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Proposed program for the early identification of hearing-impaired infants

Lee Elizabeth Shideler

The University of Montana

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A PROPOSED PROGRAM FOR THE EARLY IDENTIFICATION
OF HEARING-IMPAIRED INFANTS

By
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B.A., University of Montana, 1970

Presented in partial fulfillment of the requirements for the degree of
Master of Arts
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1972

Approved by:

[Signatures]
Chairman, Board of Examiners
Dean, Graduate School
Date
ACKNOWLEDGEMENTS

The initiation and accomplishments of the program described in this study have been attained only through the cooperative and generous efforts of the Missoula physicians, the administrative and nursing staffs of St. Patrick and Missoula Community Hospitals and the author's advisory committee. Very special appreciation is extended to Dr. James Law, who has so unselfishly contributed his time and skills in support of the program. Particular thanks is due Dr. Charles Parker, whose guidance and concern have been a continuing source of encouragement for the author.
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CHAPTER I

INTRODUCTION

There is little disagreement concerning the need for early identification of hearing loss in infants. Glorig (1965) states that hearing impairment should be detected before six months of age "so that medical or educational therapy can be initiated." Davis (1965) reported that most of the participants in a conference on hearing conservation agreed that the first year is probably critical in determining the speech and language development, but that "there is no clear evidence that a delay of six months is critical from the point of view of development of language." In general, most educators and audiologists emphasize the importance of initiating habilitative procedures as early as possible in order to develop residual hearing and maximize normal social, speech, and language development (Pollack and Downs 1965). This necessitates an effective screening program aimed at selecting those infants with probable hearing impairments, to be administered within the first few weeks of the infant's life.

The Problem and Purpose

Downs (1967) felt that the most logical approach for early identification of hearing loss would be mass screening of infants in the hospital nursery, since at this time there is a large number of infants, centrally located among professional persons who could
efficiently administer the proper testing procedures. Her program
(Downs and Sterritt, 1967) was instigated in Denver, Colorado,
employing extensive routine screening of newborns. Ten thousand
infants were screened and 150 of these were suspected of having
hearing impairments. Further audiological evaluation of these 150
infants "revealed 4 with 'true hearing impairments', 3 of whom
were in the "at risk" category.¹

In 1970 Downs compiled data from programs presently underway
in this country and Canada to identify hearing loss in newborn infants.
Of the 61,530 screened infants, 31 were reported to have confirmed

Other than these above mentioned data, there appears to be a
paucity of programs initiated specifically for early identification
of these hearing-impaired infants. However, when there has been
wide scale screening of newborns, it seems there has been much time
and effort expended, resulting in a relatively small number of
positive identifications (Downs, 1970, Altman and Shenhav, 1971).

Goldstein (1971) has reviewed the Downs and Sterritt program
and accounted for the high number of false positives by possible
"conservatism" on the part of the examiners. Infants having normal
hearing were mistakenly included in the "hearing-impaired" category
because (1) the response criteria were ambiguous and (2) possible

¹The particular family and/or medical history or pre- and perinatal
conditions would lead one to expect a higher than normal probability
that these children would have hearing impairments. Throughout the
remainder of this study, the phrase "at risk" shall convey this meaning.
habituation to the repetitive test tone resulted in a failure to respond. Additional inadequacies in Downs' and Sterritt's procedure as discussed by Goldstein are (1) that the 90 dB 3000 Hz tone may cause a response in infants with severe losses who recruit, (2) a tone of 90 dB may still result in a positive response in children with mild to moderate losses, (3) a child with a unilateral loss will still respond and (4) degenerative hearing losses are not detected, since children with such losses often respond normally to sound within the first few weeks, are consequently thought to have normal hearing, and are not followed up.

The identification of four hearing-impaired infants in Downs' study, three of whom were at risk is indicative that utilizing an at risk check list may be a productive means of initially selecting these infants with probable hearing impairments (Black et al., 1971). Bordley and Hardy (1972) also state:

...there is a considerably higher instance of hearing impairment in the offspring of high-risk population; therefore we recommend the development of high-risk registries...where such offspring could be flagged for special observation. (p. 353)

Black and colleagues (1971) have compiled a "High Risk Check List" at the University of Colorado Medical Center for identification of infants with hearing impairments. This check list, however, having been designed at and for use in a highly specialized, medically-oriented training center was not thought practical for utilization in

\[\text{2}^{\text{High risk and at risk are used interchangeably in current literature, the latter being the accepted terminology in Britain, where such programs have also been developing.}}\]
the more traditional smaller community environments, such as Missoula and Western Montana; it was felt the professional resources of the community were too fragmented and functioned in a less specialized and integrated capacity than this check list required. Because of the problems inherent in newborn screening and in utilization of the only available at risk check list, and because of the tremendous need to attempt early identification of children with hearing impairments, the author initiated an experiment to:

(1) modify the High Risk Check List compiled at the University of Colorado Medical Center by Black and colleagues

(2) employ the modified check list on an experimental basis in the city of Missoula, Montana, to initially identify possible hearing-impaired infants in the hospital nurseries

(3) institute routine audiometric follow-up for these possible hearing-impaired infants

(4) initiate a program of education for physicians and hospital personnel concerning the need for early identification of hearing impairments and their concomitant handicaps and

(5) outline procedures for long-range continuation and evaluation of the program of hearing loss identification and medical and rehabilitative referral in the city of Missoula.
CHAPTER II

