A Health Supervision Index to Measure Standards of Child Care

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HEALTH supervision of children is considered an important aspect of the medical care they receive from birth through adolescence (*1–4*). This care includes periodic visits to primary care professionals for physical assessment; advice regarding feeding, growth and development; parental guidance concerning anticipated behavior; administration of vaccines for immunizations; and screening for specific diseases.

Standards for health supervision have been established by various professional and governmental bodies (*5–9*). These indicate the frequency of visits and times for administering vaccines for immunizations and performing screening tests. They are accepted by the providers of health care and are adhered to whenever possible. They are also recommended by child care experts in the lay literature (*10–12*), and many mothers expect the care of their children to meet these standards.

Over the years, the standards for health supervision have been altered as new knowledge, experience, and reason have dictated. Current immunization and screening practices would not have been recognized a decade ago, and 10 years hence the frequency of health supervision visits may well be reduced in response to a relative decrease in the number of providers of primary care.

The health supervision received by individual children and by groups of children can be measured by using an index which reflects the number and timing of visits, immunizations, and screening tests provided. Such an index could be useful in quantitative determination of the health supervision provided for individual patients, in comparisons of health care programs, and in surveys of the levels of positive health care of specific population groups. In this paper, we define a health supervision index that can be used for these purposes.

Because the health supervision infants and chil-

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dren receive is comprised of well-baby visits, immunizations, and screening tests, the health supervision index must reflect these components of care. The health supervision index (HSI) then is derived from the well-baby visit index (WBVI), the immunization index (II), and the screening index (SI). There are many considerations which must be weighed in assigning relative values to the WBVI, II, and SI in the overall determination of the effectiveness of health supervision.

The content and depth of well-baby visits will vary by provider and recipient of the care. A pediatrician may provide a different level of care than a general practitioner, and a pediatric nurse practitioner or a public health nurse may provide a different focus of care than either the pediatrician or the general practitioner. Maternal factors of parity, emotional stability, education, culture, and socioeconomic status will influence the substance of the visit. The presence or absence of continuity of care by a single provider will also affect what transpires in well-baby visits.

We must also consider the worth of the service to the individual person and its worth to society. The purpose of a well-baby visit is to detect early symptoms and signs of disease and to prevent physical and mental illness. Its worth to the individual child is self-evident. Its worth to society is measured by decreased use of expensive and scarce health and social resources and in increased individual productivity. Immunizations and screening tests also have different values for the individual child and society. Tetanus immunization is of more worth to the individual child than to society, whereas rubella vaccine administered to a male child is of more worth to society than to the child. Similarly, determining the hematocrit value as a screening test is of less value to society than giving a tine test. These factors must be weighed in assigning relative values to each component of the II and the SI.

The formula for the health supervision index is as follows:

$$\mathrm{HSI} = \mathrm{WBVI} + x\mathrm{II} + y\mathrm{SI}$$

The letters x and y are factors which reflect the weight given to the II and the SI relative to the WBVI in the determination of the HSI.

The health supervision index we have devised is applicable to children during their first 2 years because most well-baby visits, primary immunizations, and basic screening tests recommended for children are concentrated during this time. The principles and methods we have used in constructing our index can be used to construct an index of health supervision for any given age.

The Well-Baby Visit Index

Barron and Mindlin (*13*) have constructed, as part of an infant health supervision index, a formula which can be used to calculate the WBVI for the first year of life.

$$\mathrm{WBVI} = \frac{650n}{\sum_{t=1}^{12} (12 - p)\,(t - p)}$$

t = baby's age this month, in completed months
p = baby's age, in completed months, at the time of the last visit, prior to this month ($p = 0$ where there has been no visit prior to "this month")
n = number of months during the first year that a visit was made.

Visits made in the early months are given more weight in this formula than are visits made toward the end of the infant's first year. A regular pattern of visits receives a higher score than does an irregular pattern. A detailed discussion of the methodology used in formulating the WBVI is given by Barron and Mindlin (*13*).

This formula, although having certain advantages, gives credit for visits over and above the number recommended for the first year of life by the American Academy of Pediatrics. The Academy recommends visits monthly during the first 6 months, bimonthly during the second 6 months, and trimonthly during the second year (*5*). A child who has had a well-baby visit each month during his first year of life would score higher than one following the recommended pattern of visits. This score, which would indicate a higher level of care, would not necessarily give a true picture. Visits made too frequently may lead to overdependence upon the primary care professional and not allow the mother to develop independent thought, decision making, and action in child rearing practices. We have modified Barron and Mindlin's formula to cover the first 2 years of life and to give maximum credit for the well-baby visit schedule recommended by the American Academy of Pediatrics.

