 weeks or to 3 months but it is variable. In most children acute otitis media clears spontaneously after antibiotic treatment. Treatment of antibiotics for a week to 10 days is usually effective. There may be improvement within 48 hours even without treatment. Acute otitis media is not contagious though the upper respiratory tract infection that may precede it could be.

Acute otitis media is associated with pain, hearing loss and ear discharge. Fever may be present in a child of any age. Continuous buildup of the pus in the middle ear can exert pressure on the tympanic membrane, which may bulge to the point of rupture. Thus, with the rupture of the tympanic membrane the pus escapes into the external auditory canal relieving the patient from pain and hearing loss and also the possibility of central nervous system complications greatly diminishes. The hole in the tympanic membrane due to its rupture is usually healed with medical treatment.

**Chronic suppurative otitis media (CSOM)**

Chronic otitis media is associated with permanent perforation of the tympanic membrane and chronic inflammatory process within the middle ear. The onset of the chronic otitis media is insidious that is, the
rate of pathological changes taking place is very slow. Hence, chronic infections may show less severe symptoms and may not be noticed. So the infection may remain untraced for long periods of time. A chronic infection is more dangerous than the acute infection because its effects are prolonged and repeated and may cause permanent damage to the ear.

Chronic otitis media may be the result of acute ear infection that does not clear completely or may be the result of recurrent ear infections. Pain is uncommon in chronic otitis media, presence of pain shows the severity of the disease. Since the infection remains untraced for a longer period of time due to its insidious nature the pus accumulated in the middle ear may damage the bones of the middle ear. The perforation found in the tympanic membrane may be central, anterior, posterior or inferior to the handle of malleus (see Fig.1.7). The ear discharge may have foul smell due to the underlying bone destruction in the middle ear.

Pus cultures show that chronic otitis media is caused by multiple organisms both aerobic and anaerobic. Common aerobic organisms are *Bacillus proteus*, *Escherichia coli*, *Staphylococcus aureus*, while anaerobics include *Bacteriodes fragilis* and *Streptococci*.

Trauma or other disorders may cause chronic ear infection. Infection from tonsils, adenoids and infected sinuses may also be responsible for the disease. This is most common in children. The discharge is apparent mostly at the time of upper respiratory tract infection or an accidental entry of water into the ear. Due to the presence
of discharge, there is hearing loss which is of conductive type and also the severity of hearing loss varies from person to person. The discharge may be continuous or intermittent. Sometimes, the discharge is so scanty that the patient may not even be aware of it.

Since pain is uncommon in chronic otitis media its presence is considered serious as it indicates extra dural, perisinus or brain abscess. There may be persistent headache, which is suggestive of an intracranial complication. There may be fever and vomiting. The infection may spread into the mastoid bone and abscess round the ear (mastoiditis) can be seen. Irritability and neck rigidity (meningitis) may also be present. The symptoms may be continuous or intermittent and may occur in one or both the ears.

1.2.2 Specific otitis media

Tubercular otitis media

The process of tubercular otitis media is slow and insidious. Usually the infection is secondary to pulmonary tuberculosis. Here the infection reaches the middle ear via eustachian tube. Sometimes it is blood borne.

In tubercular otitis media ear pain is characteristically absent but the discharge is often foul smelling due to the middle ear bone destruction. The classical sign of the disease is that multiple perforations usually 2 or 3 in number are seen in pars tensa and oftenly these may coalesce into a single large perforation. Hearing loss is severe mostly
conductive but it may have sensorineural component due to the involvement of labyrinth. Complications may include facial paralysis and it may come unexpectedly which may be the main feature in the child.

Tubercular otitis media may be indistinguishable from the chronic otitis media in presence of secondary pyogenic infection but culture of ear discharge for *Tubercle bacilli*, histopathological examination of granulations and other evidence of tuberculosis in the body help to confirm the diagnosis.

**Syphilitic otitis media**

It is a very rare condition. This is also indistinguishable from chronic otitis media. This infection may also be blood borne. Since syphilitic lesions are present in nose and nasopharynx, spirochaetes reach the middle ear via eustachian tube causing infection in the middle ear. Spirochaetes also invade sensory end organs of the inner ear and their nerve leading to sensorineural hearing loss, tinnitus and vertigo. Bone necrosis is common leading to foetid ear discharge.

**1.2.3 Adhesive otitis media (AOM)**

Adhesive otitis media is the end result of recurrent acute otitis media or secretory otitis media. The word adhesive is used to describe the tympanic membrane which is intact, immobile, scarred and retracted. It is considered to be an unfortunate disease because the reconstruction of the ear in this case is extremely difficult but it could be possibly prevented only when it is recognised in the early stage.
1.2.4 Non-suppurative otitis media

Serous otitis media (SOM)

Serous otitis media is also called as secretory otitis media, otitis media with effusion, mucoid otitis media and glue ear. The onset of this infection is also insidious. In this case a non-purulent effusion can be seen in the middle ear cleft. The effusion is sometimes thin and serous else, it is normally thick and viscid (see. Fig. 1.8). It is most commonly found in school going children.

It normally results due to the inefficiency of the eustachian tube to aerate the middle ear due to various reasons like enlarged adenoids, chronic rhinitis or sinusitis, chronic tonsillitis, tumors of nasopharynx and palatal defects like cleft palate and palatal paralysis. It may also be due to the increased number of mucus or serous secreting cells. This infection may also be the result of certain seasonal allergy to food stuffs which is common in children. It may also be due to unresolved otitis media. It may also be due to the viral infection wherein various adeno and rhinoviruses of upper respiratory tract may invade middle ear mucosa and stimulate it to increased secretory activity.

1.3 EPIDEMIOLOGY

Epidemiology may be defined as the study of epidemics or the science of epidemics. Epidemics is the wide spread occurrence of an infectious disease in a community at a particular time. Thus epidemiology is concerned with the incidence and distribution of disease
and other factors relating to health. Susceptibility to otitis media varies primarily as a function of age, sex and ethnicity, however the biological attributes influencing these variables remain unclear. The epidemiological data regarding this disease can provide information of risk features in children who have recurrent and severe disease and helps in postulating the methods of prevention and therapy. Longitudinal studies are considered to be the best studies which can provide a rich source of information about otitis media.

