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Identification Audiometry

A Report Prepared with Support
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U. S. Department of Health, Education, and Welfare

by the

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Identification Audiometry

Foreword

For several years there has been expressed a need for general guide-lines and the resolution of various confusing issues regarding audiometric standards and procedures for screening and monitoring programs. In an attempt to meet this need a conference of experts in hearing and hearing tests was arranged by the American Speech and Hearing Association through a grant from the Children's Bureau, Department of Health, Education, and Welfare and administered by the Maryland State Department of Health. A committee representing the American Speech and Hearing Association met with the consultants from medicine and public health to plan the conference. In the interests of economy of time and expense, the number of participants was sharply limited. The group of specialists was convened in Baltimore, May 26-28, 1960. Three members of the group had been invited to prepare discussions of pertinent topics for general reference. Thereafter, the general group was subdivided into three work-groups, each discussing the entire agenda in detail. Both general and individual experiences, opinions, and reactions were distilled in several plenary sessions in order to develop a reasonably clear consensus. The proceedings were recorded in their entirety. This provided the material of the monograph.

Identification Audiometry includes many aspects of program development, procedures, problems of personnel and management, interpretation, and follow-up, with regard to preschool-age children, school-health programs, and different aspects of industrial and military audiology. All these facets are pertinent to the basic problem of identifying the individual who has, or who offers a predilection for, hearing impairment. The basic considerations for inclusion of material were common sense, practicability, and reasonable agreement among the participants of the conference. Aside from the three prepared papers, the body of the material here includes no direct quotations. The general participants were not asked to express an opinion about this material; accordingly, there is no individual responsibility for affirming or denying its content. This is the responsibility of the planning committee, whose members did their best to distill a very considerable amount of data, fact, opinion, and experience.

The special appreciation of the sponsoring agencies goes to Frederic L. Darley, Editor of Monographs, American Speech and Hearing Association, for his determined and sensitive efforts to produce a monograph from several tape-miles of recorded discussion and deliberation. Sincere thanks go to the members of the conference for their earnest willingness to devote time and effort to the better understanding of *Identification Audiometry*.

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Preface

Remarks Presented at the Opening Session, National Conference on Identification Audiometry

I want to express my appreciation to you for giving your time to this important meeting. It is a subject in which we have been interested for a long time, and one which has a great many ramifications.

I would like to take just a few minutes to talk about the Children's Bureau, particularly the aspects of the Bureau that are related to this Conference. We are an agency in the Department of Health, Education, and Welfare, and one of our functions is that of administering grants to state health departments and state crippled children's agencies, one grant for Maternal and Child Health and one for Crippled Children's Services. These federal funds, together with state and local appropriations, constitute the financing of these programs, which are administered by the state agencies.

Basically, the Maternal and Child Health Program is preventive, and this is expressed in such activities as prenatal clinics, well-baby clinics, clinics or conferences where infants and preschool children can receive health supervision, school health services, immunization, various kinds of specialized services—such as special services for prematurely born infants—and a scattering of other specialized clinics and services. In providing the services under this program, we find physicians and others coming into contact with babies and children of preschool age and school-age children.

The Crippled Children's Program is basically a medical care program. While it has preventive elements in it, it is fundamentally a program to locate handicapped children and to provide diagnostic and treatment services including hospital care, surgery, medical services, after care, and appliances. This program is very diverse in terms of diagnostic composition of the approximately 325,000 children who received medical services last year. About half of these children had an orthopedic handicap. The rest had one or more of the whole gamut of handicapping conditions.

With both the Maternal and Child Health Program and the Crippled Children's Program there is the potentiality —if not always actually realized—for case finding, for providing preventive health services and health supervision, for providing diagnostic services and referring these children to an appropriate medical care program in the same state.

The Maternal and Child Health Program reports that some 3 or 3½ million children have their hearing tested by audiometry through the services of the state health departments each year. For the most part these children are of school age and more typically live in rural areas than in the large cities. Both the Maternal and Child Health and Crippled Children's Programs put particular emphasis on children in rural areas. On the other hand, when the children of school age in the large cities have their hearing tested, generally this is done under the auspices of departments of education. These are examples of some of the administrative complexities which pertain to the subject of testing of hearing.

In states where there are well-developed state and local health department services, we see a close correlation between case finding through the hearing testing services provided by the Maternal and Child Health Program and the diagnostic and treatment services of the Crippled Children's Program.

Maryland was one of the first states to develop a conservation of hearing program. This state is fortunate in having in its health department people who are well trained in pediatrics and public health with staff positions in the Johns Hopkins School of Hygiene and Public Health. Of particular significance is the availability of the Speech and Hearing Center of the Johns Hopkins Hospital where there are people—like Dr. Hardy —who are not only specialists in audiology but who also have particular interest in the relationship of the Speech and Hearing Center to organized community health programs. As a result, both in the cities as well as in the counties of Maryland, children who are identified as having hearing impairment can have something done about it. Failure of children to receive such follow-up service is one of the most critical problems over the country. It seems easy to get audiometers and carry them around and test myriads of children, but too often this seems to be almost the beginning and the end of the hearing program.

About 20,000 children last year received medical and related services in the Crippled Children's Programs following diagnosis of hearing impairment, representing an increase of about 100% since 1950. A small number of these children had mastoid disease. This group has declined appreciably. A great deal more can be done to increase the number of such children coming in one way or another to the audiology clinics for diagnosis and treatment from whatever organization provides the more gross screening testing.

Now with respect to the methods of hearing testing, for the most part, the people in health departments are obviously not specialists in this area, although 28 state health departments now employ one or more speech and hearing consultants. A variety of methods are employed and recommended for hearing testing. For those of us who are not specialists, the whole picture is rather confusing. What are some of the best methods of doing screening? Some people prefer group methods; some people find individual screening methods good, as well as quick and economical. Almost all of the testing is on school-age children, because they are available in the classroom in a group. However, we are finding that our public health people are expressing interest in some method of screening the younger children. In well-baby clinics there are varying numbers of babies and preschool children. Where the staff of these clinics consists of general practitioners, pediatricians, public health nurses, and volunteers, is it possible to do some sort of screening of the hearing of these children whether in groups or individually? Can these clinic personnel contribute to the screening of the hearing of these younger children?

For answers to these and similar questions we look to experts. No doubt the fact that a group of people like you has come together to discuss this very problem will be instrumental in stimulating a great deal of interest in furthering the objectives of such testing programs; in increasing the activities which are directed toward more accurate diagnosis and treatment; and in clarifying for those of us in public health, in the private practice of medicine, or in hospital out-patient departments, this whole question of what are the best methods, the most practical methods, and the most productive methods of identifying all the children who are in need of further attention because of hearing impairment.

Arthur J. Lesser, M.D.
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I. Identification Audiometry: Definition, Objectives, and Program Responsibility

Identification audiometry refers to the application of any of a variety of hearing testing procedures to persons of any age for the purpose of identifying those individuals with hearing sensitivity less than that generally defined as within normal limits. Once the identity of these persons has been ascertained, they may be subjected to audiological, otological, medical, psychological, educational, and other scrutiny so that a comprehensive description of their total problem may be derived, a diagnosis made, and a sequence of steps in management prescribed. But the ascertaining step—the original discovery of a hearing impairment which results in the setting apart of an individual as one to be watched or examined further—is denoted by the term *identification audiometry*.

Other terms, some in more common usage, have been applied to this process of identification audiometry (screening, search, assessment, detection, probe, case finding, surveillance). Perhaps no term states the objective quite so well, however, as *identification audiometry*. The most frequently used term, screening audiometry, suggests the use of certain instruments for the testing of designated frequencies at stated intensity levels, but in a comprehensive view of the problem of identification of hearing impairment it is readily apparent that at certain age levels and with certain individuals at all age levels the use of a pure tone audiometer is not feasible. Often, as in industry or the military establishment, limited frequency screening is inadequate and a complete audiogram is necessary if all the purposes of identification audiometry are to be achieved. Identification audiometry is wide enough in scope to encompass any procedure the purpose of which is the identification of a hearing problem. But the term does not refer to *diagnostic* procedures. Identification audiometry is not designed to answer the questions 'How much impairment does the individual have?' 'What type of impairment does he have?' 'What is responsible for the hearing deviation?' or 'Is the problem treatable?'

Nor does identification audiometry include the endeavors on the part of personnel from many disciplines known collectively as the hearing conservation program. Identification audiometry is only one important aspect of a hearing conservation program, that limited part of it planned specifically for the most efficient and the earliest possible detection of those persons whose hearing behavior suggests that they warrant further, more definitive examination. An analogy is that of a microscope with initial minimum magnification selected to view a large area. One then progresses to more and more powerful lenses if more detailed knowledge is needed.

This monograph sets forth the general and specific goals of identification audiometry, suggests procedures to be followed at various age levels, describes optimal conditions for testing, and makes recommendations to individuals charged with responsibility for such testing.[1] As a preamble to these presentations certain assumptions or principles are stated upon which subsequent discussion of methodology stands.

Basic Principles

1. The fundamental concern is the maintenance of an optimal state of health for every individual, his health being defined in the broadest possible way: physical, emotional, social, and mental. Obviously knowledge about the state of an individual's sensorium is crucial, but not simply for its own sake. The implications of a hearing problem must be viewed comprehensively; the specialist in the measurement of hearing loss must continually view his data in perspective and consider the impact of the hearing problem on the subject's welfare—physical, emotional, social, and mental.

A comprehensive program of identification and management includes the following:

a. Prevention—in specific terms (for example, appropriate management of ear infections to prevent hearing loss) and in general terms (for example, public education regarding the causes and significance of hearing loss).

b. Early case finding.

c. Early diagnosis.

d. Early medical treatment.

e. Habilitation and rehabilitation.

[1]For definitions of technical terms the reader is referred to glossaries provided by Davis and Silverman (*2*, pp. 553-557), Hirsh (*8*, pp. 334-344), and Watson and Tolan (*16*, pp. 574-580).

2. Hearing loss is no respecter of persons. Consequently programs of identification audiometry need to be established on the broadest possible base to reach the largest possible numbers of people. The study of existing practices shows that from state to state and locality to locality direction of programs varies as do age levels and population segments reached (see Appendix A). Ideally programs of identification audiometry accomplish their purposes best when grounded on what may be called a public health concept, which offers minimal obstacles to total coverage. A program which fails to reach and benefit individuals because they are too young, too old, too poor, in institutions for correction or custodial care, or not in public schools falls short of its ideal achievement.

3. Identification audiometry is not an end in itself. Program personnel who are eternally bent on locating more 'cases' but who fail to provide anything constructive for the ones found have failed to understand the goal of the program. Identification audiometry is only one phase of a much broader hearing conservation program with medical, legal, and rehabilitative aspects. The reader is referred to generally available published materials (*5*, *6*, *7*, *9*, *10*, *11*, *12*, *14*, *15*) which describe in some detail how hearing conservation programs may be established and operated. Brochures describing local policies and practices can be secured from most state Departments of Health or Crippled Children's Services.

The management of hearing disability is fundamentally a health problem, and all hearing conservation programs should have the benefit of consultation from an otologist, with the possibility of surgical or other medical intervention for all patients who need this attention. Because of the equipment and staffing problems of hearing testing, the problems of the differentiation of hearing loss from other disabilities, the complexity of modern rehabilitative procedures, and the necessity for special classroom instruction, various other specialties must be involved. The assistance of special educators, public health and school nurses, psychologists, family counselors, acoustic physicists, audiologists, medical personnel, and others is required as members of a health effort, all focused upon the needs of the individual.

A high degree of co-operation and maximal efficiency of communication should characterize the relationships among these professional co-workers. Those who find the cases with actual or suspected hearing impairment and those to whom these persons are referred need to talk readily with each other; they need to understand each other's purposes and procedures. Placing the welfare of the patient uppermost, they must see to it that everyone receives the benefit of available services and that nobody gets lost in a dead end of inaction.

Broadly stated, the goal of any hearing conservation program is to determine debilitating defects as efficiently and economically as possible and to ensure prompt medical attention and the preventive, rehabilitative, and educative steps which are necessary. In this context, the goals of identification audiometry are subgoals; a proper concern for optimal hearing testing alone, as presented in this monograph, should never lead to the neglect of other important phases.

4. Identification audiometry is a compromise with the ideal program of hearing evaluation. The term refers to the screening of large numbers of people in a limited amount of time by personnel who do not have extensive training and experience. For the sake of reaching a large population economically, a degree of accuracy and a large amount of detail are sacrificed. If one demands more complete information and data of unassailable reliability and validity, he must resign himself to test fewer people at greater cost. But if the premium is on fuller coverage of the population, he will adopt certain less detailed procedures in full awareness of their limitations and of the need to supplement his findings through other measures.

The procedures described in this monograph will not lead to the discovery of every child who may at some time in his life have a hearing loss, for it is not proposed that every child shall have frequent otological examinations and threshold audiograms. Hopefully the procedures outlined here will lead to the identification of most persons with a hearing condition for which something can be done medically or educationally.

5. In spite of the fact that programs of identification audiometry have limitations built in, they have purposes which can be attained only as high standards are established and implemented. Effective identification audiometry is not easy to set up nor to run continuously, nor can it be done without budgetary preparation.

The point is not to design a limited program of identification audiometry in order to meet some minimum standard. The idea is to outline procedures which will ensure that the fewest possible individuals are or would be victimized by inadequate programs, from the deaf child who is tragically classed as mentally defective to the adult falsely accused of malingering and the senior citizen unnecessarily denied the pleasures of hearing.

This goal necessarily implies the importance of good equipment, of appropriate testing environments, of suitable training and supervision of personnel, of dissemination of information about the handicap of hearing impairment, of reducing the subjective element in hearing evaluation through the use of standard procedures repeatable from setting to setting, of calibration of equipment and calibration of personnel, so that the often disparate results from some current identification audiometry programs may be replaced with data of useful reliability and validity in the future—data that will be of use in epidemiologic prediction as well as in proper management of the individual.

This proposition involves the profound conviction that because the goals of identification audiometry are vital and the procedures are demonstrably valid, the costs can and will be met.

6. A longitudinal approach to identification audiometry is needed. Although different audiologists may be engrossed with the identification of hearing losses within population subgroups differentiated by age or occupation, all share a common concern for early identification and treatment. The goals of identification audiometry at the preschool, school-age, and adult age levels are hardly unique or mutually exclusive. Many of the hearing problems discovered in adulthood have their origins in childhood and youth. If one is to grapple with hearing problems in a comprehensive way, he must seek solutions at every age level.

The ideal is to conduct a reliable test as early in life as possible, preferably in infancy. Even in the neonate it is possible to check for variations from normal responses and to identify those who can profit from medical attention and reassessment. Following this earliest test, the preschool child should be tested, especially so that language retardation can be prevented where possible and so that significant hearing problems can be discovered.

Even with these earlier tests, the school system will desire information in the kindergarten and first grade about whether each child's hearing acuity will allow him to handle typical school communication or whether special instruction is indicated. The basic audiogram accomplished in kindergarten or first grade will constitute a useful reference so that threshold shifts can be identified in later years. At intervals during the child's school life he should be reexamined to assure the earliest possible treatment and to ensure that no hearing problem, invisible to the otoscope and insidious in onset, may unnecessarily become a handicap.

When the individual enters the labor force, a carefully derived threshold audiogram for reference purposes should be collected for medico-legal reasons. Such a reference audiogram is especially needed in the armed forces. In certain environments which have an adverse effect on hearing occasional monitoring audiometry is advised.

Special problems exist with the institutionalized, as in tuberculosis sanitaria, and with those who have multiple handicaps (such as the cerebral palsied or the partially or totally blind) for whom the audiologist must adapt standard techniques. Much more can be done for the aging population. Hearing conservation here has an especially fruitful and rewarding role, not only in rehabilitation-education but also in instituting effective testing to identify the aged who need special services, medical or otherwise.

The foregoing principles constitute the philosophy upon which programs of identification audiometry are based. The goals of such programs are clear. Some may apply in all programs, whatever the age level or occupational status of the subjects involved, while others pertain to specific groups identified by age level—preschool, school age, and adult.

General Goals

The general goals of programs of identification audiometry include the conservation of human resources, economy, public education and information, adequate programming for future services, and the development of new knowledge through research.

Conservation of Human Resources. Programs of identification audiometry share a basic humanitarian philosophy:

a. The optimal functioning of the individual—physically, intellectually, emotionally, socially, and vocationally.

b. Acceptance of the individual by his peers without damage to his personality.

c. Maximal use of personal skills so that achievement may reasonably match aspiration.

Programs of identification audiometry, then, emphasize the prevention of handicapping conditions, the prevention of educational retardation, and the prevention of emotional disability caused by hearing impairment. But they go a step farther: they concern themselves also with persons not appropriately considered *handicapped*. There are important preventive objectives. They follow the person who has only a slight hearing loss to see if his hearing deteriorates; even though no otoscopic abnormalities are evident and even though the loss of sensitivity constitutes no impairment of hearing for speech, the individual with any decrease in hearing sensitivity should be identified and observed for preventive purposes. These programs also serve the person with unusually acute hearing who with a partial hearing loss may no longer be equipped to do the skilled job he was doing. Every individual's potential is to be considered a precious resource, zealously watched and guarded.

Economy. One goal of identification audiometry is to save money. The importance of this is especially obvious in the industrial or military settings with their mounting compensation claims for hearing impairment. Clearly it behooves a businessman, for example, to identify pre-existing hearing losses in his employees so that upon termination of their employment the business will not be improperly charged for responsibility. Similarly it is a responsibility of an industry or a military service to keep tab on the hearing of its personnel who work in critical noise levels in order to determine the effectiveness of its noise controls and the advisability of job adjustments for those whose hearing appears to be deteriorating.

No less practical in terms of economics is the prevention and early identification of hearing losses in young children. The taxpayer does not pay *the child* who suffers a hearing loss as the employer pays the laborer who is the victim of acoustic trauma—but he pays nevertheless. Facilities for the education and rehabilitation of children with hearing losses who are not properly identified, referred, and treated involve great financial outlay. Money spent for prevention of hearing loss or early treatment of a problem with consequent restoration of normal hearing or significant improvement of hearing is money saved.