EXPERIMENTAL PROCEDURE

A two and one-half month experimental program has been developed and initiated cooperatively between St. Patrick and Missoula Community Hospitals, the city and county physicians practicing in infant and child care and the Department of Speech Pathology and Audiology at the University of Montana to Determine the feasibility of utilizing an at risk register as a means of screening and identifying hearing-impaired infants. This experimental procedure will be reviewed in approximately six months with the pediatricians to determine if any significant changes in procedures should be made. The study as described in this writing served as the initial phase of a continuing identification program to be reviewed at the end of one year. At that time, it is hoped that its success will merit the approval of a five-year longitudinal study to determine the long-range effectiveness of this kind of early identification of hearing-impaired infants and young children. The author conducted several meetings with a committee composed of a pediatrician, a speech pathologist, two audiol-ogists and a clinical psychologist to: (1) develop a modified at risk check list which can be used as a screening device in a rural-urban area such as that served by the health professionals of the city of Missoula, (2) to outline the procedures to be followed in the administration of the check list, and (3) to outline procedures to be used in identification and follow-up of the at risk infants.
Development of the Modified At Risk Check List

The check list compiled by Black and colleagues at Denver consists of numerous entities which, through clinical observation, have been shown to be concomitant with hearing loss, if only occasionally:

I. Overt (genetic)
II. Occult (genetic)

Abnormalities that can be identified or suggested only by:
1. special physical examination
2. family history

III. Congenital acquired deafness of prenatal, perinatal, or neonatal origin. (p. 31)

Downs (1970) reported that failures of at risk programs in the past can frequently be attributed to the fact that too much time is required of the physician in acquiring and recording the necessary information on each infant; therefore the author felt it imperative to keep the time contributed by the infant's physician at a minimum. An additional consideration was to insure that the list remain as comprehensive as possible without overburdening any individual involved in the data gathering. It has therefore been decided with advisory committee approval that the check list be divided into three sections (see Appendix A): the first to be completed by the obstetric nurse while the newborn is in the nursery, the second section to be completed by the mother during her postpartum hospital stay, the third section (the responsibility of the infant's physician) to be completed ideally at the time of the infant's first physical examination, approximately six weeks. As this at risk register has been developed, the infant's physician has three months from the child's birth date to gather the data that he contributes on each
infant, although it is anticipated that his contribution will be made at the first office examination and by the time the infant is approximately six weeks of age.

The basic categories of the Colorado High Risk Check List as suggested by Black et al. (listed above) have been retained, but the general consensus was that the specific subdivisions of each category outlined in the check list be omitted, as their inclusion lengthened the list and did not significantly contribute medical information useful in categorizing the infant. Another deviation from the original list involved incorporating some of the less medically-oriented questions, which were more related to familial history, into the mother's section. This was done primarily to reduce the time required by the nurse in filling out her section of the list. While the basic concept of Black's High Risk Check List has been retained, the information will be gathered from three sources instead of just from the physicians, each section has been developed to a length deemed acceptable to the individual contributing the information, and each section has been vigorously screened to retain questions most pertinent to the immediate purposes of the study.

As the check lists are compiled on each infant, they are being reviewed independently by the infant's physician and an audiologist in terms of at risk indications for hearing loss. All at risk infants are to receive audiological assessment, including long-term follow-up until hearing acuity is considered to have been validly evaluated. Appropriate habilitative measures including parent counseling will follow.
Referral Procedures

The first two sections of the check lists compiled on each infant are gathered by the author at the respective hospitals, and are reviewed by an audiologist at the Speech and Hearing Clinic in terms of at risk indications. After being photocopied they are entered in an "Initial At Risk" or "Initial Non-At Risk" file and the duplicates are mailed to the infant's physician. The uncompleted third portion of the at risk check list for which the physician is responsible is enclosed with these photocopies, and he has been asked to return a duplicate of this third section to the Speech and Hearing Clinic as the infant's physical examination is completed. This procedure has been designed to allow both the physician and the Speech and Hearing Clinic to have all the information gathered concerning a child's suspected hearing loss. (The physician's section has been printed on NCR duplicate paper.)

After reviewing the data available to him, the physician has been asked to indicate on his section whether or not he feels the child is at risk for hearing loss. If the physician feels that upon subsequent examination the infant has developed indications of an at risk nature, such as signs of a progressive deafness as discussed by Black et.al. (1971) and Davis (1965), it is expected that he will make the appropriate referrals so that the infant can be integrated into the audiological program at the Speech and Hearing Clinic. Categorizing the infant remains subjective on the part of both the physician and the audiologist, in that there is no pre-determined number or type of category which, if checked as "positive," implies that the infant is at risk. All infants considered by the physician to be at risk are
being scheduled for audiological testing at the Speech and Hearing Clinic. If the audiologist at the Speech and Hearing Clinic categorizes an infant as at risk where the physician has not done so, the audiologist consults with the physician to discuss his reasons for considering the infant to be at risk. Categorization of the infant to at risk is changed if the physician agrees to such change and supports the need for audiological assessment of the infant. The infant's file is then transferred to the "Final At Risk" or "Final Non-At Risk" section.