Large number of epidemiological studies of otitis media have been undertaken some of them are given as under.

An epidemiological survey carried out in Riyadh among Saudi children, 1.5 per cent had chronic ear disease, these results were compared with other developed and developing countries. Other predisposing factors like environmental and genetic factors were also studied (Muhaimed, et al, 1993). In another study 404 children of age 3 were examined in a town in Denmark at different periods over a 6 months period. It was found that 20 per cent of the children had middle ear effusion at each of the four examinations, 42 per cent of the children had atleast one episode and 6 per cent had persistent effusion at all four examination (Fiellau-Nikolajsen, 1983). 3413 Italian school children aged 5-7 years were examined for the presence of otitis media with effusion, it was found that young children had significantly more bilateral and unilateral effusion (Marchisio et al., 1998). When 613 children were evaluated in a village in Haryana 15.3 per cent had chronic suppurative
otitis media. This contributed to 71.6 per cent of hearing impaired 
(Verma-Amit et al., 1995). 164 infants less than 1 year were studied in 
Matsuyama Red cross hospital, Japan. The study revealed that infants 6 
months old or older are more susceptible to otitis media than those 
younger than 6 months. 76.6 per cent of the older group had bilateral 
otitis media in the younger group (Maruyama et al., 1996). A heavy 
burden of ear disease and hearing loss is reported from the study of 642 
Aboriginal children living in Eastern Goldfields of Western Australia 
(Watson, Clapin, 1992).

71 per cent of 2,565 children had one episode of acute otitis media 
and one third had three or more episodes when the children by 3 years of 
age were studied in Boston, Massachusetts (Teele et al., 1980). 50 per 
cent of 2,404 Swedish children by five years of life had one episode of 
otitis media and 18 per cent had more than four episodes (Pukander et 
al., 1984). All these epidemiological studies showed higher incidence in 
males except in a community study of otitis media patients in Claveston 
Texas (Biles et al., 1980).

**Incidence and prevalence**

Incidence of otitis media measures the risk of developing otitis 
media in a population; the incidence rate is calculated by dividing the 
number of new cases of otitis media during the specific period by the 
population number during that time whereas prevalence measures the 
disease burden in a population and is calculated by taking the number of
existing cases of otitis media at a given time divided by the population at that time (Daly, 1991).

Many studies have been undertaken to show the incidence and prevalence rates of otitis media.

There was no significant difference in the prevalence of chronic otitis media in urban and rural children studied in northern Tanzania (Boston et al., 1995). The prevalence rate of chronic otitis media with effusion was 4.4 per cent upto the age of 24 months, the maximum risk being at the age of 16 months. This was studied in randomly selected local private hospitals in Finland, with a random sample of 2512 children (Alho et al., 1995). 2.6 per cent and 1.5 per cent of adults had inactive and active chronic otitis media respectively when the UK national study of hearing set out to ascertain the prevalence of ear disease, hearing impairment and associated risk factors and this active condition was more common in older individuals and those in manual occupations (Browning and Gatehouse, 1992).

A significant decrease in the prevalence rate was observed in 1990 in the Inuit Elementary school children in the eastern Canadian Arctic when they were compared with the studies of past two decades (Baxter et al., 1992). In another study (Giles and O'Brien,. 1991) a significant decrease in the prevalence of otitis media was observed when a survey of hearing among Maor school children in the eastern north Island of New Zealand was conducted. When 1439 two year old children in the Netherlands were screened, it was observed that the prevalence rate was
high compared to the results quoted in the previous literatures that is, 80 per cent of the children had otitis media with effusion on at least one occasion before the age of four (Zielhuis et al., 1990). Point prevalence rate of 1.56 per cent of otitis media with effusion was found when a pilot study for the prevalence of otitis media with effusion was undertaken by the investigators on a group of 255 children with ages ranging from 6 to 7 years old, and this point prevalence was noticeably lower when compared to the prevalence reports of West which ranges from 2.3 per cent to 14 per cent in age compatible children (Yue et al., 1997). The prevalence of otitis media with effusion was lower among the 2202 Jamaican children aged 5-7 years when compared to the same age group in the developed countries (Lyn et al., 1998).

A study of mixed ethnic groups was conducted in the Hong Kong city which revealed that the Chinese children had a significantly lower point prevalence (1.3%) than the Caucasian children (9.5%) and also the point prevalence from this mixed ethnic group children was also significantly higher than that of local Chinese school children (Rushton et al., 1997). In another study in Malaysia the prevalence rate of otitis media with effusion was higher in the urban district (17.9%) than in the rural district (9.48%) (Saim et al., 1997). A pilot study of 254 children aged 6-10 years was performed in order to determine the prevalence of hearing impairment and otitis media in rural primary school children in India and it was found that 91.2 per cent of children with hearing impairment were associated with middle ear infection, while only 53.4 per cent of these with middle ear disease were detected as having hearing
impairment (Jacob et al., 1997). A study was conducted to find the relationship between the prevalence of otitis media with effusion in school entrant children in Red Car and Cleveland and the distance of the homes of these children from known industrial emission points, a significantly greater proportions of study entrants with otitis media with effusion lived within 1000 meters of an industrial emission point than further away (Holtby et al., 1997). The prevalence of chronic otitis media was significantly higher among the rural (9.44%) than in the urban (1.3%) school children in Daresslaam, Tanzania (Minja and Machemba, 1996). In another prevalence study held in two greenlandic towns, 51.7 per cent and 54.1 per cent presented pathologic middle ear infection in Nuuk and Sisimiut towns respectively with highest prevalence rate of secretary otitis media being 23 per cent and 28.2 per cent in Nuuk and Sisimiut respectively (Homoe et al., 1996).