Public Education and Information. Ongoing programs of identification audiometry serve to awaken awareness and interest on the part of the citizenry in the prevention and treatment of hearing problems. Parents need to be concerned, as do teachers and school administrators, employers and supervisors. The fact that hearing losses sometimes go unrecognized or misdiagnosed for years suggest that even physicians and nurses may be helped by the reminders provided by good testing programs. An unpublished study[1] of preschool children diagnosed at the New York Hospital as having hearing losses was conducted to determine under what diagnosis the referral of these children was made. In less than 40% of the cases was hearing loss cited as a possibility. At least 60% were referred as mentally defective or aphasic or emotionally disturbed. Such findings suggest that various persons who deal with children on a professional level often lack sophistication concerning the behavioral patterns of young hard-of-hearing children.

Future Programming. A clear goal of any case-finding project is to gather information on the basis of which communities can estimate the nature and extent of their future needs. Thus, programs of identification audiometry can supply the facts to show what personnel, services, and facilities must be mustered. They can spark the imaginative utilization of existing resources and the active development of new resources for the management of those with hearing impairment.

Research. Knowledge concerning why, how often, and in whom hearing impairment occurs, or what can be done about it, is far from complete. But as more and more people engage in the systematic standardized collection of reliable data on the hearing sensitivity of large masses of the population, the answers to certain questions should emerge: 'What prenatal conditions are significantly related to incidence of hearing loss?' 'What diseases tend to cause impaired hearing?' 'How is incidence of hearing loss related to socioeconomic status and other population variables?' 'How can hearing impairment be more reliably detected in babies?' 'Are diagnoses of central deafness in children supported by evidence gathered in follow-up examinations?' 'What happens to hearing during the aging process?' 'How much noise can be tolerated for how long?' 'How can one account for the differential sensitivity of individuals to exposure to noise?' 'How can the efficiency of noise controls be increased?'

There is no end to the questions, but some of these questions have answers obtainable in part through the longitudinal approach of identification audiometry. The data gathered on hear-

[1]Reported at the National Conference on Identification Audiometry by Leon I. Charash.

ing losses coupled with information from case histories can throw new light on the epidemiology of hearing impairment and help minimize and prevent hearing losses in future generations.

Specific Goals by Age Level

Preschool Children. There are many reasons why it is desirable to test a child's response to sound very early.

It is important, first, to detect every child who gives indication of a developmental retardation. Those who have been engaged in programs of identification audiometry with neonates and young children report that the procedures described in Chapter II lead to the discovery not only of children with hearing problems but also of children with other problems whose early study and differentiation is important in terms of economics and the conservation of human resources: profoundly defective children, cerebral palsied children, and other multi-handicapped children. Early discovery of any physical or intellectual condition that deviates from normal means better management and greater possibilities of correction of the deviation.

Second, the child with even a mild hearing problem will suffer some degree of isolation during crucial developmental stages. Communication skills are developed early. To acquire them the child must hear and understand and cope with what he hears. If he is to be helped to belong and to learn and to develop functional speech and language, his potential handicap must be recognized; he must be helped to compensate for it.

Third, early medical management, enlightened early training by parents in language skills, and placement in an appropriate educational setting (special nursery schools or other facilities where enriched speech stimulation, lipreading instruction, auditory training, and training in the use of hearing aids can be provided) may make it possible for the hearing-impaired child to fit into a regular classroom when he reaches school age. The prevention of educational dislocation is one of the primary goals of identification audiometry at the preschool level.

Fourth, an important legal purpose is served by identification audiometry in the area of child adoption. Social agencies concerned with adoption and child placement need routinely to know as much as possible about all the sensory modalities of each child involved.

Who shall be screened in this program of identification audiometry at the preschool level? Every child should be examined who exhibits in his personal or family history any unusual conditions or untoward incidents. Indications of parental Rh incompatibility; rubella during pregnancy; other maternal rashes and infectious diseases during the first trimester of pregnancy; birth injury; hearing loss in the parents, siblings, and more distant relatives; and obvious multiple handicaps should make a child subject to as early and thorough a test as possible. A study in England[2] of such a population of children belonging to 'high risk' groups indicates that the prevalence of hearing problems may be as high as 15%, from three to five times higher than that found in the general school population.

Unfortunately all conditions predis-

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[2]Reported at the Conference by Aram Glorig.

posing to hearing loss have not yet been identified. Nobody can specify all the predilections and tell precisely where in the population hearing problems are scattered. Therefore the day should come when *every* child between the ages of seven and 15 months will be subjected to appropriate measures for the detection of hearing loss. Arrangements to do this are easier where populations of children are 'captive' as in orphanages, institutions, and hospitals. Complete coverage is more difficult in other segments of the population, but it is not wildly unrealistic to work toward the routine use of methods (see Chapter II) which can be readily applied by pediatricians, general practitioners, and private and public health nurses, as well as by trained audiological personnel in offices and well-baby clinics the country across. Equally important is the development of programs for the testing of children between the ages of two and five. Until these programs are readily available, the public must be alerted so that children who are suspect will be brought by their parents to get a hearing test.

School-Age Children. Medical, social, and educational justifications for identification audiometry loom largest between the ages of five and 16.

The goal is to locate children who have even minimal hearing problems so that they can be referred for medical treatment of any active ear conditions discovered to be present and so that remedial educational procedures can be instituted at the earliest possible date. Programs should be designed to identify not only children with a chronic disability but also children who have difficulty during only certain times of the year or under certain conditions. The period when a child may not be hearing well (as during a respiratory illness or during a season with high pollen-count) and consequently be functioning at a low level may be just the time when social and educational demands on him are great. Such children are among those composing the group of pseudo-mentally retarded.

Classroom teachers and school nurses can be trained to spot the youngster who is failing to fit in and to participate alertly in the classroom; they can learn to suspect that a hearing loss may underlie his apparent slowness or stubbornness. Some children who might endlessly flounder along as 'slow learners' or 'trouble makers,' or ultimately drop out as failures, can be recognized as needing special care within the school system—preferential seating, lipreading, speech correction, or placement in special classes where they can perform at their best.

In the school-age population children in corrective and custodial institutions (homes for the mentally retarded and institutions for orphans and other wards of the state) should have the benefits of hearing testing.

Adults. Some adults constitute 'captive' populations subject to identification audiometry programs.

a. Personnel in the U. S. Armed Forces. The goals of identification audiometry in the military setting have been summarized as follows (*1*):

(1) to select or reject men as a part of the regular physical examination;
(2) to provide information for the otologist concerning the extent and nature, the probable cause, and the progress of individual hearing losses in relation to the disease and to the effectiveness of treatment and preventive measures;

(3) to establish the amount of hearing loss for compensation purposes, including the determination of the original state of hearing before any service-connected or employment-connected hearing loss has developed;
(4) to enable personnel officers to determine whether certain individuals are qualified for certain military specialties that involve special kinds of hearing ability;
(5) to obtain new information as to (a) the causes and the prevention of hearing loss; (b) criteria for hazards to hearing; and (c) the effectiveness of particular tests and instruments for accomplishing the above objectives.

b. Personnel in industrial establishments. In some states the laws dealing with occupational disease and injury include or are interpreted to include impaired hearing caused by working in noisy environments among the conditions to be considered grounds for compensation. One purpose of identification audiometry in industry is to discover hearing losses existing prior to employment so that the industry shall not be required to pay compensation for losses for which it is not responsible. The importance of economic protection of industry should not unduly over-shadow other purposes served by identification audiometry, however; industry seeks to keep its personnel well, whole, happy, and producing. In this connection the ear has in recent years been added to the family of things industry tries to protect. Identification audiometry is the key to this protection.

The function of identification audiometry in both the military and industrial settings might be reviewed as follows.

(1) The preplacement audiogram (sometimes called reference audiogram), preferably a threshold audiogram, determines whether the individual shall be selected for military service or for employment in industry; if his hearing sensitivity falls below the standard set for acceptance, he is excluded.

(2) If he is selected, this audiogram represents information regarding his hearing ability at the point of entering the military service or an industrial plant (or a given job within that plant). One justification for it is medico-legal. Another is its importance with regard to job placement, for some jobs require more sensitive hearing than others.

(3) Subsequently the goal of monitoring audiometry can be combined with identification audiometry in that periodical hearing assessment, perhaps less stringent than the initial test, provides information about job adequacy. It tells whether the person still retains his ability to perform the job, whether any hearing loss has occurred, and whether any such loss is progressive. It leads to appropriate medical management of any problem discovered. It helps to determine whether a man should be temporarily withdrawn from a particular job environment or whether noise controls in that job should be restudied and made more effective. It suggests the need for 'preventive maintenance'—accepting counseling and getting started on lipreading or the use of amplification, once it is known that deterioration of hearing which cannot be prevented has begun.

(4) The final stage in the monitoring is the terminal audiogram at the time of departure from the service or plant or job. This audiogram may provide the basis for special compensation and is therefore important. Special care is warranted in all such hearing evaluations, for when hearing loss becomes associated with a profit motive, an in-

dividual's behavior during hearing testing sometimes changes. Identification of the person with a nonorganic problem is important in both the military and industry.

And what of the rest of the people? What of those who leave the military after a few months or years of service—and those in industry who change to jobs where identification audiometry is not a standard routine—and those who never have worn nor will wear a uniform or enter an industrial plant? In the light of the first two general goals listed above it follows that ideally everyone should have the benefit of identification audiometry and the services to which detection of hearing impairment leads. Because of their role as breadwinners men need hearing testing as a group more than women, especially since the incidence of hearing loss is reportedly higher in males than in females (*3, 4*). Farmers who drive tractors, other nonindustrial workers who operate noisy machinery, persons who use firearms—all these are 'special risk' personnel with regard to hearing loss and should be screened periodically. Inmates of prisons and other corrective and custodial institutions may have hearing losses; some research indicates a higher than average incidence in such populations (*13*). The ultimate rehabilitation of these persons should include attention to any hearing problem that might have contributed to anti-social behavior. Middle-aged and elderly people may avoid years of empty isolation or relative deprivation through the benefit of such resources as community- or state-sponsored hearing-testing units.

Hearing needs are *individual* needs and those needs must be found and met where they are. It is to be hoped that the near future will see audiograms as readily obtained as tuberculin tests and chest x rays.

Responsibility for Programming

Whose responsibility shall it be to make the attainment of these goals a reality? Obviously in the armed forces the particular service of the Department of Defense—Army, Navy, Air Force—has responsibility for the detection of hearing loss in its own personnel. And in industry individual companies provide their own programs of identification audiometry; increasingly, however, it may be noted, they are consulting state and local departments of health in setting up their programs.

The responsibility for determining whether infants up to two months of age are responsive to auditory stimuli does not appear to belong to any particular organization. Whoever provides medical care for the child should assume the responsibility. In many cases this person will be a pediatrician, in others a general practitioner in private practice or serving in a well-baby clinic. In some areas registered nurses will bear the responsibility. Whoever is seeing the child can be trained to observe startle reactions in order to detect profound insensitivity. With children seven months of age and older eye movements, general orientation toward the test sounds, or other orienting responses are readily available; the services of a trained observer will be necessary in some general service setting under medical supervision.

Between the ages of 2½ and four years, all but the most seriously involved children will respond with the use of speech signals in identification audiometry. By four to five years of age, children can be tested with reasonable reliability in the same ways as school-age children. Who can best administer identification audiometry programs for these preschool and school-age children? It is strongly recommended that state and local departments of health carry this responsibility. This recommendation is made in full cognizance of the fact that in many states and localities departments of education or public instruction are presently assigned this responsibility by law (see Appendix A). Although a uniform pattern of health department responsibility is not immediately possible throughout the country, such a thing is a desirable goal for a least two reasons:

a. More complete coverage of the preschool and school-age population. Children in parochial and private schools, a group composing between 30% and 40% of the total population of children, would not be excluded from the program as is often presently true when programs are the responsibility of a department of public instruction.

b. More effective liaison between the administrators of the identification audiometry program and medical personnel involved in follow-up. A more comprehensive and smoothly-running hearing conservation program can result.

When programs of identification audiometry for the general adult population (other than those covered by programs in the armed forces and industry) are considered, once again departments of health appear to be the logical responsibile agents. The services offered to school-age persons can be extended to all citizens; potentially all persons can be reached in much the same way that they are reached in current identification programs conducted in the areas of tuberculosis, cancer, and heart disease.

Until such time as practices are uniform with regard to department of health sponsorship, it needs to be emphasized that co-operation between educational personnel and health personnel is absolutely essential in the administration of identification audiometry programs. Regardless of who holds the *legal* responsibility, all personnel share responsibility for providing maximally efficient service to the largest possible number of people.

Summary

Identification audiometry refers to the application of hearing testing procedures leading to the original discovery of a hearing impairment. These procedures result in setting apart an individual as one to be watched or examined further. Among the general goals which programs of identification audiometry seek to attain are the conservation of human resources, economy, public education and information, adequate programming for future services, and research. The fundamental concern of such programs is the maintenance of an optimal state of health for every individual.

Programs of identification audiometry are designed to serve large numbers of people with reasonable accuracy at the least possible cost. They are not an end in themselves but constitute one phase of broad programs of hearing conservation designed to meet the needs of individuals with hearing loss. Programs of identification audiometry require careful planning and administration with adequate budgetary support. To be effective, they should

serve the individual in a continuing and periodic way from infancy through adulthood.

Those responsible for the medical care of neonates should be responsible for applying procedures to them which will identify possible hearing loss. Local and state departments of health should be responsible for identification audiometry programs for preschool children, school-age children, and the general population of adults. Identification audiometry programs in industry and the military, with their special purposes, should be the responsibility of the individual companies and the particular branch of military service.

References

1. Armed Forces-National Research Council Committee on Hearing and Bio-Acoustics, Problems in military audiometry: A CHABA symposium, 8. Audiometry in the armed forces. *J. Speech Hearing Dis.*, 22, 1957, 752-756.
2. Davis, H., and Silverman, S. R., *Hearing and Deafness* (rev. ed.). New York: Holt, Rinehart, Winston, 1960.
3. Glorig, A., Some medical implications of the 1954 Wisconsin State Fair hearing survey. *Trans. Amer. Acad. Ophthal. Otolaryngol.*, 61, 1957, 160-171.
4. Glorig, A., Quiggle, R., Wheeler, D. E., and Grings, W., Determination of the normal hearing reference zero. *J. acoust. Soc. Amer.*, 28, 1956, 1110-1113.
5. *Guide for Self-Study of Hearing Programs.* Washington: American Hearing Soc., 1955.
6. Hardy, W. G., *Children with Impaired Hearing: An Audiologic Perspective.* Children's Bureau Publication No. 326. Washington: Dept. of Health, Educ., Welfare, 1952.
7. Hardy, W. G., Clinical audiology in public health and school health programs. *Am. J. pub. Health*, 40, 1950, 575-579.
8. Hirsh, I. J., *The Measurement of Hearing.* New York: McGraw-Hill, 1952.
9. Lederer, F. L., Quinn, Marion, and Neville, Mary T., Hearing conservation programs: their accomplishments and deficiences. *J. School Health*, 25, 1955, 292-298.
10. Newby, H. A., School hearing conservation programs. *Hearing News*, 26, 1958, 9-14, 16-22.
11. Newhart, H., and Reger, S. N., *Manual for a School Hearing Conservation Program* (sec. rev.). Amer. Acad. Ophthal. Otolaryngol., Committee on Conservation of Hearing, 1956. (See bibliography for additional bulletins dealing with hearing conservation programs.)
12. *Services for Children with Hearing Impairment.* New York: American Public Health Assn., 1956.
13. Siegenthaler, B. M., and Krzywicki, Doris F., Incidence and patterns of hearing loss among an adult mentally retarded population. *Am. J. ment. Def.*, 64, 1959, 444-449.
14. Sortini, A. J., Importance of a hearing conservation program in a school system. *Hearing News*, 22, 1954, 11-12, 18, 20.
15. Symposium: conservation of hearing. *Trans. Amer. Acad. Ophthal. Otolaryngol.*, 57, 1953, 334-355.
16. Watson, L. A., and Tolan, T., *Hearing Tests and Hearing Instruments.* Baltimore: Williams and Wilkins, 1949.

II. Identification Audiometry for Preschool Children

Procedures

The methodology of hearing testing of preschool children may well be treated in three parts according to age level: the neonate (birth to age two months), the infant (between the ages of seven and 24 months), and the young child (aged two to five years).

The Neonate. In the testing of a child from birth until approximately two months of age use can be made of the startle response (Moro reflex). In a baby with good hearing and an intact central nervous system any sudden moderately loud sound will bring about a widespread response: the ongoing muscular activity is inhibited, the hands are pronated, the eyelids blink, etc. These startle responses are so uncomplicated, relatively speaking, that they may be easily observed.

The general procedure is simply to create a sudden noise by almost any means at a time when the infant is quiet. Perhaps the best time is when he has just fallen into a light sleep; his response to the noise will consist of awakening, crying, and gross body movements. Hardy, Dougherty, and Hardy (*8*) have reported that the most consistently effective stimulus is the presentation of a very short percussive peak of noise of 55 or 60 db intensity produced by a 'clacker.' The response of the child to an initial presentation of such a noise is extremely important because his adaptation is very rapid. The examiner may choose therefore to vary the stimulus, using whistles, clickers, bells, and other noisemakers of different pitches, varying also the intensity of the stimulus and the distance from the ear. A delay between successive stimuli up to as much as one minute may be indicated. In general, every effort should be made to see that the infant is ready for each successive stimulation.

The observation of the infant's response with a startle reflex must be made with care for much of a waking infant's ongoing activity may closely resemble the startle reflex. Examiners have sometimes found it useful to test two babies together, the child in question and a control child, the children being observed and compared simultaneously. Stimuli other than auditory may be used to determine the child's general level of reaction. For example, a child's reaction to light stimuli may indicate that his observed reduced reaction to auditory stimuli is attributable to general lethargy rather than to a specific hearing problem. The independent judgment of a second observer is also helpful in reducing the biases of the experimenter.