Filing Procedures

At the Speech and Hearing Clinic the data gathered on each infant born in the Missoula hospitals is kept in the above-mentioned At Risk File. This file is composed of three major divisions, the first contains the names of all infants born at both hospitals. This section has been organized alphabetically and chronologically to facilitate identification of those infants for whom all data has not been received by the time the infant is three months of age. In those instances, the physician is contacted and asked to send his portion of the check list to complete the infant's file if his physical has, in fact, been administered. The second section, the "Initial At Risk" and "Initial Non-At Risk" section is an "inactive section where the check lists are filed until all data is gathered on a particular infant. As all the information on an infant is compiled, his folder is transferred to the third section, a "Final At Risk" or "Final Non-At Risk" file, and attended to accordingly. It is recognized that optimum performance of the program may not be achieved; there will be
instances where an infant's check lists may never be fully completed or whose families may be unable or unwilling to pursue the follow-up audiological testing as outlined in this writing.

The author has instructed a departmental secretary in the filing and referral procedures to be followed for the next year, as previously described. These procedures have been specifically outlined in written form and filed in the clinic for general reference (see Appendix B).

The proposed check list and procedures which were developed by the author with the approval of her advisory committee was submitted for endorsement at a meeting of the Missoula pediatricians and physicians practicing in infant and child care, and two representatives from one of the hospital administrative staffs. The author consulted informally on several occasions with the second hospital's staff to discuss the procedures which were proposed. The ensuing suggestions and concerns were discussed with the advisory committee, appropriate modifications were made, and all parties endorsed the check list and procedures as indicated in this writing.

**Audiological Testing and Follow-Up**

With the approval of their parents and physicians, all at risk infants between two and four months of age are scheduled to receive initial audiological assessment at the University of Montana Speech and Hearing Clinic. Follow-up testing will be administered at the discretion of the audiologist until substantive data indicates the nature of the child's hearing acuity.

The audiologist responsible for parental counseling will need to be sensitive to the parents' anxiety concerning their child's hearing.
It is of great importance that he communicate to the parents at the first meeting that the hearing tests are being administered to verify normal hearing in their child and to insure that any possible incipient or progressive hereditary loss will be identified. By no means should the parents be led to believe their child is hearing-impaired until such time as there is sufficient audiological data to support this suspicion; incidentally, the infant's physician is also provided copies of the audiological reports after each evaluation and will aid in parental counseling whenever appropriate.

Behavioral tests are utilized as the primary means of hearing evaluation for the infant between two and four months of age. It remains to be proven that any test administered at this age is a valid measurement of hearing impairment (Bordley et al., 1971). A longitudinal study undertaken at Johns Hopkins University by these authors beginning in January of 1968 revealed:

..198% failing an audiometric screening test at eight years gave normal responses...during the newborn period. (p. 353)

However, although it may not measure degree or type of auditory impairment or determine auditory thresholds, this type of test can identify the more severely impaired infants who will require immediate habilitative measures. Calibrated noisemakers such as bells, clackers and the Phonic Ear Infant Audiometer have been found to be effective means of eliciting a Moro reflex, which should be clearly identifiable at this age (Altman, et al., 1971). Rose (1971) reports:

This reflex is characterized by an extension of the arms with the spreading, adduction, and half-flexion with the fingers and an extension of the legs and toes. (It) usually consists of symmetrical and consecutive outward,
upward and inward grasp motions of the arms with crying often accompanying them. (p. 382)

Pure tones are also being utilized to elicit startle responses.
The acoustical-palpebral reflex, which is observed as a quick opening and closing of the eyelids after a loud acoustic stimulus, is also being utilized as a means of identifying the more seriously hearing-impaired infants. In addition to the gross behavioral testing, the mother is questioned at each visit with regard to her observations and impressions of her child's hearing acuity, reflected through his response to sounds in the home, and his use of jargon and babbling.

At approximately six months of age behavioral audiometry is employed in conjunction with electric response audiometry (ERA).

Gesell and Armatruda (27) indicate that after two-three months, the infant is no longer as responsive to very loud sounds and seems to assume a listening or attentional posture in the presence of loud sounds. As maturation continues into the fourth or fifth month, the infant may respond to sounds with a change in facial expressions, and within a few weeks an attempt to localize is evident. (Rose, 1971, p. 379)

A report on ERA Testing in Neonates by Engel from the ERA Study Group in December 1971 states:

...the newborn is an excellent subject for ERA. If we could know only early in life which child is highly suspect of a hearing loss, we would be well advised to test him early, because we don't have to worry about sedation in early infancy. (p. 60)

At nine months and twelve months behavioral audiometry and ERA are employed routinely to all at risk infants still being examined. By nine months, the normal child will have begun to initiate sounds, and at a year the child should begin to demonstrate comprehension of simple commands and to use single words meaningfully, such as "bye-bye, mama, dada, etc." He should also be able to localize sound and
turn his eyes or head towards the direction of the stimulus source. (Rose, 1971). Pure tones should be effective in eliciting listening behavior at this time. Ideally through the at risk program the hearing-impaired infants will have been identified by this age. For children two years and older who for various reasons are integrated into the program at a later date, play audiometry and ERA will be employed. ERA will not be attempted if other tests suggest hearing to be within normal limits. Play audiometry might be defined as a technique developed to attract and hold a child's attention while attempting to test (Rose, 1971). Examples are: conditioning the child to pure tones by having him drop objects into a play house upon hearing a tone, having him point to the ear in which he hears a tone, giving him simple commands such as "Show me you nose" or requiring the child to point to a particular picture placed among several pictures, the requests given by the examiner at various intensity levels. Both pure tones and speech stimuli can be used to elicit responses from the child.