In a study conducted on 9540 Saudi children, it was noted that the prevalence of acute otitis media from different provinces varied, being higher in those from the southern and central regions (Zakzouk et al., 2002b). A study conducted on the healthy children from birth to 9 years of age revealed that the prevalence rate was almost constant (25%) during the first five years of life dropping (7%) in eighth and ninth year of life (Stagerup and Tos, 1985). The prevalence rate was 14.2 per cent for secretary otitis media in a multicenter study in Italian school children (Marchisio et al., 1998). In Finland, the prevalence of acute otitis media in children younger than 10 years was 25 per cent, 51 per cent in 1-2 year old and 75 per cent in 6-11 years age group (Ingvarsson et al., 1984.
At the Centre for Disease Control (CDC) epidemiologists who made a survey of diagnosis recorded in office practices in the United States identified 24.5 million visits at which the principle diagnosis was otitis media (Schappert, 1992) wherein the diagnosis of otitis media increased from 9.91 million visits in 1975 to 24.5 million visits in 1990. Boston children had an average of 1.2 and 1.1 episodes of otitis media in the first and second years of life (Tele, D.W. et al., 1989). One can easily extrapolate from the Boston data that from the sample size of approximately 4.3 million children currently born in United States each year, 23.65 million episodes of acute otitis media occur each year in children from birth through the seventh year of life, a figure similar to the 24.5 million episodes identified by the CDC (Bluestone and Klein, 1996). The Boston study also showed that children having three or more episodes of acute otitis media were 46 per cent and those having six and more episodes were 16 per cent by three years of age (Teele, 1989).

A significantly higher incidence of recurrent otitis media with effusion was seen when 113 children with bilateral otitis media with effusion were studied (Salam and Wensraf, 1992). When a random sample of 2512 children in Finland were monitored to an average age of 2 years, it was noted that the incidence of the first episode of acute otitis media up to 12 months of age was 42.4 per cent and the corresponding figure up to 24 months of age was 71 per cent and it was also noted that risk of experiencing an episode of acute otitis media increased at the age of 6 to 12 months and decreased slowly at the second year of life (Alho et al., 1991). Decrease in the incidence of chronic otitis media was noted in
the central province of Saudi Arabia (Zakzouk et al., 2002a) the study which was completed in February 2000, in which 9540 children aged upto 12 years were examined. When 877 children were observed for atleast one year it was evident that the incidence reached its peak during the second six months period of life in a greater Boston study (Teele et al., 1989).

In another study healthy children were observed from birth to nine years of age and it was found that the incidence was highest in the first year of life (22%), second year of life included 15 per cent, 10 per cent in the third and the fourth year and 2 per cent in the eighth year. Thus by the end of the third year of life 50 per cent of all children had atleast one episode of acute otitis media and at the age of 9 years 75 per cent had an episode (Stagerup and Tos, 1986). In 1975 a random sample of records of patients aged 0 to 8 years were studied which showed that the annual incidence rate was 55.1 per cent for this age group and the highest incidence was recorded in the age group of 0 to 2 years with a steady decline in risk with increasing age (Biles et al., 1980).

1.4 CAUSES OF OTITIS MEDIA

1.4.1 Genetic predisposing factors

The concept of hereditary tendencies in infectious disease has been showing a positive co-relation since long decades. Works which have been carried out in the past have always shown a positive trend of involvement of genetic predisposing factors in susceptibility and resistance to the infectious disease. Hence the epidemics in history reveal...
that the populations and the individuals have varying genetic pre-
dispositions to infection by various pathogens. It is seen in epidemics
that most of the individuals who are susceptible, die out, but the
survived ones have some degree of natural resistance which may be
attributed to the presence of some genetic component.

Population based studies have shown that certain ethnic groups
have differential susceptibilities to otitis media (Klein, 1990; Marchant,
1984; Goycoolea, 1988). Such results reveal the possibility of involvement
of genetic element in determining the susceptibility to various infections.
A strong relation between genetics and otitis media has been
demonstrated in many studies (Teele D.W. et al., 1989; Klein J O, 1989,
Kvaerner, K.J, 1997). Significant genetic tendency in the development of
otitis media was demonstrated among the Norwegian twins by Kvaerner
et al. (1997) (Garth et al., 1999). In another study, a method of
monozygotic and dizygotic twin pairs showed that otitis media in children
has a strong heritability component (Casselbrant et al., 1999). Although
physicians might not be accustomed to thinking about heredity in
common illness such as otitis media, several studies compel the
clinicians and the researchers to undertake a new methodology for the
study of infectious disease thus, giving more impetus for integrative
approach to the study of medicine.

Since not all the studies undertaken show positive relation between
otitis media and heretability, it may be ascertained that establishing the
relationship between otitis media and genetics is a complex business
which inturn shows the complexity of genes involved in the determination of the same. In other words, probably many genes contribute to the overall phenotype of the disease. Again this complexity in deciphering the genetic components in otitis media also comes from the fact that various population groups are heterogeneous groups, hence, variety of populations should be studied in order to search for the gene responsible for such diseases. Recently in center for genomic sciences, Pittsburg laboratory has mapped a gene associated with severe pediatric gasterophageal reflux, a physiologic disorder that has been linked with otitis media (unpublished data, May 1999). Otitis media can be thought of as having some adult onset diseases, such as coronary artery disease, which have genetic and environmental components as well as postulated infectious link (Danesh, 1997; Epstein, 1999).

A Boston study demonstrated that single or recurrent episodes of otitis media were more likely to have siblings with histories of significant middle ear infection than were children who had no episodes of otitis media (Teele, 1989).

Most present research focuses on racially inherited anatomic anomalies that may facilitate middle ear infection and also related to eustachian tube size is the inherited degree of cellularity of pneumatization of the mastoid process as well as aeration of the middle ear cleft, both of which may determine susceptibility to otitis media or to the particular form of inflammation (Daniel et al., 1988). Children who had congenital conditions such as Down syndrome and cleft palate
predispose to persistent middle ear disease (Downs et al., 1980; Paradise et al. 1978, Schwartz et al., 1984). An association between blood group A and otitis media with effusion has also been reported (Mortensen et al., 1983).