Study of infants indicates that in a surprising number the Moro reflex disappears by four months of age. Although it is true that certain aspects of the Moro reflex such as the eyeblink can be observed in persons of any age in response to a loud auditory stimulus, the more obvious details of the startle response apparently disappear early. This is one aspect of adaptation, or accustomedness. Accordingly, the use of a startle response as an identification audiometric technique with infants is recommended only up to two months of age.

Considerable research is yet needed to determine the best procedures to use in testing the neonate and in interpreting the results obtained. It is important to remember that at this age one is not 'testing hearing' (the neonate has not yet learned how to hear), but, rather, his *responses to sounds* of known frequency and intensity. Nevertheless it is to be hoped that testing hearing by observing the startle pattern of large numbers of neonates may become general practice. As experience and knowledge accumulate, procedures can be refined.

The Infant from Seven to 24 Months. With babies ranging in age from seven to 24 months procedures are most useful which involve what have been called distraction responses. One recommended procedure is the use of the Ewing techniques (*5*, *6*). These involve the presentation of acoustic stimuli which are intrinsically interesting to the child such as the noise created by a spoon stirred in a cup or the crinkling of tissue paper. By the time he is about seven months of age the infant should have learned how to hear and how to relate himself consistently to minimal acoustic stimuli. The child with normal hearing should be expected to turn his head toward interesting sounds.

Techniques for administering such tests have been described by the Ewings (*5*, *6*) and by Hardy, Dougherty, and Hardy (*8*). A film produced at the Johns Hopkins University[1] demonstrates techniques which may be followed.

Gross tests of the localization of sound by the infant can be given to the infant from seven to 24 months of age. For example, one procedure[2] involves the placement of a loud speaker in each of the four corners of a large sound-treated room. The child to be tested is placed in the middle of the room and sounds are presented at random from the various speakers. The observer notes the effort of the child to localize the sound by turning his head or his eyes. Even severely physically handicapped children can be tested by such a procedure. Refinements of localization may involve the use of earphones with the presentation of the sound first in one ear and then in the other, the observer noting the child's glance to the appropriate side. One procedure (*10*) uses a stereophonic sound pickup and two earphones; a phantom sound is made to move around the head, constituting a stimulus to which eyeball rotation and head movements are the universal response in very young children who have normal hearing.

Some feel that widespread screening of children by these techniques, or modifications of them, between the ages of seven and 24 months is feasible and is to be desired in preference to mass screening of neonates. Others prefer mass screening of neonates with testing between the ages of seven and 24 months to be confined to children known to fall in a high risk group for hearing defects and to children who show evidence of speech and language

[1]Available from the Bureau of Preventive Medicine, Maryland State Department of Health, Baltimore.

[2]Described at the Conference by Louis M. DiCarlo.

retardation. These points of view rather more express a difference in emphasis than a difference of opinion. Screening of both neonates and infants is desirable and practical. Observation of responses of neonates is much less refined; when a neonate does not respond according to expectations, he is simply tabbed for further observation of development. When the infant, seven months or older, does not respond appropriately, he is referred immediately for refined clinical assessment.

Children from Two to Five Years of Age. A great variety of procedures is available for the testing of children between the ages of two and five years. These techniques are listed and described by Newby (*12*), Davis and Silverman (*3*), and Boies *et al.* (*2*). Only a few of the more commonly used procedures are referred to here.

In this age group a surprising percentage of children can be tested with conventional pure tone audiometric techniques. With patience and expenditure of considerably more time than with older children audiologists can often do both air conduction and bone conduction audiometry. These procedures should be tried wherever possible because of their high yield of detailed functional information.

It must be emphasized, however, that all these procedures for very young children, including pure tone audiometry, have been developed for use in a clinical setting by expert audiologists. It has been made clear in this discussion that, in general, the first stage of identification audiometry is not carried out by expert audiologists. Without doubt, both validity and reliability are seriously affected by the exigencies of widespread testing. For the three-year-old, familiar sounds, particularly controlled speech associated with picture identification or object recognition, offer a much more useful screening device. As the child matures, more careful distinctions of auditory sensitivity can be employed. There is a tendency to lump two-year-olds and four-year-olds together, without recognition of the great differences in their behavior.

A commonly used adaptation of pure tone audiometric techniques is known as play audiometry. Here the child is taught to make a motor response such as dropping a marble in a box, placing a ring on a peg, inserting a block in a hole, or hitting a ball with a hammer, when he hears the stimulus tone. The use of such procedures has been demonstrated in the film *Too Young to Say* (*16*) produced by the John Tracy Clinic. Play audiometry has been found successful with children as young as two years of age who present a loss of sensitivity.

Several tests are available which make use of the technique of presenting familiar sounds for identification. Other techniques involve an appraisal of the child's response to speech. A game can be played in which the examiner states, 'I am going to say some words. You say the same words to me.' Or the child may be asked to follow instructions and point to or manipulate pictures, objects, or body parts.

A variety of electrophysiological procedures has been developed and are described in the literature (*1, 4, 7, 9, 11, 13, 14, 15, 17*). Such procedures are more useful in diagnostic audiometry, however, than in programs of identification audiometry.

Responsibility

The pediatrician is the key figure in the assessment of hearing in the neonate. Ideally this type of appraisal should be incorporated into the pediatrician's initial examination of the infant's reflexes. The pediatrician, or in other cases the general practitioner who examines the child in the hospital nursery, is able to consider the infant's response to sound in the perspective of the child's total reactions to stimuli. An alternative procedure is for a hospital audiologist or otologist to appraise the infant's response to sound as manifested by the startle pattern. Another alternative is to use the hospital or public health nurse who has had inservice training and workshop experience in the recommended procedures and possesses some fundamental knowledge of the nature of acoustic stimuli.

Similarly, pediatricians, otologists, or audiologists, as well as nurses who have particular training in the techniques already described, are competent to identify those children in the age range from seven to 24 months who may have hearing problems. The sound localization procedures for children from seven to 24 months of age and the procedures appropriate for the testing of children from two to five years of age should be carried out by a trained audiologist. Not only should he have technical qualifications but he should be competent to work well with children.

Whether the testing of children from two to five years of age is done by personnel in state health departments or in departments of public instruction, it is important that school administrators and educational personnel should have as much information as possible about the hearing impairment or suspected hearing impairment of children at the time they first enter school.

Summary

It is recommended that use be made of startle responses in testing children from birth to approximately two months of age. Tests using distraction responses and gross tests of the localization of sound by the infant can be used with children aged seven to 24 months. A variety of procedures, including conventional pure tone audiometric techniques, are available for testing children between two and five years of age.

The pediatrician, the general practitioner, a hospital audiologist or otologist, or a hospital or public health nurse may be responsible for screening hearing in infants from birth to 24 months of age. Training materials are available pertaining to techniques which may be used. Programs for testing preschool children from two to five years of age may be set up by public agencies such as health departments. Such programs should be under the administration of a trained audiologist.

References

1. Barr, B., Pure tone audiometry for preschool children. *Acta otolaryng.*, 1955, Suppl. 121, 84 pp.
2. Boies, L. R., Canfield, N., Carhart, R., and Keaster, Jacqueline, Hearing loss in preschool children: A guide for diagnosis and treatment. *Trans. Amer. Acad. Ophthal. Otolaryngol.*, 56, 1952, 835-846.
3. Davis, H., and Silverman, S. R., *Hearing and Deafness* (rev. ed.). New York: Holt, Rinehart, Winston, 1960.
4. Derbyshire, A. J., and Farley, J. C., Sampling auditory responses at the cortical level. *Ann. Oto. Rhino. Laryng.*, 68, 1959, 675-697.

5. Ewing, A. W. G. (ed.), *Educational Guidance and the Deaf Child.* Manchester: Manchester Univ. Press, 1957.
6. Ewing, Irene R., and Ewing, A. W. G., *Opportunity and the Deaf Child.* London: Univ. of London Press, 1947.
7. Goodhill, V., Rehman, I., and Brockman, S., Objective skin resistance audiometry. The electro-audiogram (EAG). *Trans. Pacific Coast Oto-Ophthal. Soc.*, 34, 1953, 215-240.
8. Hardy, Janet B., Dougherty, Anne, and Hardy, W. G., Hearing responses and audiologic screening in infants. *J. Pediat.*, 55, 1959, 382-390.
9. Hardy, W. G., and Pauls, Miriam D., The test situation in PGSR audiometry. *J. Speech Hearing Dis.*, 17, 1952, 13-24.
10. Hennebert, P. E., Nystagmus audio. *Acta otolaryng.*, 51, 1960, 412-415. (English translation: *J. aud. Res.*, 1, 1960, 84-87.
11. Irwin, J. V., Hind, J. E., and Aronson, A. E., Experience with conditioned GSR audiometry in a group of mentally deficient individuals. *Training School Bull.*, 54, 1957, 26-32.
12. Newby, H. A., *Audiology.* New York: Appleton-Century-Crofts, 1958.
13. Rosen, J., The place of GSR audiometry in work with young children. *Volta Rev.*, 58, 1956, 387-391.
14. Sokolov, E. N., and Paramonova, N. P., Objective examination of the residual hearing of deaf children. *Translations of the Beltone Inst. for Hearing Res.*, 1959, No. 10, 15 pp.
15. Statten, P., and Wishart, D. E. S., Pure tone audiometry in young children: Psychogalvanic-skin-resistance and peep-show. *Ann. Oto Rhino. Laryng.*, 65, 1956, 511-534.
16. *Too Young to Say.* 15-min. sound-color film. Dept. of Cinema, Univ. Southern Calif., University Park, Los Angeles 7. Rental: $4.50. Purchase price: $120.00.
17. Withrow, F. B., Jr., and Goldstein, R., An electrophysiologic procedure for determination of auditory threshold in children. *Laryngoscope*, 68, 1958, 1674-1699.

III. Identification Audiometry for School-Age Children: Basic Procedures

General Test Methodology

Identification audiometry in the school-age population is best described in two stages. The first has traditionally been called screening audiometry. It involves the testing in an abbreviated way of large numbers of children resulting in the ready identification of those who have no hearing problems and the tentative identification of those who may have hearing problems. The second stage involves a test of minimal hearing sensitivity; this is a more detailed test by more highly trained personnel with more elaborate equipment. Its purpose is to lead to the final identification of those who should be referred to an otologist, or other physician, for a complete diagnostic work-up.

The first stage of the procedure involves either individual or group limited-frequency testing. Procedural details are presented in this chapter and the next. Only pure tone audiometric procedures are considered. It is strongly recommended that individual pure tone testing be planned for all grade levels whenever possible. Many experts believe that periodic screening on an individual basis is better than an annual screening using group procedures. However, if a choice must be made between group pure tone audiometry or none, group procedures are possible at least at third grade level and above.

Local considerations having to do with scope of the total program, the ages of the children to be tested, and the amount of time and money available for the program may make it necessary to resort to group methods (*4*, *8*, *13*). Data from several state programs indicate that group testing is considerably less expensive than an individual screening program: for example, in one state costs for individual pure tone screening run between 25 and 35 cents per capita, whereas group pure tone screening procedures involve a cost of between 15 and 17 cents per child.[1] Figures from the Michigan Hearing Conservation Program indicate that relatively untrained technicians can do accurately between 70 and 80 individual sweep check hearing tests per day; through the use of group pure tone screening procedures between 200 and 250 pupils can be tested per day with comparable accuracy when an adequately quiet testing environment can be achieved. In a community where group hearing testing equipment can be left in one room, the procedure would involve considerable economy. However, where this is not possible, the time spent in setting up and servicing the equipment would no doubt reduce the amount of saving involved in group testing procedures. Group procedures requiring paper and pencil responses can be employed satisfactorily only with children in the third grade

[1]These data from an unpublished time-cost study conducted by the Hearing Conservation Section, Michigan Department of Health, were reported at the Conference by Courtney D. Osborn.

and above. Younger children cannot be relied on to make appropriate responses to this kind of test.

Descriptions of appropriate group testing procedures can be found in standard textbooks. Group procedures using fading numbers are not recommended. Criteria for failure which are presented at the end of this chapter may be applied to group as well as individual techniques using pure tones. Where group procedures are used, the equipment should be carefully calibrated and checked regularly and the results of its use validated against the results of individual hearing testing so that administrators may be sure that the program is functioning with acceptable efficiency.

In the second stage of the process, the threshold test, standardized procedures should be followed. Descriptions of these procedures can be found in standard textbooks (*5, 12*).

It is possible that in the future some of the automatic audiometric techniques mentioned in Chapter V may be adapted for use with school-age children. Administrators of hearing conservation programs may well want to investigate developing automatic audiometric procedures and the variations of use to which they may be put.

Environment

It is useless to carry out the recommended identification audiometric procedures unless the results obtained can be assumed to be valid. Their reliability depends upon three important aspects: the environment in which the testing is done, the equipment used, and the personnel operating the equipment. If there is a breakdown anywhere, the results of the program become meaningless.

A good acoustic environment is necessary. It can safely be said that millions of dollars and thousands of man hours are now being spent on worthless programs simply because space has been utilized because of its convenience rather than because of its suitability for the purpose. If an examiner is screening at 15 db above audiometric zero while the environment induces 20 db of masking, spuriously large numbers of subjects will be identified as having hearing problems and will be referred on to successive stages of the program. Initial expenditure of money for a suitable testing environment results in substantial savings of money spent for the referral of children erroneously thought to have hearing impairment.

The amount of space to be planned for hearing testing will depend upon whether the first stage makes use of group audiometric techniques or whether both stages involve individual testing. Regardless of the type of test used, the testing environment must be one in which valid measurement can be obtained. This requirement necessitates the use of acoustic treatment in all enclosures used for testing.

In existing school buildings appropriate space may conceivably be found and adapted for this use. Past experience suggests that this possibility is often unlikely. Useful space should be located as far away as possible from heating and other mechanical equipment, the school shop, the music room, the typing room, the cafeteria, rest rooms, and other sections where student traffic and regularly scheduled activities can be expected to induce high masking levels. In planning to adapt already existing space or in planning space designed for hearing testing in new construction, administrators will find it advisable to make sound level and spectral analyses in order to determine whether the rooms meet the specifications established by the American Standards Association.[2]

They may also secure the services of acoustical consultants available in nearby universities or industrial establishments. Cox (2) has recently defined the minimal noise levels allowable for testing various frequencies at given intensity levels. It is earnestly to be hoped that school boards will come to see the need for specifying the inclusion in each new school building of space planned for the efficient implementation of hearing conservation programs. It is also to be hoped that architects who plan the space will give due consideration to the problems involved.

It is likely that the program will demand sound treatment beyond what the usual existing school can provide or what local carpenters can well construct. It is, therefore, strongly recommended that in schools which cannot provide adequately quiet quarters, sound-treated prefabricated booths be purchased and installed. A portable booth which can be conveniently dismantled and set up again is not recommended, as the best of these portable structures achieves only from 20 to 25 db of attenuation in the frequencies tested. A standard sound-treated booth made by a commercial manufacturer which can guarantee at least 40 db attenuation is recommended. Such booths are available at a cost of between $1200 and $1500. School boards may find it less expensive to procure mobile testing units–specially constructed buses or trailers–that provide the necessary sound isolation to guarantee reliable test results. Such units are useful, too, for covering large areas of sparse population. In the larger mobile units, group as well as individual testing can be performed.

[2]ASA Standard S3. 1-1960, American Standard Criteria for Background Noise in Audiometer Rooms.

Only through planning a program in accordance with such stringent criteria for test environment can those responsible for the program be sure that they are measuring the hearing levels of the children and not just the background noise of the school. The required outlay of funds is reasonable and essential. Schools which lack appropriately designed space will find a kind of precedent set by industry. It is an impressive fact that upon the insistence of noise engineers and audiologic and otologic consultants to industry, over 1,000 prefabricated sound-treated booths have now been installed in industrial situations in the United States.

A supervising audiologist will want to make frequent check of the number of individuals identified because of failure in the low frequencies tested. If he finds an inordinate number of failures at 500 cps or below, in cases where normal hearing is found in the higher frequencies, he will know that the screening level he has adopted is inappropriate for use in all frequencies in the testing environment he has.

Frequencies to be Tested

Since a complete threshold test of every child at all frequencies may not be feasible, a selection of certain frequencies must be arrived at through some process of compromise. Certain factors which enter into the making of this compromise must be carefully weighed. These include the time devoted to the initial screening, the time required in the retesting of children who fail to meet the criteria of the initial screening, the realities of the acoustic conditions of the testing environment, and the reliability of instrumentation in the testing of certain frequencies.

At present, definitive data are not available which would make a decision about the frequencies to be tested clear-cut. Data do not exist which incontrovertibly indicate that the extremes of the frequency spectrum should be included, for example, 125 cps and 8000 cps. Similarly there is a lack of incontrovertible evidence that limited frequency testing using only one or two frequencies will result in the identification of an acceptable percentage of hearing losses in a school-age population.

In the absence of these definitive data, it is recommended that no less than four, preferably five, frequencies be tested. *The frequencies recommended for identification audiometry at the school-age level are 500, 1000, 2000, 4000, and 6000 cps.*

There are several reasons why elimination of the lower frequencies is recommended. It is generally agreed that useful clinical information is seldom gained by testing at 125 and 250 cps. It is difficult in most testing environments adequately to combat interfering environmental noise in testing these frequencies.

Some audiologists recommend not including 500 cps in the screening of school-age children. In many testing environments there is considerable masking at 500 cps. There is some evidence to indicate that even under excellent testing conditions the use of 500 cps does not necessarily improve the effectiveness of the screening if 1000 cps is used. A study conducted in one state indicated that when 500 cps was used in the initial screening, almost one-fourth of the total failures on the screening test were due to failures to reach the criterion level on 500 cps only. It was found that if this frequency were eliminated, only 2.2% of the medically significant hearing losses confirmed by detailed testing in otological clinics would have been missed; thus 97.8% of the medically significant losses would have been identified without testing at 500 cps.[3] On the basis of the economic considerations indicated by such information some programs may very well prefer to omit 500 cps, in this way probably reducing the number of children referred for threshold testing and thus permitting personnel to devote more time to the initial screening of larger numbers of children.