Thus, in the revised formula, credit is given for one visit per 1-month period for the first 6 months, one visit per 2-month period for the second 6 months, and one visit per 3-month period for the second year. There is then a total of 13 periods during which visits are recommended (6 monthly, 3 bimonthly, and 4 trimonthly). This pattern results in the following formula for WBVI:

$$\text{WBVI} = \frac{700n}{\sum_{t=1}^{13} (13 - p)\,(t - p)}$$

t = baby's age this period, in completed periods
p = baby's age, in completed periods, at the time of the last visit before this period ($p = 0$ where there has been no visit before "this period")
n = number of periods during the first 2 years that a visit was made.

A child following the pattern of visits recommended by the American Academy of Pediatrics during his first 2 years would score 100 on the WBVI. In actual practice, most pediatricians follow a well-baby visit schedule which calls for visits during the 1st, 2d, 4th, 6th, 9th, 12th, 18th, and 24th months of life. Therefore, most children following practiced well-baby visit schedules would attain a score of 44.7 on the WBVI during their first 2 years.

Our formula can be modified for use in assessing populations of 1-year-old children:

$$\text{WBVI} = \frac{900n}{\sum_{t=1}^{9} (13 - p)\,(t - p)}$$

In this instance, the visit pattern recommended by the American Academy of Pediatrics would score 100, and the practiced visit pattern would score 48.6.

The Immunization Index

An immunization index has its basis in the specific immunizing agents administered, their number, and the timing of their administration. Each immunizing agent incorporated in the index is assigned a relative value based upon the following factors:

1. The risk to the individual person of acquiring the disease if unimmunized, assuming current immunization rates

2. The morbidity and mortality of the disease if acquired

3. The importance to society of a high immunization rate in the population.

An immunization index will vary from locale to locale because of the prevalence of specific diseases and because the means available for treatment and control of spread of these diseases may differ. Therefore, immunization indexes for developed countries will be determined from different criteria than immunization indexes for underdeveloped countries.

An immunization index within any given locale will change over time as its components change and as the criteria affecting the relative value of those components change in response to advances in medical knowledge and modification in the epidemiology of diseases. Thus smallpox vaccination, an important component of all pre-1972 immunization indexes, will now not be incorporated in future indexes.

An immunization index will vary with the age of the individual child to whom it is applied. An optimum immunization status for a 1-year-old is different from one for a 2- or a 5-year-old. The immunization index we have devised can be used from birth through the age of 2 years.

In 1972 in the developed countries, an immunization index for children during the first 2 years of their lives should reflect the relative importance of immunizations administered to protect them against those diseases to which they may be exposed and to which they may be susceptible. Those diseases are diphtheria, pertussis, poliomyelitis, rubeola, rubella, and tetanus. Immunization for mumps is not included here because it is not currently recommended except in selected cases until the preadolescent period (*8,9*). Each of the immunizing agents used is rated on a scale of 1 to 4 for each of the three factors previously listed. The scaled score for each agent on each relative value factor is shown in table 1. If immunizing agents are combined, as with dipththeria, tetanus, and pertussis (DTP), the most important agent determines the scaled score for the combination.

The scaled scores for each immunizing agent must in turn be weighted by the importance of each relative value factor. The weight applied to each factor will depend upon one's view of an individual person's health against the public's health. We have chosen to assign a weight of 2 to the "risk to the individual" factor, 3 to the "morbidity and mortality" factor, and 4 to the "importance to society" factor. Applying these weights to the scaled scores, we then have the weighted, scaled scores for each immunizing agent (table 1).

Having determined the total weighted, scaled score for each immunizing agent, we can construct a formula for the immunization index. DTP, having the highest weighted, scaled score, is assigned a factor of one and each of the other immunizing agents is assigned a smaller factor, determined by using its weighted, scaled score as the numerator and the weighted, scaled score for DTP as the denominator. Thus the immunization index formula can be stated:

$$\text{II} = a + 0.6b + 0.4c + 0.5d$$

a = DTP immunization, b = poliomyelitis immunization, c = rubeola immunization, and d = rubella immunization.

The values for a, b, c, and d (immunization against specific diseases) are determined by the number and timing of administration of the specific immunizing agents in question. In administering these agents, the potential for achieving optimum antibody responses and the possibility of untoward reactions at certain ages are taken into consideration. A full score of 10 indicates an optimum pattern of immunization against each disease at age 2 years. The methods by which a score of 10 is reached for each immunizing agent are shown in table 2.

Applying these values to the immunization index formula yields an optimum score of 25 for a 2-year-old child.

$$\begin{aligned}\text{II} &= a + 0.6b + 0.4c + 0.5d\\ &= 10 + 0.6(10) + 0.4(10) + 0.5(10)\\ &= 10 + 6 + 4 + 5\\ &= 25\end{aligned}$$

The optimum score of 17 for a 1-year-old child is calculated as shown below:

$$\begin{aligned}\text{II} &= a + 0.6b + 0.4c + 0.5d\\ &= 5 + 0.6(5) + 0.4(10) + 0.5(10)\\ &= 5 + 3 + 4 + 5\\ &= 17\end{aligned}$$

The scaled scores for each immunizing agent on each relative value factor and the weighting applied to each relative value factor (table 1), as well as the scoring for varied patterns used for each immunizing agent (table 2), can be altered by individual investigators should they not agree with the values used here.