The eustachian tube, tensor veli palatini and cranial base relations of Eskimos and American Indians differ from that of blacks and caucaceans (Doyle, 1977; Berry et al., 1980). The embryology of eustachian tube affects the amount and degree of pneumatization of the mastoid process because head carriage and orthograde posture are related to pharyngeal pouch proliferation (Oltersdorf, 1962). Otitis media in intrauterine life or early childhood disturbs pneumatization of the temporal bone (Wittmack, 1918; Ruedi, 1963). Any obstruction to the eustachian tube may also result in an intratympanic vacuum which subsequently results in the degree of pneumatization (Tumarkin, 1961). Difference in the size of left and right mastoids and volume of the middle ear mastoid air cell system among different subjects has also been reported (Molvaer et al., 1978).

The smallest air cell systems have been found in ears with a history of secretory otitis media or chronic dysfunction of the eustachian tube (Tos and Strangerup, 1985). They also found sexual differences in the size of the mastoid process with young boys (age 2-7) having more bouts of otitis media and subsequently smaller mastoid cell systems than the younger girls within their samples. On one hand evidence shows that if pneumatization is hampered by hereditary factors, the mastoid bone remains diploic or compact and if infection occurs in such bone the
mastoid will become sclerotic (Proctor, 1973). More sclerosed mastoids were found in brachycephalic skulls than in dolichocephalic ones, even though dolichocephals skulls had reduced pneumatization (Hildmann et al., 1987).

A variety in the type of middle ear disease manifest among Caucasians, Eskimos and Algonquin Indians living along the Labrador and Northern Newfoundland cost was found (Ratnesar, 1976) and also this variability corresponded to the different degrees of aeration of the middle ear by virtue of eustachian tube size. The air cell system comparison of mastoid pneumatization in population of India and western countries revealed that the duration of infection reduced the pneumatization of the mastoid process (Arora et al., 1978).

The racial variations discussed above can be regarded as a form of familial predisposition, though, few genetic studies have been made on a more specific level of familial occurrence. Investigation of a familial pattern in native Americans showed a familial predisposition in white mountain Apache Indians at Canyon Day Arizona (Todd, 1987). Increased prevalence of otitis media has been reported in children with cleft palate (Paradise et al., 1969). A high parent offspring correlation was also found in the incidence of otitis media and other respiratory tract infections (Van Cauwenberg 1985). There are other studies which show that genetic traits may cause a high susceptibility to infectious organisms, perhaps through an inherited immunoglobulin deficiency however, all studies do not support this model (Zonis, 1970; Berg et al., 1971).
The main effect of otitis proneness was statistically significant for IgG2. Thus it was assumed that the low levels of IgG2 in otitis prone children are considered to be one of the cause for high frequency of acute otitis media (Matsuoka A, 1994). In another study by twin method it was demonstrated that among the females the heretability of recurrent ear infection was estimated to be 74 per cent and the remaining 26 per cent was explained as having individual environmental factors. At the same time among the males the heritability was accounted for 45 per cent, 29 per cent by common familial environment and the remaining 26 per cent by individual environmental effects (Kvaerner et al., 1997). Another study suggest that the children who were otitis prone had more number of otitis prone fathers and otitis prone siblings hence, suggest the involvement of hereditary elements in determining the otitis proneness (Stenstrom et al., 1997). Prevalence of acute otitis media was higher among children whose parents were cousins compared with non-relative parents (Zakzouk et al., 2002b).

A number of studies have reported a familial clustering of otitis media (Teele et al., 1989; Visscher et al., 1984; Zielhuis et al., 1989) recurrent otitis media (Harsten et al. 1989; Teele et al., 1989) and chronic otitis media with effusion (Black, 1985; Kraemer, et al., 1983; Teele et al., 1989). Hence when such kind of family clustering are seen, it compel us to think that both shared genes and environment plays a important role in the susceptibility to the disease. However it must be noted that sibling history of otitis media reflects both shared genes and environment while parental history shows only the shared genes but not the
environment since parents and children do not share the common environment. Another study showed that the parents of children who were undergoing surgical treatment of chronic otitis media with effusion were more likely to have tympanic membrane abnormalities indicating an otitis media history (39%) than those parents whose children were undergoing other surgical procedures (14%) (Rockley, 1986).

Groups prone to otitis media include those with Craniofacial anomaly, Down’s syndrome, congenital velopharyngeal insufficiency, achondroplastic dwarfs, large adenoids, family history of otitis media, immune system abnormalities, tumors, those with congenital cilia abnormalities and members of particular races; Indians, Eskimos, Aborigines, Caucasians and Negroids with prevalence decreasing in the given sequence (Todd, 1986). Also it is shown that children who had congenital conditions such as Down syndrome and cleft palate have a high prevalence of recurrent otitis media (Downs, Paradise, 1978; Schwartz et al., 1984). Another study which was designed to separate racial and environmental effects showed that Apache children adopted into non-Apache families had rates of otitis media similar to those of Apache children living in the reservation and higher than those of their non Apache siblings (Spivey et al., 1977). An association between blood group A and otitis media with effusion has also been reported (Mortensen et al., 1983).

Thus, from the above studies it can be ascertained that otitis media which is a common pediatric disease has a strong heritable component in association with environmental and infectious etiologies.
1.4.2 Extrinsic predisposing factors

Apart from the possible genetic factors lot of environmental and biocultural factors are responsible for the causation of common infectious ailment like otitis media. These extrinsic factors are discussed as follows:

Age

As it is already very well said that otitis media is the disease of infancy and childhood but it can also occur in adults. The peak age of first episode of acute otitis media occurs between the age of 6 to 18 months, earlier the onset, more number of subsequent or recurrent episodes are experienced later in life than those who had have little or no experience with otitis media by 3 years of age (Bluestone and Klein, 1996). Again the reason for such early occurrence of the disease may be attributed to the possibilities of maturing anatomic, physiologic and immunologic factors some of which are identifiable but many of which are still to be defined. Some of the studies which show co-relations with age are:

The infection rate was highest (61%) among the age group of 6 to 9 years and lowest (5%) among the age group of 15 and above (Oyeka et al., 1995). Otitis media with effusion was more common in 5 year olds with an annual prevalence of 17 per cent when compared to 6 per cent in 8 year olds (Williamson et al., 1994). When children born in a semi rural Swedish municipality were followed up from birth to their 7th birthday to estimate the recurrence rate it was found that at age 3 years, 38 per cent
of the children had made one visit to the physician, 10 per cent had three
visits and 4 per cent had five visits and by their 7th birthday 61 per cent,
24 per cent, 12 per cent and 2 per cent of the children had made at least
one, three, five and ten visits respectively to the physician because of this
disorder (Rasmussen, 1994). Another study also showed that the
recurrent ear infections were in the age group of 1 to 2 years (Hardy and
Fowler, 1993). An increasing tendency of the prevalence of otitis media by
age was noted in a nation-wide survey conducted in Korea to estimate the
prevalence of otitis media and allied diseases (Kim et al., 1993). When the
occurrence of otitis media in an arctic region was investigated, 40 per
cent of the patients were younger than 6 years (Andersen et al., 1997).