On the other hand, when the hearing testing environment can be made to meet the criteria set forth herein, as can usually be done, it is highly desirable to test at 500 cps. The purpose is to identify as many children with hearing problems as possible, and certain published information (*3, 9*) supports the view that 500 cps *may* be a critical frequency in identification audiometry for school-age children.

[3]Data taken from unpublished study by Evan Lounsbury, Regional Audiologist, Hearing Conservation Section, Michigan Department of Health. Reported at the Conference by Courtney D. Osborn.

There is no general agreement about which of the higher frequencies should be included in a screening test. There is fairly good agreement that reliable testing at 8000 cps is difficult. It is felt that no audiometer presently available can consistently hold ASA standards at 8000 cps. The response of earphones frequently begins to fall off sharply at 8000 cps and an audiometer is easily put out of calibration at that frequency. The Armed Forces-National Research Council Committee on Hearing and Bio-Acoustics (CHABA) (*14*) has recommended that 8000 cps not be used in identification audiometry.

The inclusion of 4000 and 6000 cps for identification purposes has been widely debated. Some feel that the identification program should be concerned primarily with medically reversible conductive-type hearing losses; therefore testing of the higher frequencies is advised against. Others feel that high frequency hearing losses should be discovered in the initial screening if possible.

It is known that a substantial part of the population demonstrates a dip at 4000 cps. In some cases this dip can be related to environmental noise, for example, the noise of tractors which farm children may drive.[4] Apparently in some individuals the presence of a 4000-cycle dip has little significance, and when serial audiometry is done, no change in the amount of loss is found over a period of years. Since such large numbers of children are found with a 4000-cycle dip, many otologists have indicated that they prefer not to have referred to them children with a loss at only that frequency. Many audiologists feel that it is important to test at both 4000 and 6000 cps; if hearing is normal at 6000 cps, one can dismiss a dip at 4000 cps as of minor significance. However, if a loss is found at 6000 as well as at 4000 cps, there is evidence of a more pervasive involvement and the child should be referred for threshold testing and possibly for an otological examination. In line with this reasoning, some audiologists prefer to screen only at 6000 cps and not at 4000 cps.

It may be restated that no valid data exist supporting the use of a sweep-check hearing test at all frequencies; nor are there adequate data available yet to support limited frequency audiometry using only one or two frequencies (*6*). In programs of preventive medicine, however, if one too early strips his data-gathering down to the minimum, he will fail to answer all of the pressing questions about hearing loss. The procedure of choice, then, is to test more frequencies rather than fewer frequencies until such time as definitive data are available justifying the use of only one or two frequencies.

Intensity Levels and Criteria for Failure

Current practices with regard to the use of given intensity levels are based upon recommendations made by the American Academy of Ophthalmology and Otolaryngology in 1943 (7). These recommendations were apparently based on clinical practice and not upon some statistical determination of what would constitute the best screening

[4]A study in progress, 'Incidence of 4000 cps binaural losses in school children,' is a research project of the Division of Special Education, Iowa Department of Public Instruction, supported by Research Grant #B-1970 (A), S.D.(A), National Institute of Neurological Diseases and Blindness.

level and the most appropriate criteria for failure.

In the discussion that follows it is to be remembered that a two-step audiometric procedure is undertaken prior to referral of a child to an otologist. The first step is a four- or five-frequency screening test. (Some audiologists may prefer to insert an immediate re-screening step following this in case of a child's failure to meet the criteria.) The second step consists of a threshold test involving all frequencies. *The criteria for failure apply to both steps.* The first test is designed to yield a considerably larger number of cases than are found in the second step to have a significant hearing loss. The second step is designed to identify those children most appropriately referred to an otologist for a diagnostic examination. The interposition of the second step is designed to prevent unnecessary referral.

Current criteria for referral (*12*, p. 210) specify failure at two of the frequencies tested at a sensation level of 20 db or failure at one frequency tested at a level of 30 db. A 15 db sensation level has been adopted as the screening level for identification audiometry almost uniformly across the country. The historical basis for this choice is that 15 db is a level about two standard deviations above the mean threshold of individuals with normal hearing. A second justification for the use of this level is that disability in understanding speech in some situations begins at about 15 db above audiometric zero.

It is now recommended that practice be altered as follows: *only four frequencies shall be considered in the criteria for referral: 1000, 2000, 4000, and 6000 cps. It is recommended that screening be done at the 10 db level* with reference to the present American Standard audiometric zero *for the frequencies of 1000, 2000, and 6000 cps, and at the 20 db level for the frequency of 4000 cps.* A child would be judged to have failed the screening test and to be a candidate for referral for the next step if he failed to hear the 10 db level at either 1000, 2000 or 6000 cps, or if he failed to hear the 4000-cycle tone at the 20 db sensation level in either ear. It is to be remembered that if screening is done at 15 db, a person who has a 15 db hearing loss is passed. The use of 10 db as the screening level at 1000, 2000, and 6000 cps results in the clear labeling of the person who has a 15 db hearing loss as warranting further attention.

Choice of Equipment

Noisy environments can lead to the spurious identification of individuals as having hearing losses. The audiometers themselves may also be responsible for the erroneous identification of apparent losses. To many users of audiometric equipment the instruments are very impressive and seem to imply high reliability. In actuality, many audiometers are relatively unstable and much care must be exerted in their selection and maintenance.

The audiometer to be used in the first stage of identification audiometry should meet the requirements established by the American Standards Association for limited frequency audiometers.[5] This equipment allows for the testing by air conduction of five

[5]ASA Standard Z24.12-1952: American Standard Specification for Pure-Tone Audiometers for Screening Purposes.

or six frequencies with an output up to 70 or 80 db. It need not provide for masking or for bone-conduction testing. (See also *11.*) The audiometer to be used in the second stage for the obtaining of the threshold audiogram should meet the requirements established by the American Standards Association (*1*) for diagnostic audiometers. (See also *10.*) Such audiometers can, of course, also be used in the first stage of screening.

The purchaser of a new audiometer should request that the manufacturer supply data corresponding to the specifications established by the American Standards Association. The purchaser of audiometric equipment for school testing purposes should be aware of the fact that audiometers are generally most efficient in the measurement of hearing loss of a considerable degree. It is technically easier to make the attenuation linear at levels above audiometric zero than it is at or near audiometric zero. Whereas the otologist will more usually be concerned with measurements in the 40 to 70 db range, personnel working with school-age children will be more concerned with the linearity of audiometers at levels near audiometric zero where measurements of children with normal or near normal hearing are made.

The equipment purchased for individual audiometry should include head sets with two earphones so as to reduce the masking effect of ambient noise. When group testing equipment is purchased, it should provide up to 40 pairs of phones in head sets with cushions. Only one phone of each set need be live, but there should be provision for covering the ear not under test.

Attention should be given to the size of the earphones used with individual children. Especially with the school-age group heads and ears vary greatly in shape and size, and some obtained differences in hearing may be attributed to differences in the fit of earphones. Headbands should provide pressure adequate to hold cushions tightly against the head; headbands providing more degrees of freedom in all directions are to be preferred.

Purchasers of equipment for testing school-age children will be interested in following the progress made in the development of supra-aural muffs; some muffs that have been developed promise to provide an economical answer to problems of masking in environments not specifically planned for hearing testing. It is to be hoped that such muffs will be standard equipment on audiometers in the near future; also desirable is a universal type of cushion appropriate for both children and adults or separate cushions for different age groups tested in the identification audiometry program.

Purchasers of equipment will also be interested in the simplicity of design of the equipment (the types of circuits involved, the number of tubes, etc.), the smoothness of function of the controls, the durability of the chassis, and the convenience of placement of the dials and control levers. Audiometers of desired ruggedness and stability with a variety of special features are available but obviously at greater cost to the consumer. Suffice it to say that the inexpensive audiometer ordinarily purchased for use in the testing of school-age children may well be relatively unstable and requires the constant vigilance of the user if valid results are to be obtained from it.

Maintenance of Equipment

The person in charge of the hearing testing program should have a clearly stated policy of what the individual audiometrist is expected to do with regard to maintenance of the equipment and what he is expected not to do. The audiometrist who daily operates the equipment should be responsible for testing of tubes; the replacement of earphone cords, fuses, and line cords; and the biological calibration of the audiometer daily to detect any marked shift at given frequencies. He should periodically listen to each phone to be sure that it is operating and to determine whether increasing the intensity 5 db results in corresponding changes in loudness. The audiometrist, who knows his own audiogram, should check his hearing daily and at least bi-weekly check the audiometer with a group of individuals not noise-exposed and known to have normal hearing. Personnel should be warned against soldering joints and replacing the earphones from one audiometer with those from another.

Beyond this first-echelon maintenance, it will be helpful to have some kind of independent evaluating agency available to users of audiometers for consultation on calibration procedures. If local demands are great enough, calibration check centers should be established by departments of health to serve programs within states or within still larger regions. Several new devices are being developed which will be useful for checking the calibration of earphones in the field without returning them to the factory. The critical point in calibration of audiometers is the intensity output at various frequencies. Four companies now offer calibration equipment which can be purchased for use in a regional or state calibration center. Such equipment can be used to determine whether an individual audiometer needs to be returned to the factory and can also be used to check on the adequacy of factory calibration.

In the absence of such an evaluating agency a supervising audiologist would be responsible for making the next level check, to determine whether an audiometer needs a factory overhaul. It is strongly recommended that an audiometer should be returned to the factory (or factory-designated regional center) for calibration check, re-calibration, and any necessary repair after every four months of use or, if this is not possible, after six months of use, and in any case no less frequently than once each calendar year.

Summary

Identification audiometry for school-age children consists of mass screening of large numbers followed by a test of hearing sensitivity for those suspected of having hearing problems. Mass screening may be done by individual or group screening methods. Individual screening is more accurate but more costly.

Quiet environment is essential for reliable hearing testing. Testing rooms should be acoustically treated. It is recommended that schools purchase commercial sound-treated booths, which are available at reasonable cost.

The frequencies recommended for

identification audiometry at the school-age level are 500, 1000, 2000, 4000, and 6000 cps. It is recommended that screening be done at the 10 db level (with reference to the present American Standard audiometric zero) for the frequencies of 500, 1000, 2000, and 6000 cps and at the 20 db level for the frequency of 4000 cps. It is recommended that the criteria for failure be failure to respond to the 10 db level at 1000, 2000, or 6000 cps or to the 20 db level at 4000 cps.

Equipment should meet the requirements established by the American Standards Association for limited frequency and diagnostic audiometers. Equipment should be properly calibrated and maintained. Independent regional calibration check centers should be established where needed by departments of health. Calibration checks of audiometers should be made after each four months of use and in no case less frequently than once a year.

References

1. *American Standard Specification for Audiometers for General Diagnostic Purposes* (ASA Z24.5-1951, approved March 21, 1951). Reprinted in Hirsh, I. J., *The Measurement of Hearing*. New York: McGraw-Hill, 1952, pp. 321-327.
2. Cox, J. R., How quiet must it be to measure normal hearing? *Noise Control*, 1, 1955, 25-29.
3. Farrant, R. H., The audiometric testing of children in schools and kindergartens, *J. aud. Res.*, 1, 1960, 1-24.
4. Harris, J. D., Group audiometry. *J. acoust. Soc. Amer.*, 17, 1945, 73-76.
5. Hirsh, I. J., *The Measurement of Hearing*. New York: McGraw-Hill, 1952.
6. House, H. P., and Glorig, A., A new concept of auditory screening. *Laryngoscope*, 67, 1957, 661-668.
7. Hughson, W., and Westlake, H., Manual for program outline for rehabilitation of aural casualties both military and civilian. *Trans Amer. Acad. Ophthal. Otolaryngol., Supplement*, 48, 1943-44, 3-15.
8. Johnston, P. W., The Massachusetts hearing test. *J. acoust. Soc. Amer.*, 20, 1948, 697-703.
9. Lawrence, C. F., and Rubin, W., The efficiency of limited frequency audiometric screening in a school hearing conservation program. *Arch. otolaryng.*, 69, 1959, 606-611.
10. Minimum requirements for acceptable pure tone audiometers for diagnostic purposes. *J. Amer. med. Ass.*, 146, May 19, 1951, 255-257. Reprinted in Hirsh, I. J., *The Measurement of Hearing*. New York: McGraw-Hill, 1952, pp. 304-310.
11. Minimum requirements for acceptable pure tone audiometers for screening purposes. *J. Amer. med. Ass.*, 144, Oct. 7, 1950, 465. Reprinted in Hirsh, I. J., *The Measurement of Hearing*. New York: McGraw-Hill, 1952, pp. 311-313.
12. Newby, H. A., *Audiology*. New York: Appleton-Century-Crofts, 1958.
13. Nielsen, S. F., Tonaudiometermethode zur Gruppenuntersuchung des Gehörs des Schulkinder. *Acta otolaryng.*, 32, 1944, 263-283.
14. The medical principles of monitoring audiometry. *AMA Arch. ind. Health*, 17, 1958, 1-20.

IV. Identification Audiometry for School-Age Children: Implementing the Program

Periodicity of Testing

Practices and philosophies vary with regard to the frequency with which hearing tests should be administered to children in the school-age group. Some audiologists feel that the ideal program involves testing every child every year. Because of the fact that such a practice involves large numbers of people and the outlay of large amounts of money, many kinds of compromises have been suggested. Perhaps the most reasonable compromise is dictated by two considerations: (1) detection of hearing loss is particularly important in the younger part of the school-age population; if a child fails an early screening test, there is reasonable probability that he will fail subsequent tests; (2) some children constitute special referrals for hearing testing outside of the routine periodicity of tests.

In newly-established programs an effort should be made to test all of the children during the first school year. Thereafter an adequate program includes aggressive attention to the possibility of hearing problems in the early years in school. This can be implemented by *annual testing in kindergarten and grades 1, 2, and 3. Less frequent testing can be planned in subsequent school years, but no child should experience more than a three-year interval between tests from grades 4 through 12.*

Some programs prefer to operate a screening program in such a way that children will be tested once every two years, for example, in grades 1, 3, and 5, or 2, 4, and 6, plus one test at high school level. More important than to schedule hearing testing in certain grades every year is to insure that no child fails to have his hearing tested at least every two or three years. Accounting, then, should be *by child* rather than *by grade.*

Extension of periodical hearing testing into the high school age is recommended. Because of the tendency for otosclerosis to appear late in school-age, it is important that high school students be tested in grade 10, 11, or 12.

The time of year at which the identification audiometric program is conducted should be selected with care. Clinical findings indicate that there are important differences between the results of tests given at different times of the year. Some have suggested that hearing testing should be done in the 'worst' season of the year with regard to hearing conditions. There are perhaps two seasons of the year when the prevalence of hearing problems increases significantly: the so-called 'cold' season in mid-winter, extending through January and February, and the allergy season, the time and duration of which will vary in different parts of the country. There are always difficulties in designing a program which identifies the maximal number of problems during both seasons. Ideally a child should not have his hearing tested at the same season on successive hearing tests.

The most reasonable compromise would seem to be to test hearing as early in the school year as possible. The supervisor of the program must exercise judgment in deciding how best to use the personnel available to him. He may choose to consolidate his hearing testing personnel and have them move as a group into a school to accomplish the complete routine hearing testing in the briefest possible time, moving on successively to other schools, and thus accomplish the total identification program within a matter of weeks or months rather than stretch it out over the entire year.

In addition to the routine periodicity discussed above, an adequate program should include opportunity for immediate testing of the following types of children (*1*):

(1) All pupils who are new to the individual school or to the school district.

(2) Pupils discovered by previous tests to have a hearing impairment.

(3) Children with delayed or defective speech.

(4) Pupils returning to school after a serious illness.

(5) Pupils enrolled in adjustment or remedial classes or programs.

(6) Pupils who appear to be retarded.

(7) Pupils having emotional or behavior problems.

(8) Pupils referred by the classroom teacher for hearing testing for any reason.

Records

Records of hearing testing through the school-age years should be made a part of the child's general health record. Space should be provided for recording information from a series of audiograms over the school years, with the dates of the tests, the recommendations, and the follow-up.

Such records should be kept as long as is reasonable. Some school systems, having limited storage space, keep the records no longer than they are required to keep them, usually three years after the child's graduation from school. When records are maintained by state health departments, the period is often three years beyond the limit of children's programs, which typically deal with individuals up to age 21.

Medical personnel, vocational rehabilitation personnel, and personnel in military service and industry who have access to records of hearing testing done during the school-age years would find these helpful as reference audiograms in relationship to subsequent hearing tests. School or health agencies can turn such records over to the families of the children involved, particularly if they suggest that the child had had some history of hearing loss.

It seems obvious that if current hearing test records are to be maximally useful, they should be available to medical and educational personnel as well as to parents. They should be used in the planning of educational programs as well as in programs of health. The school and public health nurse, physicians, and school and community speech clinicians should all have the opportunity to scrutinize these records in connection with their various programs.

Personnel

Identification audiometry with school-age children usually requires personnel at two levels, supervisory and technical. A supervising audiologist should hold the certificate in hearing of the American Speech and Hearing Association or at least meet the academic and practicum requirements for that certificate. He has responsibility for selecting the most appropriate procedures for testing the particular population to be studied; selecting, training, and supervising audiometrists; referring certain children for more complex audiological study; supervising equipment calibration; discussing test results with otologists; educating various segments of the public in acceptance of the program of identification audiometry; following up on referrals; and in general carrying out the entire subprogram of identification audiometry.

At the second level are audiometrists capable of performing both individual and group screening tests and individual threshold tests. If possible these audiometrists should have at least one college-level course in audiometry, including supervised practice in testing. More detailed academic training than this is certainly desirable but in some cases even less training may have to be accepted if enough personnel are to be available to man a program.