Impedance testing, pure tone air and bone testing by ERA and familial history of congenital conductive impairments may suggest the possibility of a conductive component to an infant's hearing loss. Any child suspected of having a conductive impairment is referred for medical and/or surgical treatment before being considered a candidate for amplification. When the need for amplification is indicated, the child is fitted for an appropriate hearing aid as soon as possible and the parents are counseled so that they may aid in realistically guiding their child towards the most normal speech, language and social development possible.
CHAPTER III

EXPERIMENTAL PROGRAM

Pilot Study

Before the experimental program officially began, the author initiated a ten-day pilot program in the two hospitals in order to assess any problems encountered by the obstetric nurse or the mother in completing their respective portions of the at risk check list. Physicians had previously approved their section of the check list in the meeting described on page 10. Data was collected on twenty-nine infants; the obstetric nurses completed their portion and also attended to any questions raised by the mothers concerning their section of the at risk check list. Of the twenty-nine births surveyed in this initial pilot program three were felt by the obstetric nurse to be at risk, and were so indicated on the infant's at risk check list. These three infants have been brought to the attention of their physicians. At the termination of the pilot study the author conferred with the obstetric nurses of the respective hospitals regarding any difficulties in the administration and interpretation of the nurse's or mother's sections of the check list.

Nurses in both hospitals reported that about ten minutes were required to complete their section and made minor recommendations for changes in the pilot check list. Their suggestions were reviewed by the author and the advisory committee, at which time modifications were made again.
A letter of intent addressed to the hospital administrative staffs was written by the chairman of the Department of Speech Pathology and Audiology describing the purpose of the proposed program and the responsibilities assumed by that department (see Appendix C). It was recognized that the department will be involved in the testing and social, educational and habilitative planning for each individual child and that the program will be subject to a joint yearly review by hospital administrative personnel, physicians, and the Department of Speech Pathology and Audiology.

Study Program

Following this pilot study a full scale program was initiated. As of June 1, 1972, data has been compiled on 87 infants born since April 4, 1972, in Missoula County. Pediatricians have completed and returned check lists on 30 infants at least 7 weeks old by June 1, 1972. None of the 30 infants who have completed check lists have been considered by their pediatricians to be at risk for hearing loss. However, in reviewing these check lists, the author and an audiologist consulted at the Speech and Hearing Clinic have selected 7 at risk infants. The following entities or combinations thereof are thought to be indicative of an at risk categorization of these 7 infants:

(1) Blood transfusion prior to pregnancy
(2) Abnormal presentation at birth
(3) Significant type or degree of deafness in family
(4) Respiratory distress syndrome at birth
(5) Apnea and/or cyanosis at birth
(6) Toxemia of pregnancy
(7) Submucous cleft of palate, cleft lip
(8) Ototoxic drugs taken during pregnancy
(9) Bleeding indicating threatened abortion during pregnancy
(10) Kidney infection during pregnancy
These infants and their at risk check lists have been discussed with their pediatricians and in all cases, permission has been granted to initiate audiological assessment through the Speech and Hearing Clinic. An additional 5 infants are questionable at risk cases. In these latter instances, a familial history of hearing loss has been indicated on the mother's form. Each child's physician has been contacted and asked to have the mother specify, when she brings the infant for his physical examination, whether or not the hearing loss is in the immediate family. He is further being asked to refer the infant for audiological evaluation if the familial history indicates he is at risk for hearing loss.

At the completion of the initial experimental phase of this project, the total newborn population on which all sections of the at risk check lists are completed has yielded 23.3% at risk infants. This figure compares with the 30% at risk incidence in a study by Altman and Shenhav (1971).

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3 As of June 1, the revised mother's form includes this specific question.
CHAPTER IV

PROGRAM ASSESSMENT AND DISCUSSION

The development of the particular at risk program in Missoula County has been a time-consuming, complex organizational task. It has required a degree of clinical sensitivity particularly in terms of recognizing and respecting the professional roles and responsibilities of those individuals and organizations who have been involved. The program seems to have been successful in that there has been a high degree of cooperation among the hospital staffs, the mothers and physicians in contributing the requested data. The physicians have been considerate and prompt in the completion of their portion of the check list. To date, there has been no increase of suspected hearing-impaired infants on the part of the physicians, as measured in terms of the number of referrals for audiological assessment. However, it has proved invaluable to have at hand the necessary data filed in the Speech and Hearing Clinic, so that at risk infants who may have otherwise been overlooked can still be identified through review by clinic personnel. The physicians in charge of the 7 at risk infants have been contacted personally by the author, and in all cases permission has been granted to evaluate the infants audiolgically.

An important addition to the advisory committee has been the pediatrician\(^4\) acting as professional liason between the Department of

\(^4\)Dr. James Law is a practicing pediatrician and faculty affiliate of the University of Montana.
Speech Pathology and Audiology and the medical community. His professional guidance has alleviated many problems ordinarily inherent in the organization of a program involving and depending upon the contributions of a number of individuals and professions. Procedural and organizational difficulties have been minimized because of the willingness of this physician to work in this capacity.

The need for utilization of at risk registers has been emphasized by Downs (1970), Bordley et al., (1972), Hardy, et al., (1970), Altman and Shenhav (1971) and Richards, et al., (1967). Their programs suggest that because there is a significantly higher incidence of congenital hearing loss in at risk populations this is the more accurate and efficient means for early identification of hearing impairment, as compared with mass neonatal screening in the nursery.