The proportion of developing one episode or more than one episode
of middle ear effusion between age 61 days and ages 6, 12 and 24
months were 47.8 per cent, 78.9 per cent and 91.1 per cent respectively
(Paradise et al., 1997). The incidence of acute otitis media among the
Saudi children was found to be higher among the children upto 4 years
old and lower in the age group 8-12 years (Zakzouk et al., 2002b). The
highest age specific incidence for all episodes of acute otitis media was in
one year of age (Moriniere et al., 1998). Children form birth to 7 years of
age were studied in Greater Boston which revealed that 62 per cent of the
children had experienced one or more episodes of acute otitis media, 17
per cent had experienced three or more episodes; by 3 years of age, 83
per cent had one or more episodes of acute otitis media and 46 per cent
had three or more episodes, the peak incidence occurred during the
second six month period of life (Teele et al., 1989). The incidence of otitis
media was highest (22%) in the first year of life followed by second year (15%), third and fourth year (10%) to eighth year (2%) of life (Stangerup et al., 1986). 39 per cent of infants had one episode of acute otitis media and 20 per cent had recurrent otitis media by age 6 months (Daly et al., 1999). Highest incidence rates of otitis media was found in the age group of 0-2 years with a steady decline in risk with increasing age (Biles et al., 1980). The highest age specific incidence for all episodes of acute otitis media occurred between 6 to 18 months of age (Bluestone and Klein, 1996).

When Finnish infants were studied it was found that in the first year of life 35.5 per cent had one or more episodes of otitis media, 24.8 per cent had one or two episodes and 9.7 per cent had three or more attacks (Kero, 1987). Although the incidence of acute otitis media is limited in adults, a survey by the National Disease and Therapeutic Index in 1970 found that there are almost 4 million visits by adults each year to private physicians for this infection (NDTI Review, 1970). Almost 20 per cent of young Swedish adult men (20 to 30 years old) and 30 per cent of older men (50 to 60 years old) had pathologic changes with serious histories of otitis and otorrhea of long duration (Rudin et al., 1985). In another study, 74 per cent of infants had an episode of otitis media between 6 and 18 months of age (Finitzo et al., 1988).

Thus from the above studies it can be ascertained that otitis media prevalence and incidence is at peak in the pre-school years and decreases as age increases.
Sex

Most of the studies demonstrate that sex is a strong determinant of otitis media, males being more susceptible to infectious disease like otitis media than do females. The highest prevalence of this disease was recorded for boys (55%) than the girls (45%) in a study of school children in Enugu, Nigeria (Oyeka, 1995). Another study showed the significant association of repeated ear infections with male sex (Hardy A.M. et al., 1993). Males were affected more than the females when a study was carried out in Sudanese patients (Yagi, 1990). Recurrent otitis media was significantly associated with gender when Norwegian children born in 1992-93 was followed from birth to 2 years of age (Kvaerner et al., 1997). When 2253 Pittsburgh infants were studied during their first two years of life it was observed that middle ear effusion was higher among boys than in girls (Paradise et al., 1997). Another study showed the significant correlation between male gender and recurrent acute otitis media (Daly et al., 1996; Klein, 1979). Male Saudi children showed a slightly higher rate of acute otitis media as compared with females (Zakzouk et al., 2002b). In a Boston study, males had significantly more episodes than females (Teele et al., 1989). In another Boston study first episode of otitis media was significantly associated with male gender (Teele et al., 1980). Apart from these there are a couple of studies (Goodwin et al., 1980; Hallet, 1982; Robinson G.C. et al., 1967; Tos et al., 1979) which show no correlation between otitis media and sex.
Race

Race is a known epidemiologic determinant for the development of otitis media. Many studies support this type of co-relation. Studies have shown that otitis media is more frequent among the whites than in blacks (Hardy, 1993; Teele et al., 1980; Klein, 1979; Griffith, 1979; Paradise et al., 1997). 95 per cent of aboriginal infants had otitis media with effusion or acute otitis media in the first three weeks of life but otitis media with effusion was seen only in 30 per cent of non-aboriginal infants (Boswell et al., 1996). In another study recurrent otitis media occurred more frequently among children who were of North African or Asian origin (Knishkowy, 1991). Another report confirms that the population in the Republic of Palau is severely affected by otitis media and its sequelae (Chan et al., 1993).

A greater prevalence of middle ear disease can be seen among the Indians and Eskimos when compared to the whites (Ratnesar, 1976). Other researcher have also evaluated the prevalence of middle ear disease exclusively in American Indian (Nelson, 1984; Todd, 1985, Zonis, 1968) and Eskimo (Pederson, 1986) communities. A relatively high prevalence of acute and chronic otitis media compared to the whites has been reported by other researchers (Birch et al., 1984; Casselbrant et al., 1985; Kessner, 1974; National Center for Health Statistics, 1972). The incidence of pathologic ear disorders and hearing impairment was higher in white children than in black American children aged 6 months who were studied for eleven years who lived in Washington DC (Kessner,
Acute otitis media in the first year of life occurred significantly more in whites (86%) than black (62%) Cleveland children (Marchant et al., 1984). The same trend was also seen when the CDC (Center for Disease Control) surveillance of office practice in United States was carried out (Schappert, 1992).