Prescribed training might well consist of a short course lasting from two to six weeks: approximately one-half of the time would be devoted to basic information about hearing and hearing impairment and the instrumentation used in hearing testing; the other half would be devoted to supervised practice in testing. Such an intensive course would give relatively little attention to the neurology and physiology of hearing, to testing by bone conduction, and to the use of speech audiometry, GSR audiometry, and tests for malingering and psychogenic deafness. Trainees would practice using the audiometer on many individuals with different hearing characteristics, all under close supervision. Such short courses may be offered in universities and colleges or by the staffs of state departments of health.

Short courses of the type described have been successfully used in military service (for example, U. S. Navy, six weeks, 108 hours; Walter Reed Hospital, two weeks, 80 hours) and elsewhere (Michigan Department of Health, six weeks, 180 hours). The whole question of training programs for persons of limited responsibility has for some years been under consideration by the American Speech and Hearing Association. Guidelines regarding the scope of such courses have recently been published (*2*). There is agreement that it is desirable that the course be presented over a period of several weeks, as opposed to a concentrated two- or three-day institute.

How many audiometrists will be needed to implement a program for testing school-age children? One state department of health has found that an audiometrist handling the first two stages of the program and using a combination of group and individual testing can reasonably test a school population of between 10,000 and 12,000 children per school year. If the program requires a test only every other year rather than every year, the audiometrist can handle a population of about 24,000.[1]

[1]Data reported by Courtney D. Osborn.

A similar program in another state has reported comparable figures, an audiometrist serving between 12,000 and 15,000 children per school year, the exact number depending upon the distance covered by the audiometrist and the amount of travel involved.[2] In a third state reimbursement regulations recently drafted prescribe that an audiologist shall serve a population of from 12,000 to 13,000. The audiometrist in this program is envisioned as serving a population of 4,000 children, but his work is described as only part-time work in the first and second stages of testing.[3]

There is some difference of opinion about the type of personnel who should be selected for work as audiometrists. Their job, involving as it does frequent repetition of certain basic operations, does not allow for much creativity. Individuals with substantial training in audiology may find such employment unattractive for an extended period. On the other hand, if progress is to be made in hearing conservation programs around the country and if usable research data are to emerge from these programs, close attention must be given to the competence of those doing the work. Only an adequately trained person knows the implications of being careless.

Speech clinicians and registered nurses may, when they have had appropriate training, be competent to handle the first-stage screening and the second-stage threshold examination. But if they are used for these purposes, the skills which they were primarily trained to employ will be wasted. As a matter of economy, then, people other than nursing and speech correction personnel are customarily selected to handle the first two stages.

Volunteer personnel (housewives, retired school teachers) who are intelligent, highly motivated to do this sort of service, tactful, insightful in observing children's behavior, and capable of working easily with children as well as amenable to the suggestions of the supervisor, may be selected and trained. If such selection is done with discretion, problems of frequent turnover of personnel may be obviated. Where such persons are employed, administrative procedures should be set up and maintained to see that they are prevented from making evaluations and decisions which they are not competent to make; they should be prevented from doing more than first- and second-stage hearing testing.

The success of the entire hearing conservation program rests upon the validity of the hearing measurement done in the first two stages, and this validity rests importantly upon the competence of the personnel doing the testing. Efforts should continually be made, then, to help them maintain high standards of performance and to provide expert supervision to insure the validity of their results.

Referral Procedures

It is difficult to discuss the procedures of identification audiometry without making some reference to the steps which must follow. It has been stated that the program of hearing testing should provide for adequate medical consultation. Certainly the final steps in the appraisal and management of

[2]Reported by George J. Leshin.
[3]Reported by Dale S. Bingham.

individuals identified as probably having hearing impairment should be in the hands of medical personnel most competent to give the children the care they need. An otological examination of such children is not just a desirable feature which hopefully can be arranged but is a requirement if the program is to be effective.

The procedures adopted in order to accomplish this goal vary from locality to locality. In some communities the results of the two-stage identification process are studied by an audiologist in the central municipal or county or state administrative headquarters of the hearing conservation program. In some programs he alone does not make the decision about subsequent referrals but makes it together with an otological consultant. Such joint professional review of each case is particularly desirable since it permits a careful weighing of all previous data about the child's hearing together with pertinent information from the case history. As a result of this third step, a decision is finally made that a given child should have a comprehensive evaluation of his hearing, comprising a diagnostic audiological workup and an otological examination.

Some programs have developed a plan, approved by local or regional medical groups, to make such referrals directly to otologists. In other programs procedures involve an initial referral to the child's family physician, who may accept responsibility for the care of the child if he feels himself competent to do so or who may, in turn, refer the child to an ear, nose, and throat specialist. Throughout the country hearing conservation programs are increasingly endeavoring to communicate to pediatricians and general practitioners the urgency of the problems involved. Moreover, some programs have made excellent use of public health or school nurses to help parents understand the reason for the referrals that are made and to help them make and keep appointments for further audiological and otological examinations.

In every hearing conservation program problems inevitably arise concerning the number of referrals for medical examination created by identification audiometry. Efforts should obviously be made to avoid referring for complete audiological and otological workups large numbers of children who turn out to have no medically or educationally significant hearing loss. *Educators and physicans alike, however, agree that as a matter of general principle it is better to err on the side of over-referral than it is to take a chance with under-referral and thus neglect to secure necessary medical treatment for children who need it.* Cooperation among educational, audiological, and medical personnel in organizing and implementing hearing conservation programs is necessary in creating an understanding of the intent of the total program and of the possibility that occasionally children will be referred who are found to possess no significant hearing problem.

When it has been determined that a child has a significant hearing loss as a result of the sequence of referrals described above and when necessary medical and surgical treatment and followup have been provided, there is one further important step to be taken. The audiological and medical findings of the otologist must be conveyed to the parents and to other persons who are particularly concerned with the management of the child. The special education supervisor, the speech clinician, and the classroom teacher must be apprised of the child's needs and encouraged to meet them as comprehensively as possible. Appropriate entry should be made in the child's school health record so that a continuing program of care can be insured.

Program Evaluation

Administrators of programs of identification audiometry will naturally be concerned as to whether the expenditure in terms of personnel, time, and money is warranted and whether the program is yielding the desired results. Only by constant scrutiny of the results of ongoing programs can weaknesses to perceived, corrective steps be taken, and maximal usefulness be derived.

One way in which such a continuing evaluation can be made is by a comparison of the results emerging from the various stages of the process. Several steps are involved: first a validation of the first screening test by comparison of it with the results of the second-stage threshold examination; a further validation of the results of the first two stages is provided in the third-stage processing of the results by a professionally capable person in the field of audiology, ideally together with a professionally capable person in the field of otology, who can state on what basis they made a decision for further referral or not; a third validation is provided by the final clinical report made by the otologist who accomplishes the comprehensive otological examination. Careful analysis of the information yielded by this succession of tests indicates whether an efficient program of preventive medicine is being carried out.

There is another kind of evaluation which the administrator may want to make. The total number of audiograms produced in either the first or the second stage or both can be translated into a distribution of hearing losses. If the distribution deviates substantially from the distribution that one expects for a normal population, the administrator will be interested in examining into the testing environment, the calibration of audiometers, and the procedures used by individual testers.

Summary

In newly-established programs all children should be tested during the first school year. Thereafter children should be tested annually in kindergarten and grades 1, 2, and 3. Less frequent testing can be planned in subsequent school years, but no child should have more than a three-year interval between tests from grades 4 through 12. Provision should be made for immediate testing of new pupils, pupils returning to school after a serious illness, those presenting special adjustment problems, and those referred by teachers specifically for hearing testing.

Records of hearing testing should be made a part of the child's general health record and made available to medical and educational personnel responsible for the child's welfare. Such records should be turned over to the child or his family upon his graduation from school.

Supervisors of identification audiometry programs should be trained audiologists holding the certificate in hearing of the American Speech and Hearing Association. Audiometrists administering screening and threshold tests should have training and supervised practicum in these procedures. A minimum training program is suggested.

All testing procedures should be followed by medical, audiological, and educational evaluation so that each child's needs may be identified and steps taken to meet these needs.

References

1. *Hearing Testing of School Children.* Sacramento: Calif. State Dept. of Educ., 1954.
2. Report of Committee on Short Courses in Audiometric Techniques. *Trans. Amer. Acad. Ophthal. Otolaryngol.*, 63, 1959, 852-853.

V. Identification Audiometry for Adults

Industry and the Military

The interest of industrial establishments and the military services in hearing problems is similar, and the procedures that are recommended for use in the two situations are essentially the same. Both industry and the military need a preplacement (sometimes called a reference) audiogram for each individual as he enters the organization. The audiogram should be a threshold audiogram involving appraisal of hearing at the following frequencies: 250, 500, 1000, 2000, 4000, 6000, and 8000 cps. This preplacement audiogram furnishes a baseline for use in connection with noise trauma on the job, in subsequent job placement, and in determination of terminal compensation due the employee or the serviceman because of hearing loss incurred during the period of employment or service.

Group testing can be highly practicable in industry and the military service, but the size of the groups is likely to be quite different. Ordinarily in industry it is not convenient to use group techniques because there is no logical flow of subjects in sizable numbers. Rounding up enough men to make group testing efficient ordinarily means a loss of efficiency on the production line. Probably at least 12 individuals at a time are needed if group testing is to be efficient. In the military service at induction centers where men filter in continuously and at larger centers such as training centers and depots where large groups of men are concentrated under close discipline, group procedures are quite convenient. Fifty-phone arrays with a magnetic tape for presentation of stimuli have been used in deriving six-octave threshold audiograms in both ears at the rate of 150 men per hour, including time needed for audiogram interpretation.

In both industry and the military service periodical monitoring audiograms will be necessary depending upon the nature of the duty of the individual and the noise conditions surrounding that duty. A damage risk criterion of 95 db SPL in the octaves from 300 to 2400 cps defines a hazardous condition. It is probably advisable for all personnel to be tested at least once a year. Individuals whose duty requires them to continue in dangerous noise exposure areas should have a first monitoring audiogram made within three months after exposure, thereafter once a year. Such repeated tests indicate whether noise controls and personnel protective measures are effective. If threshold shifts are noted, they are to be interpreted as indicating that the controls must be altered or that additional ear protection must be furnished the individual. If the individual continues to show a deterioration of hearing, it may be necessary to remove him from the job.

Practice varies with regard to the frequencies tested in monitoring audiometry. Occasionally limited frequency audiometry is performed, involving only 2000 and 4000 cps. In more instances, full-frequency threshold tests are administered.

Both in industry and the military service automatic audiometry is finding an important place. Webster (*2*) has recently listed the automatic audiometers now in operation. The general acceptance of this type of audiometry is indicated by the recent approval by the American Standards Association and the International Standards Organization of automatic audiometers as meeting specifications of these organizations. Automatic audiometry is apparently quite efficient in the initial identification of possible hearing problems.

The use of manual audiometry is still preferred in the clinical evaluation of the individual's hearing which is part of an otological examination. Here testing must be done which is adequate for the detection of psychogenic involvement.

Details of testing procedure and the criteria for referral for otological examination are specified in various service regulations. In industry it is common practice to calculate the average loss at the speech frequencies of 500, 1000, and 2000 cps. If this average loss is in excess of 15 db, the individual is referred for a comprehensive audiological and otological evaluation. The individual ordinarily consults his own physician. However, if his problem may involve compensation, he will usually be seen by the company physician as well as by his own otologist. Individuals seeking compensation for noise damage should be examined in recognized audiological centers which provide comprehensive pure tone and speech audiometry as well as tests for psychogenic deafness and malingering, together with otological examinations.

Personnel

The military services have established their own regulations with regard to the selection and training of personnel to administer hearing programs. In the industrial setting two levels of personnel are needed for the hearing program:

(1) Audiologic consultants of high-level competence who bring to their work a general background in audiology as well as specific experience in the industrial field and specific training in acoustics and certain areas of engineering. The specialists can advise the industry with regard to noise levels and their control, sound treatment, and hearing conservation.

(2) Audiometrists who are able to do routine audiometric testing. Their qualifications and training should be comparable to those set forth for persons handling the first two stages of identification audiometry for school-age persons (see Chapter IV). It is assumed that they will work under the supervision of competent audiologists (*1*).

Smaller industries may not consider it practicable to hire a highly trained audiologist. In some plants the practice has been adopted of hiring a nurse or someone else of adequate background and intelligence who is given intensive training in audiometry in order to conduct a hearing testing program under the supervision of plant medical personnel. Where companies find it disadvantageous to maintain their own personnel, hearing testing service may be purchased. Even small industrial plants should make use through consultation of the technical services of specialists in noise and hearing. State departments of health, as well as other facilities, can offer advice regarding noise control and audiometric programs.

Testing of Other Adults

At present comprehensive programs for the hearing testing of adults not in industry or the military service are all too scarce. It is strongly recommended that community groups and agencies initiate programs for the general adult population. Such programs seem logically to fall within the area of supervision of state health departments. Representatives of agencies in a community which are concerned with problems of hearing loss may find it advantageous to form local hearing conservation committees to explore community needs and resources. Voluntary programs can be set up so that any adult can easily find out within his own or a nearby community whether he has a hearing problem. Each adult should have his hearing tested at least once every five to ten years.

Procedures to be followed in programs of identification audiometry for adults could well be practical adaptations of the types of programs for school-age children outlined in Chapters III and IV. Recommendations made in those chapters with regard to type of audiometry, screening levels, frequencies to be tested, personnel choice and selection, testing environment, and equipment apply equally to programs established for the testing of adults.

Summary

A full-frequency threshold preplacement audiogram, accomplished through either group or individual testing, with automatic or manually operated equipment, is needed as an individual joins an industrial establishment or the military service. Subsequent monitoring audiograms should be obtained at least annually, particularly when a person's duty is in dangerous noise exposure areas.

Military services prescribe procedures for personnel selection and training. In industrial programs both audiological consultants and audiometrists to do routine audiometric testing under supervision are needed.

Programs of identification audiometry for other adults logically fall within the area of supervision of local and state health departments. Each adult should have his hearing tested at least once every five to ten years.

References

1. *Guide for Industrial Audiometric Technicians*. Wausau, Wis.: Employers Mutual Liability Ins. Co. of Wis., 1955.
2. Webster, J. C., Problems in military audiometry: A CHABA symposium: 6. Automatic audiometry. *J. Speech Hearing Dis.*, 22, 1957, 748-749.

Appendix A

Laws and Regulations in Identification Audiometry: Directions and Trends

DON A. HARRINGTON

I have been asked to talk about laws and regulations pertaining to the screening tests of hearing function and to comment with reference to directions and trends in state legislation. Because the scope of this topic is a full spectrum including school audiometry, industrial audiometry, and military audiometry, I hope the preplanning committee will agree with my decision to select from this spectrum as my contribution a consideration of the one aspect of hearing screening tests for children. I have limited myself, therefore, to an investigation of the laws and regulations pertinent to just this one area.

An early study, which you may know, was a compilation in 1943 by the Legislative Reference Librarian of the Library of Congress entitled 'A Digest of State Laws Affecting the Hard of Hearing and the Deaf.' This compilation was published as House Document No. 154, 78th Congress, 1st session. An inspection of the laws cited in this 1943 publication shows that 13 states had laws requiring a general physical examination of school-age children, which could lead to an early discovery of hearing problems, and 20 states had laws which mention specifically the testing of hearing or the examination of the ear.

As I began this study of the present laws, I was fortunate in having as a starting point a questionnaire which had been sent out to the departments of health and the departments of public instruction in each of the states, inquiring whether the state had a compulsory law for the testing of hearing. The questionnaire had been sent out by Dr. Raymond Summers while he was employed by the Maternal and Child Health Division of the Indiana State Board of Health. Dr. Summers is now the consultant in speech and hearing in the Office of Vocational Rehabilitation, Department of Health, Education, and Welfare, and he has kindly made the questionnaire available to me.

Present State Laws

From a tabulation of the answers to this question, 25 states appeared to have such a law. Using this information as a guideline, a careful study of the legal codes of each of the states was made. Of the 25 states which responded that they did have a hearing testing law, only 18 proved, upon inspection of the codes, to have a law which mentioned specifically testing the function of

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hearing. The other seven states which responded affirmatively to the questionnaire had general health laws which apparently had been interpreted to include the testing of hearing. Additionally, the codes of all other states were examined to ascertain the nature of their provisions for the testing of hearing.

Our search in the codes shows that 16 states have school health laws requiring a general physical examination, which by our layman's interpretation could include the testing of hearing—and apparently does in some states, as later information about programs will show. This inspection of the codes and the supplements to the codes revealed that a total of 22 states have laws which specifically require hearing testing. Two states have repealed their laws which had been specific, substituting the requirement of a general physical examination. Whether the laws were permissive or mandatory was judged on the basis of the use of the words *shall* for mandatory and *may* for permissive. In only six of the 22 states were the laws judged to be permissive as distinct from mandatory.

Further general information about the laws which might be of interest is that in 35 states the administrative responsibility for health examinations, including hearing testing, was placed with the departments of public instruction. In 16 instances the department of health was charged with setting up or approving the criteria and standards to be used in the testing or health examinations. Since the testing program is aimed at the school-age child, it is natural that the responsibility be assigned to the department of public instruction. Likewise, since hearing testing is a health appraisal problem, it is natural that many states provide in their laws for the joint responsibility of the health and education agencies. In this respect, it is interesting to note the joint statement of policy from the Council of Chief School Officers and the State and Territorial Health Officers. This policy statement, first issued in 1951, was reprinted in 1959. Among the many policy statements made were these, which seem to be representative of the tone of the report:

> This (basic) principle is that, although statutes, ordinances, and regulations are necessary to define minimum standards for school health and although legal enforcement must occasionally follow violations in extreme cases, chief reliance for effective programs of school health services cannot rest merely on legal provisions and their enforcement. The keynotes are cooperation, leadership, and the united will to exceed all legally required minimum standards. Legal enforcement is necessary only in the cases where cooperation and leadership have failed. Such cases should be and can be rare.
>
> School health services should be planned jointly by departments of education and health with other representatives of the medical, dental, nursing, and education professions, voluntary agencies, and other groups that have a continuing interest in the health of school-age children.