Black (1971) states:

A register is particularly important in congenital conductive impairments because most current screening techniques may not identify more moderate losses found in congenital anomalies or milder sensori-neural losses....The register can be useful also in identifying those infants at risk for hearing losses that will develop later in life as a result of genetic factors. (p. 1)

In the latter instance, without follow-up the loss could develop into a severe or profound impairment and not be discovered before the optimal age for language learning.

For the sake of compiling data with respect to onset of hearing loss in children, there appears to be a positive case built for utilizing a check list on neonates. Whetnall and Fry's findings (1964) compare with Davis' (1965) who stated that 30-40% of all the sensori-neural hearing losses in children are of unknown origin. He
reported that the onset of these losses have been nearly impossible to determine, since they have not been detected until long after birth. Hopefully, by beginning to document the physical conditions of children at birth through the at risk check lists, it will be possible at some future date to not only more positively identify etiologies of congenital hearing impairments, but to begin to reduce those "unknown" categories which at this time comprise such a significant percentage of hearing losses.

It is recognized that even an at risk check list will not identify 100% of the congenitally hearing-impaired infants. Carelessness in data gathering may prevent identification of some infants. In addition, up to 45% of the total number of congenital hearing impairments are recessive hereditary types and half of this number of nearly 22.15% have no associated abnormalities (Black et al., 1971). The author saw the necessity, therefore, for including a separate (mother's) section to possibly identify a family history of hearing loss. Through this section several children born in Missoula have been categorized as at risk on the basis of hearing loss in the family. John Hall-Jones (1970) categorizes a particular group of congenital deafness into the following etiologies:

<table>
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<tr>
<th>Etiology</th>
<th>Number</th>
</tr>
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<tbody>
<tr>
<td>Hereditary</td>
<td>30</td>
</tr>
<tr>
<td>Rubella</td>
<td>25</td>
</tr>
<tr>
<td>Jaundice</td>
<td>7</td>
</tr>
<tr>
<td>Prematurity</td>
<td>10</td>
</tr>
<tr>
<td>Unknown</td>
<td>24</td>
</tr>
<tr>
<td>Possible causes</td>
<td>9</td>
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</table>

(difficult labor, diabetic mother, maternal morbilli, maternal scarlet fever, etc.)

Thus, his data also support the fact of a high incidence of hereditary congenital hearing impairments, and the need for identification methods
sensitive to this etiology.

The author feels that the check lists being used in Missoula are sensitive to the known etiologies of congenital hearing loss. Downs (1970) lists the causes of hearing loss in a group of 17 infants as:

- Rubella 1
- Trisomy D 1
- Trisomy 13 1
- Lange-Nielsen Syndrome 1
- Treacher-Collins 1
- Recessive Genetic 1
- Dominant Genetic 2
- Unknown 9

She states that by the usual neonatal audiological screening, the infants with Treacher-Collins Syndrome, Trisomy 13, and one of the 2 with dominant genetic factors may not have been identified. Their losses were conductive, and they had normal hearing in the higher frequencies (the test tone characteristically administered in the nursery screening is high frequency). On the other hand, an at risk check list alone may overlook children with recessive genetic traits, such as the renal syndrome, and Lange-Nielsen syndrome (p. 1212). However, by including in the at risk check list a historical approach, such as the mother's section of this list, this problem may be alleviated or at least markedly minimized.

Of the 30 completed at risk check lists returned to the Speech and Hearing Clinic during the 2 1/2 month study program, no infants were considered by their physicians to be at risk. Audiologists at the Speech and Hearing Clinic differed in opinion on 7 cases for the reasons mentioned previously (p. 15). According to Black et al., (1971), these early infant signs imply a higher than normal probability of the
occurrence of hearing loss. It is recognized that only long-range study and follow-up will reveal those concomitant signs or disorders which in actuality accompany congenital hearing loss. However, the immediate purpose of this study is not to necessarily select those infants who have been determined to have hearing losses, but to identify those infants who are suspected of having a hearing loss by being at risk. The data to date relative to the Missoula study indicate the audiologist is more critical in observing these early signs than the physicians, and it is expected that this study will provide a common ground between the professions of medicine and audiology for determining these at risk infants and developing more effective early diagnosis and remediation.

Holm and Thompson (1971) state:

...Physicians will assist in the early identification of these (hearing-impaired) children if they:

1. recognize conditions in infancy associated with high risk of hearing handicaps. (p. 450)

Fellendorf (1970) in a questionnaire study of 260 hearing-impaired children indicated that the methods of detection of hearing impairments were reasonably prompt (50% were suspected of a loss before one year), but that physicians comprised only 7% of those persons suspecting these children of their losses. These data also suggest that the education of medical personnel and parents in the recognition of signs concomitant with hearing loss must be a serious portion of any identification program of this kind. In cases of discrepancies in judgements of at risk infants identified through this program, it is expected that an audiologist and the infant’s physician will discuss each case individually and arrive at a mutual agreement for considering him to be at
risk. It is advised that this method of recalling at risk infants for audiological assessment be evaluated at the meeting scheduled at the end of one year, to determine its effectiveness. The check lists compiled on each infant need not necessarily be limited to the identification of hearing-impaired infants. With the permission of the child's physician the data could be made available to those other professional personnel involved in the educational and social welfare of the child such as child psychologists, speech therapists, or persons concerned with treating children having various possible learning problems. Richards et al., (1967) reported:

...there is much evidence to indicate the association between neuropsychiatric disorders and many prenatal and perinatal factors, such as toxemia, low birth weight, short gestation, neonatal anoxia, and hyperbilirubinemia, some of which may co-exist. (p. 72)

Bordley and Hardy (1972) also comment:

...early (audiometric) test failure may be a warning of neurologic deficits not related specifically to hearing loss. (p. 354)

In summarizing the available information, it is evident that in order to evoke responses in early infancy, a high-intensity stimulus is required. Rose (1971) states that the sound pressure level of auditory stimuli used to evoke responses in normal hearing neonates averages 77 dB and range from 50 to 115 dB. The unreliability of neonatal testing and the difficulty involved in identifying unilateral and mild to moderate losses in early infancy is increasingly being recognized. A key advantage to at risk programs such as the one developed is that all at risk infants will be followed audiologically until such time as their hearing acuity is felt to have
been validly determined. This procedure should reduce the number of false negative identifications who, through a neonatal auditory screening program, would be dismissed as having normal hearing. Hardy et al., (1970) supports this argument with an example:

Congenital rubella is clearly a continuing chronic infection in which the virus often persists for many months after birth. It has clearly been documented that damage to the ear has been progressive after birth in some instances. (p. 1234)

Through our knowledge of the presence of hereditary progressive hearing loss, (Black et al., 1971, Davis, 1965), we can see the need for infant and early childhood audiological testing of the at risk infant. Hardy et al., (1970) also feels that "efforts are better directed to the follow-up of the high risk infant and by screening and more definitive (audiological) testing when they are three to four months of age." (p. 1234)

At six to seven months of age, the less severely impaired infants can begin to be identified, and lack of localization response at this age may indicate unilateral losses. Also, normal-hearing infants will begin turning their heads and eyes to the stimulus source which now can evoke a response at 25-30 dB above audiometric zero (Darley, 1961, Ewing, 1944, Hardy, 1959).

ERA has been shown to be a reliable method of audiological assessment at around nine months of age (Rapin, 1970). Davis (1970) suggests that valid results can be obtained on six-month-old infants; therefore ERA will initially be administered as part of a battery of tests at this age.

In summary, studies which review the types of audiological tests
to be administered to infants suggest that valid assessments can be made at an early age. The problem is obviously the fact that as audiologists and physicians we need to raise somehow the index of suspicion of infants at risk for hearing loss. In keeping with the goals of the study as outlined on page four of this writing, this writer has developed and utilized a modified check list to select infants at risk for hearing loss. This check list is based on a High Risk Check List being used at the University of Colorado Medical Center and has been modified to meet the needs of this particular study. This check list has been successfully employed on an experimental basis in this community by dividing the data gathering among the physicians, the obstetric nurses, and the mothers. Procedures to be followed in audiological testing and rehabilitation for these at risk infants have been outlined and implemented, and specific procedures for long-range continuation and evaluation of the program have been designated. These include semi-annual reviews of the procedures by the physicians, nursing personnel and audiologists and a yearly review by these persons and the hospital administrative staffs to determine the direction and continuation of the program.

It should be emphasized that the overt signs of hearing impairment are often subtle even if conductive in nature, and may not always be identified through routine otological examinations. It is important that such children are referred for audiological evaluation.

Hearing impairments which go unrecognized or which are not identified at an early age cause irreversible social and educational handicapping conditions for the child (Davis, 1965, Whetnall, et al.,
1964). The author hopes that this study will result in the maintenance of a practical, operational technique for early identification of hearing impairments in infants where rehabilitative measures can be initiated and can better insure a more normal social and educational orientation for a larger number of hearing-impaired children.
CHAPTER V

SUMMARY

An experimental program in Missoula, Montana, has been designed and implemented to test the feasibility of identifying possible hearing-impaired infants through the use of an at risk check list as a screening device.

The at risk program as established in this city is the result of a cooperative effort among hospital staffs, the medical community and the Department of Speech Pathology and Audiology at the University of Montana. It was designed to increase the visibility of infants at risk for hearing loss and to encourage a systematic procedure for audiological referral, testing, and medical, social, and educational follow-up.

The effectiveness of the program in terms of actual identifications of hearing-impaired infants will necessarily have to be evaluated on a long-term basis. The program as outlined and implemented will be evaluated in one year by the hospital administrative staffs, obstetric personnel, the involved pediatricians and child care physicians, and the Department of Speech Pathology and Audiology at the University of Montana to determine the merits of its continuation.

It is postulated that this program can be adapted in other communities even though they may lack trained staff and sophisticated
testing equipment in one central facility, and that these procedures can lead to early diagnosis and treatment of larger numbers of hearing-impaired children than is now the case.
BIBLIOGRAPHY


APPENDIX A
HEARING LOSS AT RISK CHECK LIST

Baby's Name____________________ Father's or Guardian's Name___________
Birth Date______ Weight_______ Home Address__________________________
Mother's Name_______________ Physician____________________________

This check list may be completed by reference to direct observation of the infant during his hospital stay and by routine exam up to three (3) months of age.**

1. Any of the following observed conditions:
   a. Renal disorders: albuminuria, hematuria, G.R. infection
   b. Endocrine disorders:
   c. Heart disease symptoms:
   d. Degenerative disorders of nervous system
   e. Brain syndrome symptoms:
   f. Other neurologic disorders:
   g. Unclassified: (Such as acute osteomyelitis, recurrent pneumonia, pulmonary disease, intestinal atresia, uveitis, parotitis, dermatitis)