Doyle (1977) demonstrated differences in the position of the boney eustachian tube in the skulls of African American, Americans of the Caucasian ancestry and American Indians. A significant differences among the racial groups were present in the length, width and angle of the tube, implicating an anatomic basis for racial predisposition to or protection from otitis media (Doyle, 1977). Thus, when we compare the prevalence rates among different racial groups we should be aware that factors other than race may contribute to differences in prevalence rates like access to medical care, socio-economic status and anatomic and biological susceptibility.

**Socio-economic status**

The notion that otitis media is the heritage of the poor may be true in most instances but not in all. Since people belonging to poor or lower socio-economic strata live in unhygienic and poor sanitary condition with limited health awareness it is likely that they are more prone to common infectious disease like otitis media. Hence number of studies can be attributed in proving the above determinant of otitis media.

Recurrent otitis media occurred more frequently among children in Jerusalem, Israel who belonged to lower social and educational class
(Knishkowy et al, 1991). A strong relationship between middle ear disease and poor social conditions among Native Americans of British Columbia was noted (Cambon et al, 1965). Also studies have reported that otitis media and recurrent otitis media are common among lower socio-economic classes (Kessner et al, 1974; National Center for Health Statistics, 1972; Robinson et al, 1967; Stahlberg et al, 1986). Several researchers (Cambron et al, 1965; Reed et al, 1967; Beal, 1972) have named poor socio-economic conditions as a factor in the prevalence of otitis media among American Indians and Eskimos. Finnish children in the lowest socio-economic classes had more acute otitis media during the first year of life than did infants in the highest socio-economic class (Kero, 1987). Late presentation of the disorder by the patients was also associated with poor socio-economic conditions (Matin et al, 1997).

**Day care centers**

Day care centers vary in size from small groups to large organised groups. Some centers have adequate room and ventilation, whereas others are crowded and poorly ventilated. Hence sneezing and coughing at a close range may affect other children thereby providing ample opportunity for spread of respiratory infections. Rhinovirus and respiratory syncytial virus (RSV) can remain infective for hours to days in moist and dried secretions on nonporous materials such as toys and the organisms can survive for more than 30 minutes on cloth or paper tissues saturated with secretions (Bluestone and Klein, 1996).
The total size of the day care is an important variable in the relationship between children attending day care centre and frequent ear infections for children younger than 12 months (Marx et al., 1995). Significant influence of day care centers on higher rate of acute inflammations was noted (Danic et al., 1990). Another study stated that siblings attending day care is the most important risk factor for early acute otitis media (Kvaerner et al., 1997). A relationship between recurrent otitis media and exposure to day care centres was also established (Daly et al., 1996; Daly et al. 1999). In one study, visiting day care centers was one of the risk factors in developing otitis media with effusion (Moriniers et al., 1998). Research by Danish investigators indicates that the point prevalence of middle ear effusion may be two to four times higher in children younger than four years old attending group day care centers than in children cared for at home or in smaller home day care settings (Henderson et al., 1986). Another study showed significantly higher frequency of acute otitis media in children with day care contact (Aniansson et al., 1994). Another report shows that in urban areas of Finland where community day care centres are common, children in day care center had a higher incidence of otitis media than do children living in the country side, who are more likely to be cared for in their homes (Pukander et al., 1984). Danish children cared for outside the home had history of otitis media higher than that for children cared for in the home (Vinther et al., 1982). Approximately 3 or more episodes of otitis media occurred in 10 per cent of 150 Swedish children aged 6 to 24 months in family day care (Barenkamp et al., 1990). Pittsburg
children observed from birth who were in group day care centers had many more episodes of otitis media than did children in home care (Wald et al., 1988).

**Breast feeding**

It is generally believed that the breast fed infants are less susceptible to the infectious disease like otitis media than do bottle fed ones. However, number of hypothesis have been attributed as to weather breast feeding is beneficial or bottle feeding harmful. According to Bluestone and Klein (1996) immunologic factors of medical value are provided in breast milk which prevent various bacterial and viral infections and also facial musculature of breast fed infants develops differently from that of bottle fed infants. He also states that allergy to one or more components in low or formula milk may result in the alteration of the mucosa of the eustachian tube and the middle ear. Daniel et al. (1988) has rightly said that young children who are bottle fed while lying supine may be more prone to develop otitis media because the bottle fed material spurted jet like into the cartilaginous portion of the eustachian tube and frequently even into the middle ear cleft due to gravitational influence. Non-immune components in breast milk also play a major role in protecting the child from various infections (Bluestone and Klein, 1996). Breast milk prevents the attachment of *Pneumococci* and *Haemophilus influenzae* to epithelial cells thereby preventing adhesion of these organisms to respiratory mucosa, the initial factor in infection in the respiratory tract (Hanson et al., 1985).
Several studies have shown that breast feeding protect against the development of otitis media (Cunningham, 1977; Schaefer, 1971). In another study breast feeding was also associated with reduced duration of otitis media and decreased risk of recurrent otitis media (Teel, 1989). Exclusive breast feeding for 4 months or more protected infants from single or recurrent episodes of otitis media during the first year of life (Duncan et al., 1993). The risk of acute otitis media was significantly decreased until 4 months after breast feeding was discontinued but later without the protective effect of breast feeding and with increasing months, the children approached the risk level estimated in the group of children who were never breast fed (Sassen et al., 1994). The acute otitis media frequency was significantly lower in the breast fed than in the non-breast fed children when infants were examined at their 2nd, 6th and 10th months of age (Aniansson et al., 1994). One study was conducted to observe the short duration of breast feeding as a risk factor for developing acute otitis media which revealed that the mean duration of the breast feeding was significantly shorter with higher frequency of acute otitis media (Shaaban et al., 1993) below the age of three years. Breast feeding provided some protection against pneumonia and otitis media in the United States while early introduction of formula milk may have a separate and negative effect (Ford et al., 1993). In another study bottle feeding during infancy was statistically associated with higher incidence of otitis media with effusion (Saim et al., 1997). Another study revealed that no breast feeding was a risk factor for developing otitis media with effusion (Moriniere et al., 1998). Significant association
between increased risk of acute otitis media and children being not breast fed was shown (Teele et al. 1989). A sole feature associated significantly with persistent effusion in the middle ear after the first episode of otitis media was the practice of giving a child a bottle in bed (Teele et al., 1980). Children who were breast fed for 12 or more months had significantly less ear disease related to otitis media than did infants who were bottle fed at birth or within the first month (Schaefer, 1971).