Does it make a difference which agency, education or health, is charged with the responsibility for the program of testing hearing? In Ohio the Hearing and Visual Unit of the Division of Child Hygiene participated in a study, not published, in which this question was asked. The criteria used were the number who proceeded to complete the follow-up procedure. The study states that essentially there is no difference, by these criteria, between programs conducted by the health department and programs conducted by the education department. The study suggested that there were more differences between local programs in either category than there were differences between the two main categories of program responsibility.

The fact that a state has no law specifically requiring hearing testing is not necessarily indicative of the extent of the state's program. Many states, without specific legislation, promulgate recommendations and regulations with respect to hearing testing. I am assuming, of course, that you will keep in mind the traditional pattern of local responsibility both in the education and in the health departments. It is not possible, therefore, to compare laws against programs from state to state to determine the kind of state law which results in a good program. Nor can we compare state legislation against the regulations and expect to make judgments about the actual testing which is, after all, a local activity in all but two states. Our concern must be with the statewide recommendations and guidelines emanating from state leadership.

The elements in the laws and regulations which warrant our attention concern first, the periodicity of the tests; second, the criteria used in screening; and third and fourth, the practices with respect to follow-up and personnel. Data in addition to those in the codes were sought from the states by inviting them to forward copies of their latest regulations or publications with respect to hearing testing. Information was received from most of the states, and for the others, the data in our files which still seemed timely were used to contribute to this study.

Periodicity of Hearing Tests

The first question posed concerned the periodicity of the hearing tests. How often are they conducted? Does the state law require annual tests? How do the regulations interpret the law?

The question of deciding what is the best periodicity for hearing screening tests can be related to the question of deciding the periodicity of medical examinations and health appraisals. Not everyone is in agreement regarding such examinations. On the one hand, there are those who feel that the result in terms of referrals does not justify the time and expense involved. They point out that many of the conditions discovered are already receiving care, or are already known to the school and to the parents, or are conditions which could be determined easily by teacher observation or by investigation into the reason for pupil absenteeism. Persons who raise such objections do not necessarily advocate doing away with the periodic physical examination, but instead may suggest that it become more than a screening examination, that it become a complete and thorough appraisal of *selected* children.

On the other hand, those who support periodic physical examinations of all children feel that such procedures insure that every child will have the benefit of a health appraisal, that earlier identification of a problem is possible (hopefully, before it has progressed to an obvious and severe stage), that such examinations provide the school with information upon which to make educational adjustments for the child, and that such examinations provide the opportunity for health education and guidance which will encourage the concepts of preventive medicine and the seeking of early preventive medical care.

Hearing testing is an integral part of health appraisals, but although the usual arguments advanced concerning physical examinations are pertinent, they are not entirely applicable. For instance, the expense argument is usually raised in terms of the cost of the physician, whereas hearing testing may use lay persons and a minimum of trained specialists. Further, dependence on teacher referral for selection of those with hearing problems appears to be an inadequate technique for finding those who have difficulties in the ability to discriminate.

Although the consensus is that hearing should be tested annually, this is rarely done in practice. The National Committee on School Health Policies (Suggested School Health Policies, 3d ed., 1958, published and distributed by the Joint Committee on Health Problems in Education of the NEA and the AMA) states as follows:

> Hearing tests should be given annually in elementary schools and every two years in secondary schools, preferably with a pure-tone (discrete frequency) audiometer. Teachers, nurses, or technicians with special preparation should give audiometer tests.

Although 14 state *laws* require annual tests, very few states recommend in their *regulations* the annual testing of all children. Few interpret *annual* literally to mean all children in all grades from K-12 every year. Some state laws stipulate precisely the periodicity of the test: Connecticut law says 'every three years'; Indiana law requires testing grades 1, 4, 7, and 10; Maryland's law requires biennial tests; and Vermont's law stipulates grades 1, 2, 3, 5, 6, and 9.

Of the 39 states whose regulations were published, 36 included recommendations relative to the periodicity of the tests. Most of these states recommend a system of testing the alternate grades each year, so that each child would be tested, not annually, but every second or third year. The most typical pattern was to test grades K, 1, 3, and 5, plus, in some cases, 7, 9, and, in other cases, 7, 9, and 11. Only a few states recommended beginning in the second grade rather than in the first.

The patterns are too varied for many generalizations, but it is evident that the majority of the programs emphasize the testing of early school-age children with less emphasis on the testing of the high school student. At least two states are conducting pilot projects for testing the hearing of preschool children. However, none of the state laws and regulations referred to hearing screening at this early age. Almost all of the states provided in their regulations that all children who showed evidence of a hearing problem should be tested regardless of whether they were regularly scheduled for the screening test.

In summary, the question of how frequently the hearing screening test should be conducted cannot be answered from an inspection of the laws for only 14 state laws which require hearing testing stipulate *annual* tests and one biennial tests; three are specific in terms of grades to be tested; and two require the tests to be *periodic*. Furthermore, no definitive answer is available from the regulations. An inference can be drawn that state leadership is strongly in favor of annual testing but has compromised for expediency by a system of testing alternate grades, plus testing those children who appear to have a hearing problem.

Criteria Used

The next major problem for our attention concerns the recommendations at the state level of the criteria to be used in making a referral for further hearing examinations. Thirty-nine states' publications were used in drawing together the following material and inferences. It would not be valid, of course, to assume that only these 39 states had hearing screening programs carried on at the local level. Many states apparently have not published their recommendations and regulations.

The first question is, 'Do the state laws make a specific statement with reference to criteria?' Let me expand the usual definition of criterion to include the reference to the instrument by which the measurement is made. In California, Indiana, Michigan, New York, and Pennsylvania the law spells out that an audiometer shall be used. California law specifies that the audiometer must be approved by the Council on Physical Medicine and Rehabilitation of the American Medical Association. The appropriate law in other states either does not refer to equipment or includes a general phrase which delegates the responsibility to 'furnish tests, records, forms, blanks, and other useful and necessary appliances.' None of the laws includes specific provisions for such details as the 'decibel level' or the frequencies to be tested. Such specifics are left to the rules and regulations which the laws stipulate shall be prescribed by an appropriate department, that is, in 16 states, the department of health.

There is considerable uniformity from one state regulation to the next on the criterion of 'decibel level.' According to the 39 state publications, 20 states used 15 db as the pass-fail criterion; three states used 20 db; and two used 25 db. The publications of 14 states did not specify a testing level.

There was uniformity, too, in the recommendation by 26 states of the use of the pure tone test. Ten states indicated that a group test *might* be used, and only three highly recommended the group pure tone test.

One state referred to the use of the group whisper tests, and although I learn something new every day, this was for me a startlingly new idea. I was reminded of the stories of the superficiality of physical examinations during World War II in which the prospective soldier approached the examiner who told him to sit in the chair. When the man did, it was obvious that he could hear, could see the chair, and could move—this was evidence enough to pass the physical.

Although the use of 15 db was uniformly recommended as the 'pass-fail level,' there was no such agreement on the frequencies to be used in the screening tests. One state recommended just two: 25 db at 500 cps and 4000 cps. All other states (21) which made any recommendations at all as to frequencies used a variety of ranges; all used 500, 1000, 2000, and 4000 cps. Beyond that statement, no generalizations would hold. For the lowest frequency, 125 cps was recommended by California, Maryland, North Dakota, and Montana; 250 cps was recommended by Alaska, Arkansas, Minnesota, Colorado, Georgia, Kentucky, Massachusetts, New Mexico, and New York; 6000 cps was omitted by 10 states; 10 states included 8000 cps and one included 12,000 cps.

At this point we need to remind ourselves that these figures do not indicate what intensities and frequencies are actually being used at the local level but rather what has been promulgated by the state leadership level.

These figures just mentioned pertain to the screening tests. Criteria for referral to medical care from the threshold test are quite uniformly agreed upon. Most of the states used for referral to medical care the criteria of 'failure to hear 20 db at two or more frequencies in one ear, or failure to hear 30 db at one frequency, or evidence of pathology of the ear.'

In summary, then, we can say that the laws do not specify the kind of instrument, but the regulations tend to favor the use of a pure tone audiometer. The magic figure at which the dial is to be set is 15 db, but states do not agree on the range of frequencies which should be used in a screening test, even though (with one exception) they all do use 500, 1000, 2000, and 4000 cps. Very few publications included recommendations based on the use of 'db level criteria' for social or educational adjustments (such as that a 25 db loss warrants lip reading instruction and that a 30-35 db loss warrants the use of a hearing aid).

Follow-Up

The third category of information which seems pertinent concerns the practices with respect to follow-up. Almost every state law which required hearing testing provided that the results of the hearing test be reported to the parents. As we know, health educators recommend that the parents be informed by means of a face-to-face conference in order to motivate the parents to follow through with medical care. Some of the laws indicated that reports should be sent to the appropriate responsible departments.

In the regulations five states suggested that the nurse refer the child to an 'otologist' and an equal number suggested referral to a 'physician.' Seven states recommend referral to otological clinics, with the implication that such otological service is provided by the state for those who cannot afford it. Record keeping and motivation in the follow-up procedures are usually spelled out as the responsibility of the nurse and the teacher. The regulations sometimes indicated that the speech clinician should be responsible for testing those children who had speech problems.

Personnel

A fourth facet to the problem of hearing testing is the personnel involved. What persons actually do the testing? How are they trained? Who is responsible for this training function? In 14 states the law mentioned the use of a physician, although never in a mandatory sense. California is the only state which specified in its law that the testing must be done by an audiometrist who has a certificate from the health department or a credential from the education department. The laws of 13 states made it the responsibility of the teachers to test the hearing of their pupils.

The regulations are more explicit, of course, with respect to the personnel involved; there are provisions in at least 13 states that lay workers (volunteers) can be used to do the screening testing. In all of these states the regulations suggest that the volunteers should be given training by nurses, by health department specialists, or by audiologists in the departments responsible for the testing. Personnel at the screening level generally have a minimum of training; some have had short inservice courses, some have had a course or two in audiometry. Some of the health departments maintain a regular program of scholarships for sending lay persons to intensive training courses. The technician for the threshold testing is generally required by the regulations to be a more thoroughly trained person. Nurses are often designated, as are specially trained teachers in those schools where no audiometrist is provided or where the state has an inadequate number of audiologists.

The consultant personnel at the state level responsible for hearing testing are in the health departments in 24 states, in the special education divisions in 9 states, in the school health division in one state, and in the crippled children's service in education in one state. Personnel employed at the state level must meet state merit system qualifications if those states participate in the federal grants-in-aid. The merit system requirements attempt to insure adequate professional qualification.

Even in those states in which lay persons who do the hearing tests receive training there are seldom formal requirements for the volunteers. The personnel who do the threshold tests, however, are required by most regulations, and by implication, to be more qualified, although only a few states spell out what constitutes adequate training.

Summary

There was not enough evidence in the laws or in the regulations of the states to justify reporting on a 'trend' or direction. One notes that there has not been a sharp growth in the number of states which have this kind of legislation. However, an increasing number of states are publishing their recommendations. Some states have more flexibility than others in their laws and regulations.

Undoubtedly as professional guidance is extended to the local programs with information based on the kind of decisions and recommendations you will make here, sound programs can be promoted without much concern that there will be barriers set up by laws and regulations.

Appendix B

Hearing Levels in Children and Implications for Identification Audiometry

ELDON L. EAGLES

Since October, 1956, the American Academy of Ophthalmology and Otolaryngology, through its Subcommittee on Hearing in Children of the Committee on Conservation of Hearing, has been concerned with a long-term nationwide study of hearing problems in children. An initial study is being conducted in Pittsburgh, through the cooperation of the Subcommittee with the Maternal and Child Health Section of the University of Pittsburgh's Graduate School of Public Health, to evaluate methods for the testing of hearing in children in order to decide which methods are more efficient and economical in terms of time and manpower; to evaluate and define medical signs and symptoms which may indicate danger of hearing impairment; and to consider the psychological, social, and other effects of such impairment. A significant outcome of this study will be the development of the methods and techniques for the Subcommittee's national studies.

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Subjects

The study in Pittsburgh, which is planned for a five-year period, is being conducted on a population of approximately 5000 children ranging in age from 3 to 15 years. The school-aged children form 97.5% of the enrollment of the four elementary schools in which the study is being conducted. These schools were chosen to be representative, as a group, of the general Pittsburgh public school population. Preschool-aged children are those who will eventually attend the four schools.

Individual air-conduction hearing thresholds are being determined and otological examinations made on the children at varying intervals. Medical histories are being obtained. The relationships among otological findings, medical histories, air conduction hearing thresholds, and academic achievement and other aspects of child development are being studied.

This paper presents preliminary findings dealing with hearing levels found in the study and some of the factors which influenced these levels. The implications of these findings with respect to identification audiometry will be discussed.

The definition of an otologically 'normal' child used is a child who, within seven days of a reliable hearing level determination, was examined by one of three study otolaryngologists at the school test site and reported not to exhibit any of the following physical signs in either ear:

a. congenital malformation of the pinna, auditory canal, or tympanic membrane;

b. operative scar, adenopathy, or fistula in the auricular region;

c. occlusion of the auditory canal resulting in less than satisfactory visibility of the tympanic membrane;

d. abnormal coloration, increased vascularization, bulging, retraction, scarring, impaired mobility, or perforation of the tympanic membrane;

e. calcium plaques on the tympanic membrane;

f. discharge from the middle ear;

g. cholesteatoma; or

h. tumor of the middle ear.

Of the 3019 children who had concurrent otolaryngological examinations and a reliable hearing level determination during the first study year, 2175 were judged to be otologically normal, 457 were found with physical abnormalities of the ear, and 387 had occlusion of one or both auditory canals by cerumen. The term 'reliable,' used in respect to hearing level determinations, means 'repeatable.'

With respect to the group with abnormal otological findings, no attempt was made at this time to fit the children into diagnostic categories. These children include those with both active and inactive pathological conditions. It was found that the following physical abnormalities are associated with higher or less sensitive hearing levels:

a. abnormal coloration, increased vascularization, bulging, retraction, scarring, impaired mobility, and perforation of the tympanic membrane;

b. calcium plaques on the tympanic membrane; and

c. discharge from the middle ear.

The differences in mean hearing levels of children with and without these individual abnormalities differ somewhat with the particular finding but generally speaking range between four and 15 db.

It should be noted that the children with abnormal physical findings were in regular attendance at school at the time physical examinations were made.

The children classed as 'normal' otologically are fairly evenly distributed by age and sex between five and 14 years of age and were examined between June 1, 1958, and June 30, 1959. Children were examined throughout this period, including those seasons when respiratory infections become epidemic and those in which allergic conditions are more common. All children were untrained, but cooperative, listeners.

The numbers of children aged three and four years who were examined during the above period were small because work was concentrated on the school-aged study population. Several hundred children aged three and four years were added to the study and examined in July and August, 1959, following the period for which data are being presented. Reliable hearing level determinations have been obtained on over 96% of children tested of all ages, including those in the three- and four-year-old groups.

Testing Procedures

Hearing levels were determined in specially constructed audiometric test rooms placed in quiet locations in the four schools cooperating in the study. These rooms provided sufficient attenuation of ambient noise, as shown by acoustic surveys, to allow hearing level determinations to be made without masking at the low levels at which many children hear.

Commercial audiometers were modified to allow testing with linearity to a level of at least 30 db below the American Standard audiometric zero and were equipped with Western Electric 705A earphones. Audiometers were calibrated first at weekly and later at monthly intervals and were kept within the American Standard Specification at all times while in use. Necessary corrections were made for the following factors: the variation in sound pressure output from audiometer to audiometer within allowable limits, deviations in attenuator linearity at various intensity levels, and a statistical adjustment to allow for the distribution of thresholds within the 5 db attenuator steps. The statistical adjustment was made because hearing levels are determined in relatively gross 5 db steps. Thus, an individual who hears a particular frequency at 10 db and who does not hear at 5 db is recorded as having a

TABLE 1. Mean and median hearing levels and standard deviations for children in otologically normal and abnormal populations tested between June, 1958, and June, 1959, each frequency by ear. Hearing levels are given in db re audiometric zero, American Standard.

Frequency (cps)	*Right Ear*							
	Number Tested		*Mean Hearing Level*		*Median Hearing Level*		*Standard Deviation*	
	Normal	*Abnormal*	*Normal*	*Abnormal*	*Normal*	*Abnormal*	*Normal*	*Abnormal*
250	2029	412	—9.8	—5.2	—10.6	—6.9	7.7	12.2
500	2175	457	—7.2	—2.2	—7.4	—4.5	7.6	12.3
1000	2175	457	—5.3	—0.3	—5.8	—2.7	7.6	12.7
2000	2174	456	—4.4	—0.1	—4.7	—2.9	8.0	13.0
4000	2026	411	—3.6	+2.3	—4.1	—1.4	9.2	15.2
6000	2040	420	—1.8	+4.4	—3.0	+0.7	10.1	15.5
8000	2017	407	—3.0	+3.4	—3.9	0.0	11.0	17.8
Frequency (cps)	*Left Ear*							
	Number Tested		*Mean Hearing Level*		*Median Hearing Level*		*Standard Deviation*	
	Normal	*Abnormal*	*Normal*	*Abnormal*	*Normal*	*Abnormal*	*Normal*	*Abnormal*
250	2029	413	—10.6	—6.8	—11.1	—8.9	7.1	10.7
500	2175	457	—7.4	—3.0	—7.8	—4.8	7.3	11.4
1000	2175	457	—5.2	—0.2	—5.6	—2.8	7.4	12.7
2000	2173	456	—4.5	—0.7	—4.8	—2.8	8.2	12.6
4000	2026	410	—3.1	+1.2	—3.7	—2.2	9.1	14.0
6000	2040	419	—1.4	+3.7	—2.4	+0.7	10.3	15.7
8000	2018	406	—3.0	+3.0	—3.8	—0.5	11.1	16.7

threshold of 10 db, but he may actually be able to hear at the 6, 7, 8, or 9 db level. If it is assumed that of all individuals with hearing levels recorded as 10 db, an equal number begin to hear at each point between 5 and 10 db, then the whole group, although recorded as having a hearing level of 10 db, actually has an average hearing level of 7.5 db. Thus the hearing levels, as determined in 5 db steps, may underestimate the hearing levels for the group by 2.5 db. Because of this, it was felt that the hearing levels could be made more exact, although still approximate, by subtracting 2.5 db from each hearing level determination.