2.**The baby's mother has been asked to complete a related check list during her stay in the hospital. A nurse has been responsible for completing another section of the At Risk Check List. In summarizing the available information do you feel that this baby is At Risk for Hearing Loss?
   ____ Yes  ____ No  Comments:

3. If your answer to the above question is in the affirmative, we would appreciate your referral of the infant to the University of Montana Speech and Hearing Clinic for audiological testing and follow-up. Any information obtained at this clinic will be forwarded to you immediately.
HEARING LOSS HIGH RISK CHECK LIST

Baby's Name _______________ Father's or Guardian's Name _______________
Birth Date ______ Weight ______ Physician ________________________________
Mother's Name ____________ Hospital ________________________________
Para. ______ Grav. __________

Please complete the following check list by reference to (1) Mother's chart, if available, (2) direct observation of infant, (3) infant's chart. After summarizing the available information do you feel this infant is High Risk for hearing loss?

______ Yes  ______ No

1. _____Did the mother take any ototoxic drugs during pregnancy?  
   (Kanamycin, streptomycin, dihydrostreptomycin, viomycin, neomycin, 
   terramycin, quinine, thalidomide, chloroquine.)

2. _______Any bleeding indicating threatened abortion during pregnancy

3. _____Toxemia of pregnancy--eclampsia and pre-eclampsia

4. _______Excessive radiation exposure during pregnancy

5. _______Rh incompatibility

6. _______Rh incompatibility with rising anti-titers during pregnancy

7. _______Concurrent maternal toxoplasmosis

8. _______Concurrent maternal malnutrition sufficient to be of clinical concern

9. _______Concurrent maternal anemia sufficient to be of clinical concern

10. _____Concurrent serious maternal acute infection

11. _____Maternal alcoholism or drug addiction

12. _____Prolonged labor: Longer than 18 hours in primigravida, 8 hours in 
    multigravida

13. _____Precipitate or uncontrolled delivery

14. _____Maternal hemorrhage, abrupto placenta, placenta previa
15. _____ Rupture of placental membrane over 24 hrs. duration

16. _____ Sepsis or other infection present

17. _____ Traction on neck, high or mid-forceps delivery, prolapsed cord, abnormal presentation, version and extraction

18. _____ Gestational age under 36 weeks or over 42 weeks
   Please indicate which

19. _____ Fetal distress; heart rate sustained at greater than 160/min. or less than 100/min. for 30 seconds; passage of meconium

20. _____ Respiratory distress syndrome

21. _____ Apnea or Dyanosis. Resuscitation requiring more than suctioning only or simple stimulation

22. _____ Ototoxic drug used in treating infection in infant

23. _____ Jaundice-hyperbilirubinemia: 15/mg/100 cc and over; a history of exchange transfusions

24. _____ Prolonged abnormality of central nervous system, e.g. convulsions

25. _____ Paralysis

26. _____ Discordant twin (smaller twin 25% or more lighter and weighing less than 2000 gms at birth)

27. _____ Any of the following observed conditions: (It is recognized that many of these will not be observed on the newborn. Please underline those which are applicable.)

   a. Skeletal and cranial defects: skull abnormalities, short neck, absent clavicles, dwarfism, malformations of extremities and digit, cleft lip, cleft palate (overt or submucous), underdeveloped maxillae or mandible, facial asymmetry (including facial paralysis), external ear abnormalities, low hairline, fragile bones associated with blue sclerae

   b. Eye abnormalities: blindness, chorioretinitis, retinal and corneal abnormalities, optic atrophy, small sunken eyes, cataracts, colobomata (clefts) of eyelids or of iris, ocular palsy or paralysis, anti-mongoloid slant of eyes, dislocated lenses

   c. Pigmentary abnormalities: unusually light skin, absence of skin appendages, lack of pigment in iris, sclera and fundus, different colored irises, abnormal canthis, white forelock, wide root of nose, wide separation of eyes, clumps of pigment in retina, generalized lentigines
d. Associated ectodermal abnormalities: any unusual condition of hair, nails, teeth, skin; abnormal lack of sweating, oddly shaped nose

e. Metabolic disorder symptoms: edema (around eyes), large tongue, cool dry skin, hernias, muscle weakness, progressive ataxia

f. Other somatic disorder symptoms: low-set ears, mental retardation, facial capillary hemangioma, polydactyly, sloping forehead, posterior prominence of heels, low birth weight, failure to thrive

PLEASE SEND THIS CHECK LIST AND THE MOTHER'S QUESTIONNAIRE TO:

DEPARTMENT OF SPEECH PATHOLOGY AND AUDIOLOGY
UNIVERSITY OF MONTANA
MISSOULA
MONTANA 59801
HOSPITAL SURVEY OF THE NEWBORN INFANT

Baby's Name_________________ Home Address_________________
Birth Date_________________ Pediatrician_________________
Mother's Name_________________ Hospital_________________

We are conducting a survey of all the babies born in Missoula and their parents to see how many infants have hearing losses or a family history indicative of possible hearing problems. We would appreciate your help in this survey. If these questions cause you any concern, please feel free to consult your physician at any time. Your answers will help us give your baby the best possible care. Please realize this information is confidential and will be kept in the physician's file. If used for the purposes of the survey, the data will have no names attached. Answer the questions to the best of your ability. If you don't know the answer to a question, do not leave it unanswered, but write "DON'T KNOW" in the blank.