**Season**

Normally it is seen that the acute episodes is maximum during winter and is frequent in fall or spring and least frequent in the summer. This is because of the fact that outbreak of viral infections of the respiratory tracts are more in the winter and spring seasons than in summer.

Seasonal prevalence of otitis media was first noted by Hippocrates (460-375 BC) (Pahor, 1978). It was also demonstrated that seasonal incidence of infections of the middle ear parallels the seasonal variations of upper respiratory tract infection (Strangerup, 1985; Tos, 1979; Bircht et al., 1984; Caselbrant et al., 1985). Prevalence of otitis media with effusion was more common in the winter months (Williamson et al., 1994). The largest number of children were hospitalised for secretory otitis media towards the end of winter and lowest towards the end of summer (Sprem et al., 1993). Another study showed that the highest incidence of acute and recurrent middle ear infection occurred in autumn and winter months (61.67%) and lowest in the summer season (1.76%)
(Danic et al., 1990). A significantly higher prevalence of secretory otitis media was found during the rainy season than during the dry season (Dang et al., 1998). A study held in Svalbard showed that the frequency of otitis media was at its peak during spring and that it is apparently related to seasonal shifts in temperature (Anderson, et al., 1997). Another study showed that acute otitis media was at its peak during the winter season (Lundgren et al., 1983). One study showed that acute otitis media demonstrate the obvious role of upper respiratory infection in the pathogenesis of acute otitis media (Vesa-Sirpa et al., 2001).

1.4.3 Other host and environmental factors

Some studies have shown a mild co-relation between lower birth weight and otitis media (Warren and Stool, 1971) while others have showed no co-relation (Ziellhuis, 1989). Family size has also been reported to increase the risk of otitis media, probably by increasing the potential exposure to infectious agents (Zinkus, 1980; Visscher, 1984; Harsten et al., 1989).

Many authors have reported that exposure to parental smoking increases the risk of otitis media (Iversen, 1985; Hinton, 1989; Kraemer et al., 1983). This is because passive smoke may damage nasopharyngeal, middle ear or eustachian tube mucosa, increased susceptibility to viral and bacterial invasion or to the obstruction of the eustachian tube (Hinton, 1989; US Department of Health and Human Services, 1986). However, level of exposure to parental smoke can be influenced by a number of factors like amount smoked in the presence of
child, ventilation and so forth (Daly, 1991). Children of mothers who smoked during pregnancy had significantly higher risk of otitis media (Van Cauwenberge, 1986).

A slight increase in the incidence of otitis media was observed among the infants or cesarean births (0.504) when compared to the vaginal births (0.449) (Mansfield et al., 1993). Children living in areas of low attitude and high humidity appears to be at greater risk than those living in higher attitudes and areas of low humidity (Suchs, 1952; Anderson, 1965). Another study showed that the occurrence of middle ear effusion was highest among the urban infants and lowest among suburban infants (Paradise et al., 1997).

Thus, from the above discussed determinants, from age to other host factors, it can be ascertained that both genetic as well as the environmental factors play a significant role in the development of otitis media.
Fig. 1.1 Structure of ear
1.5 ANATOMY AND PHYSIOLOGY OF THE EAR

Anatomy

The human ear is divided into 3 parts namely, the external ear, middle ear and the inner ear. The external ear is the visible portion, which consists of auricle (Pinna) (See Fig. 1.1) and the external auditory meatus (ear canal) which goes all the way down to the tympanic membrane (ear drum). Two third of the ear canal is made up of cartilage and the remaining one third of the canal is bone. Along the ear canal are cerumin (wax glands) which secrete ear wax to protect the ear against foreign bodies entering the ear. The tympanic membrane divides the external and the middle ear which is relatively transparent in nature. The main function of the external ear is to collect the sound waves and transmit it to the inner ear via ear canal and middle ear.

The middle ear is the half inch wide air space inside the temporal bone. It consists of three smallest bones of our body called as ossicles (See Fig. 1.3) which are attached to the tympanic membrane. These bones are malleus (hammer), incus (anvil) and stapes (stirrup). In a healthy ear these three ossicles are conjoined forming an ossicular chain which greatly increases sound transmission from the external environment to the inner ear. Another part of the middle ear is the eustachian tube that links to the middle ear cavity to the nasopharynx (back of the throat) region and functions to equalize air pressure between the middle ear and the outside ear. The mastoid process can be felt as a bumpy projection immediately behind the ear. The malleus is attached to
both the eardrum and the other two small bones. The base of the stapes rests against an opening called the oval window, located in a thin layer of bone forming the boundary between the middle and inner ears. The incus links the malleus to the stapes.

The inner ear consists of mainly three parts namely, the vestibule, semicircular canals and cochlea, together called as labyrinth (See Fig. 1.6). The vestibule is a hollow tube, a quarter of an inch wide, which is filled with a protective fluid. At the lower end of the vestibule is the cochlea. The cochlea is the snail shaped structure which is divided into three fluid filled compartments or scalae namely, scala vestibuli, scala media and scala tympani. Two distinct membranes create these three compartments; firstly, Reissner’s membrane which separates the scala media from scala tympani. On the top of the basilar membrane sits the organ of corti (not visible in the diagram) also known as organ of hearing. The organ of corti houses outer and inner hair cells which, when damaged, causes a common and usually permanent type of hearing loss known as sensorineural hearing loss. There are approximately 15,000 to 16,000 of these hair cells in each ear. The three semicircular canals can be seen at the upper end of the vestibule. These help in regulating the body balance. The three semi circular canals extend out from a sac called the utricle. A duct joins the utricle to a smaller sac, the saccule. Both sacs contain fluid and both are lined with tiny hairlike nerve endings. When the head is erect two semicircular canals are in the vertical position and the other in a horizontal position.
Physiology

The auricle acts as a sound collector which funnels sound waves through the external canal hitting the tympanic membrane which causes vibration because air in the middle ear is free to move in and out through the eustachian tube. At this point the sound waves are converted into mechanical energy because when the ear drum vibrates, this vibration is passed along the ossicular chain due to the connection of malleus to the tympanic membrane. This creates the 'lever' type of action. Thus the pressure exerted onto the oval widow from the lever action of the ossicular chain causes the fluid in the cochlea to move. This motion of the fluid stimulates the cells of the organ of corti which enables them to generate electrical impulses that are carried up through the acoustic nerve to the brain. The motion of the fluid in the cochlea is possible because of the presence of flexible membrane, which covers an opening known as round window, at the base of the cochlea. If the sound is at the same distance from both ears the nerve impulses from both ears reach the brain at the same time and with the same intensity and if the sound occurs at the left ear, impulses from the left ear will reach the brain before the impulses from the right ear with slightly stronger intensity. Such differences enable the hearer to identify the direction from which a sound comes.