The data presented are available in sound pressure levels but, for the purposes of this publication it seems logical to present the data relative to the currently employed American Standard audiometric zero.

Results

The mean and median hearing levels and the standard deviations for the groups of otologically normal and abnormal children are shown in Table 1. The mean hearing levels in the abnormal group are higher, or less sensitive, than those in the normal group, the differences varying by frequency and ranging from 4 to 6 db. The median hearing levels also range from 4 to 6 db. The median hearing levels are also higher in the abnormal group than in normal children, but the differences in this instance range from 2 to 4 db.

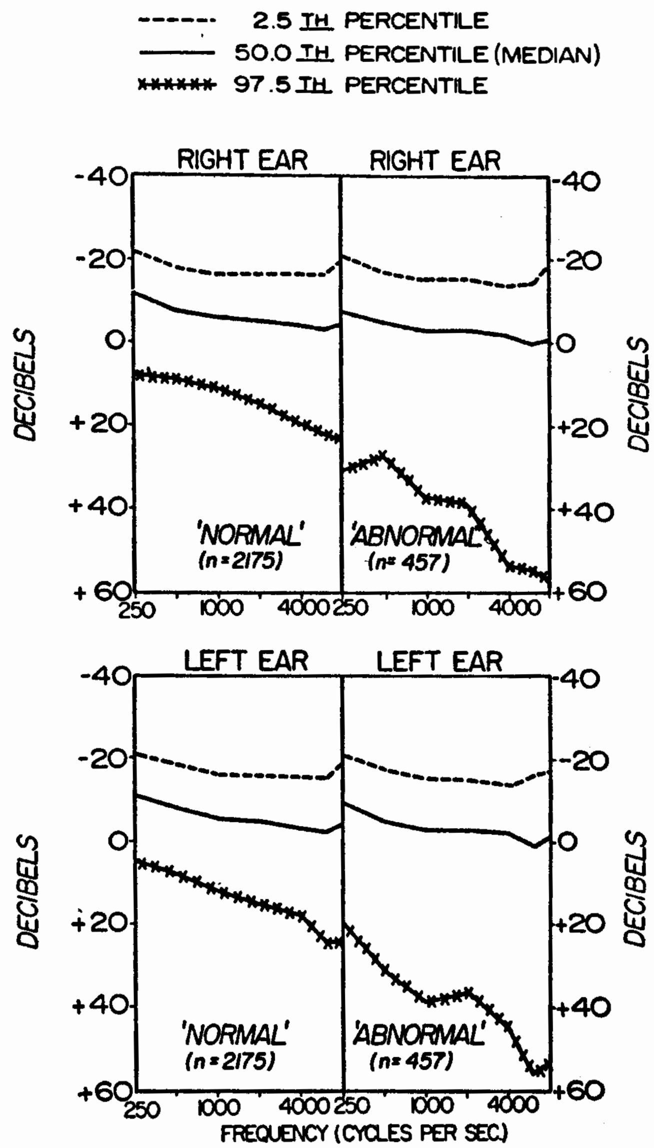
The greater differences between the means of the two groups of children as compared to the smaller differences between the medians is due to the fact that the numbers of children with more extreme degrees of less sensitive hearing influence the means more than the medians. The fact that both mean and median values for the otologically abnormal group are higher or less sensitive than the otologically normal is due to the larger number of children with less sensitive hearing in the abnormal group.

The standard deviations of both groups of children become larger as the frequencies increase. It is felt that this increase is due to the greater variability of response to pure tones at the higher frequencies.

The wider ranges of hearing levels in the otologically abnormal children are reflected in the larger standard deviations for this group. The ranges of hearing levels by ear and frequency, for both normal and abnormal groups of children, are represented graphically in Figure 1 as selected percentiles of the distribution of hearing levels about the medians.

The details of the percentage distribution at various hearing levels for the normal children are shown in Table 2. Similar information appears in Table 3 for children with otological abnormalities. In the normal population 92% of children have hearing levels below audiometric zero at 250 cps. This percentage falls progressively as frequencies increase, until at 8000 cps 65% of the normal children have hearing levels below audiometric zero. In the abnormal children 80% have hearing levels below the American Standard audiometric zero at 250 cps. This percentage also decreases as frequencies increase until at 8000 cps approximately 50% have hearing levels below, or more sensitive than, audiometric zero.

It is of interest that the percentage



NOTE: Between the 2.5 th percentile (upper line) and the 97.5 th percentile (lower line) are included 95 percent of the hearing levels of the children tested.

FIGURE 1. Selected percentiles of the distribution of hearing levels of children in otologically normal and abnormal populations by frequency and ear. Hearing levels are given in db re audiometric zero, American Standard.

TABLE 2. Distribution of hearing levels of children in an otologically normal population tested between June, 1958, and June, 1959. Hearing levels are given in db re audiometric zero, American Standard. Values indicate percentages of total number of ears tested falling at each hearing level. R = Right, L = Left.

Hearing Level	*250 cps* R	L	*500 cps* R	L	*1000 cps* R	L	*2000 cps* R	L	*4000 cps* R	L	*6000 cps* R	L	*8000 cps* R	L
	N = 2029		*N = 2175*		*N = 2175*		*N = 2174*	*N = 2173*	*N = 2026*		*N = 2040*		*N = 2017*	*N = 2018*
—35 to —31													*	
—30 to —26	0.3	0.3	*	*						*	*	0.1	0.3	*
—25 to —21	4.4	3.4	1.1	1.1	0.4	0.1	0.3	0.4	0.7	0.4	0.2	0.3	1.8	1.9
—20 to —16	18.0	18.8	8.0	8.0	4.2	3.9	3.5	3.8	3.2	2.5	3.1	2.7	5.8	6.8
—15 to —11	33.3	34.4	28.1	26.8	17.7	18.1	16.0	16.6	14.3	14.0	10.8	10.6	14.5	16.9
—10 to —6	22.5	22.8	26.3	28.7	36.3	33.9	28.0	25.5	25.3	24.3	20.3	18.9	21.8	19.6
—5 to —1	13.3	14.0	24.6	21.9	23.1	24.8	28.9	29.9	28.4	27.9	28.6	27.2	20.6	19.6
0 to +4	4.5	3.2	6.5	8.2	11.3	11.2	13.6	13.0	14.6	15.8	15.9	18.2	16.1	15.1
+5 to +9	1.6	1.6	3.3	3.6	3.8	4.6	5.6	6.4	6.9	8.3	11.6	12.0	8.4	9.3
+10 to +14	1.1	0.8	0.8	0.6	1.6	1.4	1.6	1.7	2.7	3.1	4.4	4.4	4.5	5.2
+15 to +19	0.3	0.1	0.4	0.4	0.4	1.0	1.0	1.4	1.2	1.4	1.9	2.6	2.8	1.9
+20 to +24	0.2	0.1	0.1	0.1	0.3	0.4	0.4	0.6	1.1	0.7	1.0	0.6	1.1	1.1
+25 to +29	*	0.1	0.1	0.1	0.1	0.2	0.6	0.2	0.4	0.4	0.5	0.6	0.7	0.6
+30 to +34	0.1		0.2	0.1	0.3	*	0.1	0.1	0.3	0.3	0.4	0.4	0.3	0.4
+35 to +39	*	0.1		*	0.1	0.2		0.1	0.1	0.1	0.1	0.1	0.2	0.5
+40 to +44		*	0.1	*	*	*	*	0.1	0.1	0.2	0.1	0.3	0.2	0.2
+45 to +49							0.1	0.1	0.3	*	0.3	0.4	0.3	0.2
+50 to +54	0.1	0.1		0.1	*	*	*	*	*	0.1	0.2	0.1	0.2	0.1
+55 to +59	*			*	*	*	*	*		0.1	0.1	0.1	0.1	
+60 or More			*											
No Response (+65)	*		0.1		0.1		0.1	*	0.1	*	0.2	0.2	0.1	0.1
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*Less than 0.1 per cent

TABLE 3. Distribution of hearing levels of children in an otologically abnormal population tested between June, 1958, and June, 1959. Hearing levels are given in db re audiometric zero, American Standard. Values indicate percentages of total number of ears tested falling at each hearing level. R = Right, L = Left.

Hearing Level	*250 cps* R	L	*500 cps* R	L	*1000 cps* R	L	*2000 cps* R	L	*4000 cps* R	L	*6000 cps* R	L	*8000 cps* R	L
	N = 412	*N = 413*	*N = 457*	*N = 413*	*N = 457*			*N = 456*	*N = 411*	*N = 410*	*N = 420*	*N = 419*	*N = 407*	*N = 406*
—35 to —31														
—30 to —26	0.2												0.5	
—25 to —21	2.2	1.2	0.6	1.2				0.2	0.2	0.2		0.5	0.7	1.0
—20 to —16	10.9	14.0	4.6	14.0	3.3	2.8	2.4	2.9	1.4	1.0	1.2	2.4	4.4	4.9
—15 to —11	25.8	26.7	16.2	26.7	10.3	8.8	11.2	11.0	7.5	9.8	6.4	6.7	12.1	11.6
—10 to —6	23.3	24.2	24.3	24.2	28.4	27.1	19.1	18.2	21.2	20.5	13.3	14.8	14.5	15.5
—5 to —1	16.5	15.3	24.8	15.3	21.9	26.3	28.5	31.4	24.3	24.1	23.1	21.7	17.9	20.0
0 to +4	7.3	6.8	11.4	6.8	15.8	13.6	17.3	15.1	14.1	17.6	20.5	17.2	13.5	14.5
+5 to +9	6.6	6.8	8.1	6.8	6.8	7.6	7.9	9.2	14.1	10.7	12.4	13.6	10.8	8.9
+10 to +14	2.4	1.7	4.2	1.7	6.1	5.3	5.5	4.4	4.4	6.1	7.4	8.1	7.4	7.4
+15 to +19	1.3	1.0	1.3	1.0	0.9	2.0	1.8	2.6	3.2	1.5	3.3	4.1	3.9	3.4
+20 to +24	1.0		1.8		1.8	1.3	2.0	1.5	1.9	2.4	3.8	1.7	3.9	3.4
+25 to +29		0.7	0.6	0.7	1.3	1.5	0.9	0.4	1.0	0.7	1.2	2.4	1.7	2.7
+30 to +34	0.7	0.5	0.2	0.5	0.4	0.9	0.4	0.2	1.2	0.7	0.5	1.4	1.7	0.5
+35 to +39	0.2	0.2	0.2	0.2	0.9	0.4	0.9	0.9	1.2	1.0	2.4	1.0	1.2	0.7
+40 to +44	0.2	0.2		0.2	0.2	0.6	0.2		0.7	1.2	1.0	0.7	0.5	1.0
+45 to +49		0.2	0.2	0.2	0.2	0.2		0.4	0.5	0.5	0.2	0.5	1.0	0.7
+50 to +54	0.5	0.2	0.4	0.2	0.4	0.6	0.2		0.5	0.5	1.2	0.5	1.0	1.7
+55 to +59	0.2	0.2		0.2	0.4		0.6	0.4	0.7	0.5	0.5	1.4	0.7	0.5
+60 or More								0.2						
No Response (+65)	0.7		1.1		0.9	0.9	1.1	0.9	1.7	1.0	1.7	1.4	2.5	1.5
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

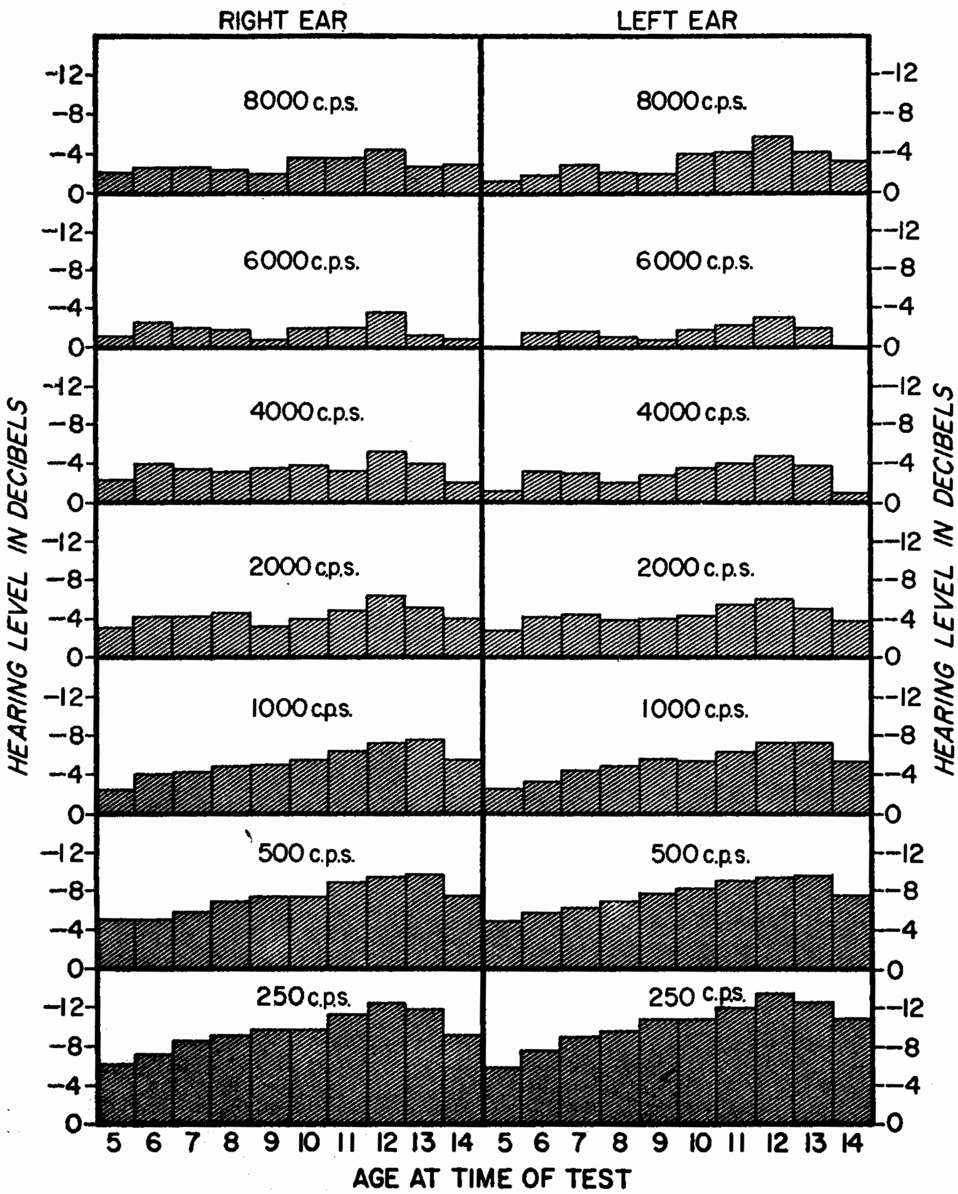


FIGURE 2. Mean hearing levels of 2175 children aged five to 14 years in an otologically normal population by frequency and ear. Hearing levels are given in db re audiometric zero, American Standard.

of children with otological abnormalities who have hearing levels less sensitive, or higher, than 15 db above audiometric zero is approximately 4% at 250 cps. This percentage increases to 18% at 8000 cps. No more than 10% of the children with otological abnormalities had hearing levels less sensitive than 15 db above audiometric zero in the speech range.

The distribution of hearing levels by age in the otologically normal children is illustrated in Figure 2. This distribution shows a trend of increasing sensitivity from five years of age to the greatest hearing sensitivity in children who were 12 and 13 years at the time their hearing level was determined, followed by a decrease in sensitivity at ages 14 and 15. The reasons for this trend are not fully understood at this stage of the analysis of the data and will be sought as the study progresses. It has been suggested, however, that part of the increased sensitivity with age may be explained on the basis of the behavior of the child. Another suggestion has been that at low frequencies, where this trend is most marked, the fit of the earphone is critical and that in younger children earphone leaks may be greater due to the shape of their skulls. It is felt, however, that the earphone leak is only roughly correlated to head size. No explanation is offered at this time for the drop in sensitivity following the peak at ages 12 and 13.

When the hearing levels in the otologically normal group are distributed by sex, it is found that at 11 and 12 years of age females show more sensitive hearing levels at all frequencies than males and, in the groups younger than these, the levels are similar for both sexes. Females show their most sensitive hearing levels at 12 years of age while males show peak sensitivity later, at age 13.

As stated previously, the data presented in this paper are preliminary findings. The analysis of data is proceeding and will be reported elsewhere. Certain additional findings, however, may be described briefly. For example, those children who have had two reliable hearing level determinations have significantly lower hearing levels on the second test. No significant differences in hearing levels are found between right and left ears on a group basis. The differences between hearing levels of white and non-white children do not appear to be significant. Mean hearing levels show variation by month, being somewhat higher in those months in which respiratory infection and allergic reactions are more common.

Discussion

At the time of their hearing level determinations and otoscopic examinations the study children were in attendance at school and functioning as children without known illness; they had no work experience and presumably no undue exposure to noise. This study differs from a number of comparable studies in that the population was unselected, of a younger age-group, and composed of untrained listeners. Testing was carried out throughout the entire year and special attention was paid to equipment and procedures.