YES NO

1. Did you have any diseases, illnesses or infections during your pregnancy? _____ _____
   Accompanied by rash? _____ _____
   Accompanied by fever? _____ _____
   What were they? ______________________________

2. What prescription medications did you take during your pregnancy? Name below.
   __________________________________________

3. What medications did you take in the 18 months preceding your pregnancy? Name below.
   __________________________________________

   Birth control pills_____ Others_________________

4. What drugs or narcotics did you take in the 18 months preceding your pregnancy?
   __________________________________________

5. What drugs or narcotics did you take during your pregnancy?
   __________________________________________
6. Do any of your baby's relatives have any inherited diseases, such as diabetes, cancer, asthma, or others? Describe below.

________________________________________________________________________________________

What is their relationship to the baby?____________________

YES   NO

7. Do you have diabetes? ________

8. Have you or the baby's father had any venereal disease, such as syphilis, gonorrhea? 

What is the relationship of this person to the baby? __________________

Was the disease treated? ________

9. Do you know anyone of the baby's relatives who couldn't hear well before they were 50 years of age? Think hard about all of your family and the father's family.

What is their relationship to the baby?__________

How old is this person now? __________________

Was the hearing loss treated? ________

If so, how? __________________________

10. Is there a blood relationship between you and the baby's father? ______

11. Did you have any excessive radiation (such as x-ray) exposure in the 18 months preceding your pregnancy? 

If so, please explain.________________________

12. Have you had any blood transfusions prior to this pregnancy? ______

13. Did you have any immunizations in the 18 months preceding your pregnancy? Describe below.

________________________________________________________________________________________

14. Have you even been addicted to alcohol or drugs? ______

15. Have you ever had any unsuccessful pregnancies? ______

If yes, please explain __________________________
16. Do you for any reason feel there is a possibility your child may have or develop a hearing loss? _____

If yes, please explain_____________________________________________________

______________________________________________________
APPENDIX B
FILING PROCEDURES FOR INFANT AND EARLY CHILDHOOD AT RISK PROGRAM

1. Hospitals mail mother's and nurse's sections of the check list to the Speech and Hearing Clinic.

2. Secretary at clinic photocopies the check lists and sends the duplicates along with the form to be completed by the physician, to the child's pediatrician.

3. Secretary gives the audiologist the original check lists to review for at risk indications.

4. Secretary types index card for each infant including the following information: (example)

<table>
<thead>
<tr>
<th>Infant's Name</th>
<th>Pediatrician</th>
<th>Date of Birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMITH, John (R)*</td>
<td>Dr. Law</td>
<td>6/15/72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out**</td>
<td>In**</td>
<td></td>
</tr>
<tr>
<td>6/19/72</td>
<td>7/30/72</td>
<td></td>
</tr>
</tbody>
</table>

*"R" indicates whether this infant is initially considered by the audiologist to be At Risk.

**"OUT" refers to the date the photocopied check lists on this particular infant were mailed to the physician. "IN" refers to the date the physician's section of the check list was received by the clinic.

5. Secretary files above index card in chronologically-ordered card file.

6. Secretary files original check lists in "Initial At Risk" or "Initial Non-At Risk" section of file, according to audiologist's instructions.
7. When physician's section for each infant is received in the clinic, secretary does the following:

(a) pulls the index card, and the original check lists on that infant, which have been filed in the "Initial At Risk" or "Initial Non-At Risk" section previously.

(b) staples all three sections of check list together (physician's form on outside), with the index card on top of all.

(c) If physician and audiologist agree on final decision, file check lists with attached index card in "Final At Risk" or "Final Non-At Risk" section. Give other check lists to audiologist.

8. The audiologist is required to call the infant's physician concerning any discrepancy in the final decisions. They together reach an agreement with respect to categorizing the infant "at risk" or "non-at risk".

9. Above infant's check list filed appropriately.

10. Secretary contacts all physicians who have not returned their portion of any infant's check list by three months after the infant's birth date.

11. Audiologist is responsible for examination and follow-up of at risk infant.

12. Files of all at risk infants being tested are integrated into regular clinic files.
APPENDIX C
TO: WESTERN MONTANA PEDIATRIC SOCIETY, ST. PATRICK'S HOSPITAL,
COMMUNITY HOSPITAL

FROM: DEPARTMENT OF SPEECH PATHOLOGY AND AUDIOLOGY, UNIVERSITY
OF MONTANA

DATE:

Please consider this statement a commitment of our time and
interest by allowing Mrs. Lee Shideler to develop a High Risk Program
with the pediatricians, nurses, and staff of Community and St. Patrick's
hospitals. We are planning to engage in a long range project, and it is
fully understood that Mrs. Shideler will be involved only in the initial
stages of the program. At the end of the initial stage it is intended
that the worth of the project be reviewed by the physicians, nursing
staff, and hospital personnel. If the project is judged worthwhile, it
is anticipated that the program will continue, subject to yearly review,
until such time as the physicians, nursing staff and administrative
personnel feel it is no longer appropriate. It is understood that this
department will compile the records as indicated in Mrs. Shideler's
proposal. We will do the necessary audiological testing for these High
Risk infants when appropriate and will be intimately involved in the
social, educational, and habilitative planning. We also recognize our
obligation to compile and report the data periodically. The data will
be used for assessment of the High Risk register in this community and
for the provision of better medical and habilitative care of the infant.
The information will be held confidential in all cases.

Signed: _______________________
Title: _______________________
Date: _______________________

cc: Dept. of Speech Pathology and
Audiology