Apart from cochlea, the inner ear contains special structures that help maintaining balance of the body, these are utricle, saccule and semicircular canals. The fluid inside these structure move when the body
moves. This moving fluid bends hairlike nerve ending which send message to the brain, which sets off reflex actions that affects body balance.

1.6 THE EVOLUTION OF THE EAR

A group of surface cells on each side of the head begins to dimple after some eighteen days into the development of human embryo, even before the brain has become a complete organ. These group of surface cells forms a hollow sphere in the shape of a bubble as it moves into the substance of the head. The cells then squirm and contort to create the various parts of the ear.

It is thought that the balance apparatus in the ear have developed prior to the hearing mechanism because early developing vertebrates such as fish have organs of balance, but no cochlea. A number of grooves are embedded under the skin of a fish, along the length of its head and body and just beneath these grooves lie the hair cells which detect differences in water pressure and also allows the fish to adjust to variations in currents and eddies and warn against the proximity of other fish, including predators. Such simple sense organs were present even in the most primitive fish at the beginning of life in the oceans. Such grooves in the head later on evolved gradually into the inner ear which are found in all vertebrates including humans. Hence we can imagin the nerve cells in the inner ear which are the adaptations of earlier hair cells sensitive to the motions of liquid.
As the evolution proceeded, fish became more amphibious and finally developed into pure land animals which required a special kind of sense organ that could detect mild differences in air pressure as a means of increasing their survival advantages, such as recognizing food, danger, friends and enemies. It is believed that probably the middle ear and the eustachian tube evolved from the respiratory apparatus of the fish and various inner ear structures were developed from parts of the fish jaw.

In combination with new environmental pressures the inner ear eventually began to change and develop. It is likely that a small part of the inner ear responsible for balancing evolved into the membrane of the oval window, which was flexible enough to transmit changes in air pressure to the fluid in the inner ear. At the same time, the inner ear was increasing in size and complexity with a small bulge in the vestibular region of the ear. This bulge during the course of evolution developed into a spiraled cochlea which today forms the hearing mechanism of the inner ear of all vertebrates.

The ear is able to detect and analyze a range of frequencies which is probably the result of evolutionary pressure to decode complex speech sounds. In the same manner, the amplitude range evolved likely due to the response to the loudest sounds in the natural environment like cracks and booms of the thunderstorm at close range, as well as the loud roar of the predatory animals. These sounds tend to rise slowly rather than abruptly, which explain why the ear has no defense against extremely loud sounds which occur suddenly without warning. Hence,
the modern cochlea, with its power to recognize the separate vibrations of each sound has an obvious survival advantage.

1.7 DEVELOPMENT OF THE EAR

A series of six tubercles appear around the first visual cleft which is the precursor of external auditory canal. This takes place about the sixth week of embryonic life. These tubercles progressively coalesce to form the auricle. The tubercle of the first arch develops into tragus and rest of the tubercles develops into a pinna.

External auditory meatus develops at the sixteenth embryonic week which originate from the first visceral cleft when cells proliferate from the bottom of the ectodermal cleft forming a metal plug. The epithelial lining of the bony meatus is formed by the recanalization of the plug, which begins from the deeper part near the tympanic membrane and progresses outwards.

Tympanic membrane develops from the three germinal layers namely, ectoderm, mesoderm and endoderm. These forms the outer epithelial layer, middle fibrous layer and the inner mucosal layer respectively.

The tubotympanic recess which originates from the first and partly from the second pharyngeal pouches give rise to eustachian tube, tympanic cavity, attic, antrum and mastoid air cells. Mesoderm of the first arch develops malleus and incus while the second arch gives rise to stapes.
The inner ear starts developing in the third week of fetal life and is completed by the time of sixteenth week. Auditory vesicle is formed when the ectoderm present in the hind brain thickens. This auditory vesicle later divides into endolymphatic duct (utricle, semicircular ducts) and sac (saccule, cochlea). The development of both external and middle ear and the inner ear is quite independent of time, they do not develop at the same time. Hence some cases with normal external and middle ear are found with malformed or nonfunctional inner ear.

1.8 AIMS AND OBJECTIVES

The primary objective of the study was to ascertain the clinical, genetic, environment and socio-cultural impact of the disease on a given group of people. These objectives can be stated as follows:

- **Epidemiology**: The study was mainly aimed at determining the incidence and prevalence of the disease among a given cross-section of people. This objective helped the researcher to know the extent of the disease in the given study area.

- **Genetic and environmental aspects**: The study manifests itself mainly into two branches that is genetic and environmental. An attempt was made to study the possible existence of family history of the disease in order to determine the pattern of inheritance of the disease. Apart from this, the environmental factors were also studied to determine the etiology of the disease.
• **Socio-cultural impact**: The study also attempts to explain the underlying socio-cultural factors which are responsible for the disease and also get affected during the course of infection. The family size, the gender bias and any other social patterning which coincides with the disease were all taken into account.
Fig. 1.2 Pinna (Auricle)
Fig. 1.3 Middle ear ossicles
Fig. 1.4 Middle ear cleft
Fig. 1.5 Infant and adult eustachian tube
Fig. 1.6 Bony labyrinth
Fig. 1.7 Types of perforation of tympanic membrane in CSOM

Fig. 1.8 Secretory otitis media