A norm on reference hearing level has not yet been established for children in this study. It will be established after the investigation of as many as possible of the factors which may influence this reference level. The data presented, however, clearly indicate that this norm is significantly lower than the reference level currently in use.

The implication of findings of this study with respect to identification audiometry should be considered in relation to desired goals. If the goal is to identify children with a hearing problem which is functionally handicapping, the implications will differ from the situation in which the objective is to locate children with a medical or health problem. The goals dictate the details of practices, procedures, and personnel to be used in identification audiometry.

Screening levels currently employed in audiometry at 15 and 20 db above audiometric zero, and sometimes higher, appear to be determined partially by recognized existing noise levels in typical school situations. The screening level of 15 db has been generally recommended because it appeared to be the lowest that might be realistically achieved. Since it is now clear that the hearing levels of children are significantly lower than has been assumed, the result has been that many school audiometric programs may have measured the ambient noise levels, when attempting threshold measurement, rather than the hearing levels of the children. If this is the case, these programs have grossly underestimated the hearing sensitivity of the children tested.

It is admitted that identification audiometry as now practiced locates many children with functional handicaps. Is it important, then, to consider the hearing levels of children below a handicapping level, whatever this may be? It is felt that it is of prime importance to realize the low levels at which most children hear and that a child can have a great decrease in hearing sensitivity or threshold shift, indicative of underlying pathology, without the decrease being detected by present identification audiometry. If we are to detect the child with decreasing hearing sensitivity, and thus be in a better position to prevent hearing loss and conserve hearing, we must have a baseline from which to measure a decrease in sensitivity and we must not be satisfied with identifying that child only when a hearing loss becomes handicapping.

Reference is made to a hearing loss which becomes a handicap. In this connection, a definition is needed for a screening level for children with hearing handicaps. Clinically we may be able to define the extremes of 'handicapping,' but between these extremes an area exists in which it is difficult to make decisions as to what constitutes 'handicapping.' In this area there may be a significant deviation from the norm which is handicapping to one child and not to another. The problem of handicapping hearing loss needs further serious study and clarification.

Audiometric screening methods used to detect handicapping hearing loss are also being used currently for health screening purposes. The data from this study show that screening audiometry for handicapping hearing loss uncovers only a small percentage of children with demonstrable otoscopic abnormalities. The missed cases will include both active and inactive pathological conditions. Active pathological conditions need treatment, and once the condition has become inactive, medical supervision and guidance are still needed in varying degree and for different periods of time. Audiometry, as one of the methods of identifying ear problems needing medical attention, has stringent demands put upon it in respect to acoustic environment, equipment, and personnel.

The acoustic environment which must be attained if hearing levels are to be determined at low levels with accuracy has been specified (*1*). From experience gained in our study and from other sources it is known that many commercially available audiometers do not measure hearing levels with accuracy at the low levels at which children hear. It was learned that audiometers can be modified to correct this defect in linearity and that it is possible for audiometers to meet the American Standard Specification.

The goals desired for identification audiometry will dictate the procedures needed for their attainment. An initial decision must be made with respect to the goals, and then a subsequent decision made as to whether the procedures are feasible and practical. If any compromise is to be made, the limitations imposed upon the identification method should be clearly understood.

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Members of the Subcommittee on Hearing in Children: Raymond E. Jordan, M.D., Chairman, Clinical Professor of Otology, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania; John E. Bordley, M.D., Professor of Laryngology and Otology, The Johns Hopkins University School of Medicine, Adjunct Professor of Environmental Medicine, The Johns Hopkins University School of Hygiene and Public Health, Baltimore, Maryland; Victor Goodhill, M.D., Professor of Surgery (Otology), University of Southern California, and Consultant to John Tracy Clinic, Los Angeles, California; Hollie E. McHugh, M.D., Associate Professor of Otolaryngology, McGill University, Montreal, Canada; S. Richard Silverman, Ph.D., Director, Central Institute for the Deaf, Professor of Audiology, Washington University, St. Louis, Missouri.

Consultants to the study from the University of Pittsburgh include Isidore Altman, Ph.D., Professor of Medical Statistics; Leo G. Doerfler, Ph.D., Professor of Audiology; Raymond E. Jordan, M.D., Clinical Professor of Otology; and Samuel M. Wishik, M.D., M.P.H., Professor of Maternal and Child Health.

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Reference

1. American Standard Criteria for Background Noise in Audiometer Rooms, S3.1-1960, American Standards Association, 10 East 40th Street, New York 16, New York.

Appendix C

Steps toward an International Audiometric Zero

J. DONALD HARRIS

At this moment the question is being discussed in many laboratories and clinics in many countries as to what should be the definition of 'normal hearing.' Many conditions have to be specified in this definition, for example, the selection of subjects, the frequencies to be considered, the exact psychometric method of determining an individual's absolute threshold at any frequency, the statistics used to denote central tendencies, and the equipment used, including the calibration of that equipment.

A committee of otologists, audiologists, physicists, psychologists, electrical engineers, and manufacturers' representatives appointed by the American Standards Association (ASA) is now completing an exhaustive revision of the ASA specifications for audiometers of all types, and the International Standards Organization (ISO) is also in the last stages of a draft on the same subject. Much of this material will modify in minor ways, if at all, the specification now extant (*9*).

However, one rather serious discrepancy exists, between the sound pressure levels (SPLs) for audiometric zero ('0') as now stated by existing ASA specifications and the SPLs being strongly recommended by current drafts circulating within the ASA and ISO committees. Inasmuch as the new suggested '0' would have the effect of adding about a 10-decibel hearing loss to all audiograms in this country, a rather extensive discussion should be had before final voting action is taken, and all affected groups should be presented with some of the facts and reasoning behind this rather drastic recommendation. It is the purpose of these remarks to review briefly the history, and probable future status, of the SPLs specified as '0 Hearing Loss' on American audiometers.

'Normal Threshold'

As soon as audiometers were invented in the early 1920's the question arose: 'What is normal threshold?' The question was answered by the manufacturer in each case: a group of people stated to have normal hearing by an otologist was simply run on the instrument, at a wide selection of frequencies, and the modal threshold value was fixed as '0' on the hearing loss dial at each frequency.

In 1938 the U. S. Public Service released bulletins (*2*), summarizing a large number of audiograms taken at many points over the country, using 17 Western Electric Model 2A audio-

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meters and 31 audiometrists. Certain data were averaged from both ears of 1242 persons, aged eight to 76 years, normal by clinical examination, with history of no loss for speech in either ear, and whose air conduction audiograms for both ears did not exceed a variation of 20 db. The mean thresholds for these 2484 ears were stated in terms of voltage delivered to the Type 552 earphone.

Shortly after this information was available, a much improved earphone was produced, the W.E. Type 705A. Three of the most stable phones of this type were compared at the National Bureau of Standards with the Type 552 units, by loudness balancing using six observers and three loudnesses (threshold, 20 db, and 40 db over threshold). The voltages at the 705A terminals were thus found which produced the equivalent threshold SPL of the Type 552 phones.

The development of the Type 9A 6cc brass coupler at NBS provided a way to pass from earphone voltage as a standard, to acoustic output in a standard cavity the volume of which has an impedance approximately equal to the equivalent volume of the ear. This includes the volume behind the tympanic membrane. The 705A earphone is placed at one end of the cylindrical cavity, and a sensitive microphone, the W.E. 605AA, calibrated in dynes/cm², is placed at the other end. Proper acoustic seals and precautions against vibration are maintained. Threshold voltage is then applied to the terminals (or usually 60 db above threshold voltage), and the SPL in the cavity is read with the microphone. By this technique the NBS is able to state 'normal hearing' as the acuity of an observer whose threshold is reached when the acoustic output of the W.E. 705A phone is such as to produce the following SPL in the 9A coupler:

CPS	*SPL in db re .0002 dyne/cm²*
125	54.5
250	39.6
500	24.8
1000	16.7
2000	17.0
4000	15.1
8000	20.9

Note: Original data were at octaves of 128 cps; data for octaves of 125 cps were obtained by graphic interpolation.

The great advantage of this standard is that a laboratory or clinic need not actually have on hand one of the three standard 705A earphones, now reposited at the NBS, with which to compare its own equipment, but can utilize a 9A coupler to transfer standards to its own 705A phone, and thence, by loudness-balancing, to any other earphone, or earphone-cushion combination, for which the 9A coupler is appropriate.

All audiometers now used in standardized audiometry in this country use earphone-cushion combinations for which the SPLs have been adjusted, by loudness balancing, to equivalence with the mean of the hearing of 1242 persons in the USPHS study of 1938.

Reasons for Dissatisfaction

From the very first, however, some dissatisfaction was felt with the USPHS norms. Bunch (*3*), for example, with probably the most extensive clinical experience in the country, set his own 'normal' at intensities up to 10 db fainter than the present standard at the higher frequencies. It is well known that the average hearing of those in the age group 20-29, tested at the 1939 New York World's Fair (*10*) was, at 3520 and 7040 cps, up to 10 db better than the same age group tested by the USPHS—even though the World's Fair study included some ears known to be seriously defective. Luscher and Zwislocki (*8*) stated that their American audiometers yielded values, on supposedly normal-hearing individuals, of 10 and 15 db fainter than our American standard.

The problem was brought to attention, and a call for international agreement put forth, by Dadson and King (*5*), who examined 99 otologically normal men 18-25 years old. Their data, purporting to compare their thresholds with those of the ASA specification for audiometric '0,' seemed to them at first look to show the American audiometer to be too loud by more than 20 db at some frequencies.

There is now no doubt that the British thresholds are fainter than the American standards, but the divergences are now understood to be much less than the 20-25 db originally reported. In the first place, the large discrepancies were founded on probe tube measurements of SPLs at the entrance to the external auditory meatus; in such work there are still some unexplained differences in probe tube microphony between laboratories. In the second place, Dadson and King slightly misread the ASA specifications: they assumed that the '0' in these specifications was based upon a sample of 342 men, aged 20-29, clinically normal and with normal hearing for speech; *but audiometric data did not enter selection of this sample*. These 342 men were drawn, not from the 1242 individuals on whom American 'normal hearing' rests, but from the much larger group of 4662 persons with normal hearing for speech, but not necessarily with no audiometric variation greater than 20 db. Of this 4662, only 1242, or about 26%, could meet this additional audiometric requirement, and the hearing of the 684 young men was actually worse by 5-6 db at 4096 and 8192 cps than that of the 1242 persons of all ages.

It is clear that a basic population should be unselected except that known hearing defects should be eliminated. It seems to the writer that there is no especial reason why one should not accept the definition of the 1242 persons in the survey as unselected, if one wishes to obtain an average for a very wide range of age, exposure to noise, medical history, intelligence, anxiety in a clinic, and a whole host of other factors which might influence threshold data. The only difficulty was that individuals of advanced age, with a certainty of some presbycusis, were included. Unfortunately the Public Health report never gave the mean thresholds for those persons aged 20-29 who formed their fraction of the total 1242 persons. If one had these figures, the writer would look no further for an unselected population upon which to base audiometric zero.

Other Surveys

In the face of these uncertainties, a

TABLE 1. Amounts (in db) by which average thresholds reported in four audiometric surveys were found to be fainter than present audiometric '0.' Data have been rounded to nearest 0.5 db.

CPS	*Surveys*			
	Harris (7)	*Corso (4)*	*Albrite (1)*	*Glorig (6)*
250	10.5	14.5	12.5	11.5
500	6.5	14.0	12.5	11.5
1000	6.0	11.0	7.5	8.0
2000	5.0	10.5	5.5	6.5
4000	—1.0	3.5	0.5	3.0
8000	8.0	12.0	5.5	10.5

number of steps were immediately initiated. Harris (7), Corso (*4*), Albrite (*1*), and Glorig (*6*) published audiometric surveys to throw additional light on norms, while the NBS exchanged phones for loudness balancing at the National Physical Laboratory under Dadson.

The best data which should be drawn on for the purpose are, in the writer's opinion, those of Glorig taken at the 1955 Wisconsin State Fair. He had many ears tested in the most approved fashion and used subject selection, retesting, and training covering the field thoroughly. His data are certainly exhaustive.

To show how such data from several laboratories agree that the current ASA specifications are too lenient, data presented in Table 1 indicate the amount by which the average thresholds were fainter than present audiometric '0.'

It would seem clear from these four independent surveys, on untrained subjects, that routine audiometry can with only a minimum of extra care yield average thresholds which are fainter by significant amounts, except perhaps at 4000 cps, than present standard thresholds. It would seem that the more stringent calibration of the old Western Electric 2A audiometer and the then contemporary Sonotone model may have been right after all!

A word should perhaps be said about other surveys which have corroborated the present zero. Data from the San Diego County Fair (*11*), the 1954 Wisconsin State Fair (*6*), and the New York World's Fair (*10*) all show averages worse or at least no better than audiometric zero. However, as in the 1955 Wisconsin State Fair, when only reasonable precautions are taken, better thresholds are always forthcoming.

Evidently, then, the present American standard is an approximately correct statement of the hearing of large populations unselected for age, previous hearing history, etc., and with only perfunctory audiometric indoctrination, but this is not to say that these large routinely-handled populations, with undoubted hearing defects, should serve to characterize a standard for unimpaired hearing.

Relative Values

In the matter of setting standards, it is necessary to balance one good against another. To keep the present

TABLE 2. Comparison of present and proposed audiometric '0's.'

CPS	*'0' in SPL by ASA*	*Proposed '0'*	*Proposed Shift in db*
125	54.5	49.0	5.5 fainter
250	39.6	27.0	12.6 fainter
500	24.8	12.5	12.3 fainter
1000	16.7	8.0	8.7 fainter
2000	17.0	10.5	6.5 fainter
4000	15.1	11.0	4.1 fainter
8000	20.9	9.5	11.4 fainter

standard is to maintain the rehabilitation load as we know it today; to adopt a more stringent standard would have the effect of earlier identification of defects. A child with a loss of, say, 5 db at 500 cps is now thought to be perfectly normal within limits of experimental error, but upon adoption of the standards implied in the table above, that child would be seen to have in reality a loss of 15 db, and to warrant immediate close observation. If many children exhibited such losses, then the workspace, or the technique, or the equipment would be laid under suspicion; thus a general improvement in audiometry would result.

In the almost unanimous opinion of bodies now deliberating, these two benefits outweigh rather heavily the advantage of retaining the present standard, which has only the effects of condoning laxity and of deferring (at the expense, it may be, of the patient's well-being) the initiation of therapy.

Once it is agreed that present standards should be changed in the direction of greater stringency, the exact amount of the shift must of course be determined. For this purpose it is wise to commandeer the widest possible thought and to utilize the data with the greatest generality. This can only mean that the appropriate international body, the International Standards Organization, should be posed the problem.

Current Developments

At this time the ISO Technical Committee No. 43 considering audiometric reference zero has just about completed its deliberations, and drafts of standards are being prepared for letter ballot. Earphones have been exchanged and directly compared by loudness balancing at standardizing laboratories in America, England, West Germany, France, and Russia, and the reference zeroes for each earphone scored in terms of SPLs in a closed acoustic coupler. These reference zeroes as presently proposed are derived from a total of 13 independent threshold determinations, four in the U.S.A., three in England, two in France, one in Germany, and one in Russia.

When the proposed reference zeroes are expressed in terms of SPL generated in a 9A coupler by a W.E. 705A earphone, the proposed shift of '0' on the audiometer is seen to change by up to 12.6 db (Table 2).

These figures, with perhaps very minor changes, will in all likelihood be adopted by the ISO in the coming year, perhaps at Helsinki in June of 1961. It then remains for national standardizing groups, such as the ASA, to decide whether to adopt them.

There is, of course, no absolute necessity for the ASA to adopt ISO recommendations in detail. It would be entirely possible for the ASA to shift present '0' by exactly 10 db at all frequencies; the few dbs of violence done to the ISO recommendations might well be counterbalanced by the ease of simply shifting the '0' by one division on the audiogram card.

The trend of present discussion within the ASA is, however, to go along with the final ISO decision. After a transition period during which one would have to specify the zero used in reporting audiograms, the ISO SPLs should be as easy to maintain as the present figures, and no violence would be done to the most accurate placement of zero at any frequency.

References

1. Albrite, J. P., Shutts, R. E., Whitlock, M. R., Cook, R. K., Corliss, E. L., and Burkhard, M. D., Research in normal threshold of hearing. *Arch. Otolaryngol.*, 68, 1958, 194-198.
2. Beasley, W. C., National Health Survey (1935-36), Preliminary Reports, Hearing Study Series, Bulletins 1-7. Washington, D.C.: U.S. Public Health Service, 1938.
3. Bunch, C. C., *Clinical Audiometry*. St. Louis: C. V. Mosby, 1943.
4. Corso, J. F., Proposed laboratory standard of normal hearing. *J. acoust. Soc. Am.*, 30, 1958, 14-23.
5. Dadson, R. S., and King, J. H., A determination of the normal threshold of hearing and its relation to the standardization of audiometers. *J. Laryngol. and Otol.*, 66, 1952, 366-378.
6. Glorig, A., Quiggle, R., Wheeler, D. E., and Grings, W., Determination of the normal hearing reference zero. *J. acoust. Soc. Am.*, 28, 1956, 1110-1113.
7. Harris, J. D., Normal hearing and its relation to audiometry. *The Laryngoscope*, 64, 1954, 928-957.
8. Luscher, E., and Zwislocki, J., The international standardization of audiometry. *Acta Oto-laryngol.*, Suppl. 64, 1948, 26-35.
9. Minimum requirements for acceptable pure tone audiometers for diagnostic purposes. *J. Am. med. Assoc.*, 146, 1951, 255-257.
10. Steinberg, J. C., Montgomery, H. C., and Gardner, M. B., Results of the World's Fair hearing tests. *J. acoust. Soc. Am.*, 12, 1940, 291-301.
11. Webster, J. C., Himes, H. W., and Lichtenstein, M., San Diego County Fair hearing survey. *J. acoust. Soc. Am.*, 22, 1950, 473-483.