Table 1. Weighted, scaled scores for each immunizing agent on each relative value factor

Relative value factor	Diphtheria, tetanus, and pertussis	Poliomyelitis	Rubeola	Rubella
Risk to individual, weight=2:				
Scaled score	4	1	2	3
Weighted, scaled score	8	2	4	6
Morbidity and mortality, weight=3:				
Scaled score	4	3	2	1
Weighted, scaled score	12	9	6	3
Importance to society, weight=4:				
Scaled score	4	3	1	2
Weighted, scaled score	16	12	4	8
Total weighted, scaled score	36	23	14	17

Table 2. Pattern of immunizations and scores assigned for DTP, poliomyelitis, rubeola, and rubella

Pattern of immunization	Score
DTP immunization:	
3 doses by 6 months of age (intervals ≥4 weeks)	5
3 doses by 12 months of age (intervals ≥4 weeks)	4
2 doses by 12 months of age (intervals ≥4 weeks)	2
1 dose by 12 months of age	1
2d or 3d dose, or both, after 1 year of age per dose	1
Booster dose given approximately 1 year following initial series of 3 doses	5
Poliomyelitis immunization [1]:	
3 doses [2] by 6 months of age (interval ≥6 weeks)	5
3 doses [2] by 12 month of age (interval ≥6 weeks)	4
2 doses [2] by 12 months of age (interval ≥6 weeks)	2
1 dose by 12 months of age	1
2d or 3d dose, or both, given after age 1 year per dose	1
Booster dose given approximately 1 year following initial series of 3 doses	5
Rubeola and rubella immunizations [3]:	
Given between 11 and 24 months of age	10
Given between 8 and 11 months of age	5
Given before 8 months of age	0

[1] Immunizations apply to monovalent and trivalent oral Sabin vaccine and injectable Salk vaccine.
[2] Subtract 1 point if any 2 doses are given at less than a 6-week interval.
[3] Based on the use of live rubeola vaccine.

The Screening Index

A screening index has its basis in the specific screening tests administered and the timing of their administration. Each screening test incorporated in the index is assigned a relative value based upon the following factors:

1. The risk to the person of acquiring the disease (incidence)
2. The degree to which early discovery and intervention may alter the prognosis
3. The importance to society of early detection.

A screening index will vary with the population to which it is applied in consideration of the prevalence of specific diseases and of the means available for treatment and control of spread of those diseases. Thus screening for sickle cell diseases is only applicable to black populations, and screening for lead intoxication is only applicable to populations exposed to lead-based paint.

Screening indexes will change over time as new screening tests that are sensitive, specific, reliable, easy to administer, and inexpensive are developed, which will either replace tests currently in use or be added to the screening profile.

Currently, the following screening tests are recommended for general use in developed countries for children during the first 2 years of their lives: determination of the hematocrit or hemoglobin value, test for phenylketonuria or blood phenylanaline level, tuberculin skin test, and urinalysis. Our screening index incorporates only these four tests. Other tests may be appropriately included in screening certain populations, such as sickle cell tests, G6PD (glucose 6 phosphate dehydrogenase activity) test, blood or urine lead levels or, in older children, hearing, vision, and psychological screening tests. Investigators studying populations with these characteristics can construct a screening index which incorporates any or all of these tests using the principles and methods described here.

Table 3. Weighted, scaled scores for each screening test on selected relative value factor

Relative value factor	Hematocrit	Phenylketonuria	Tuberculin	Urinalysis
Risk to individual, weight = 1:				
Scaled score	4	1	2	3
Weighted, scaled score	4	1	2	3
Altered prognosis, weight = 3:				
Scaled score	3	3	4	2
Weighted, scaled score	9	9	12	6
Importance to society, weight = 1:				
Scaled score	1	2	4	2
Weighted, scaled score	1	2	4	2
Total, weighted scaled score	14	12	18	11

Each test in the basic screening index is rated on a scale of 1 to 4 for each of the three factors previously listed. The scaled scores for each screening test on each relative value factor is shown in table 3. The multiple causes of abnormalities in the hematocrit value and the urinalysis are considered in assigning the scaled score for each of these screening tests.

The scoring for the urinalysis assumes complete testing, including screening for bacteriuria. An incomplete urinalysis is of less importance than a complete one and should be scored appropriately.

The scaled scores for each screening test must in turn be weighted on the basis of the importance of each relative value factor. We have chosen to assign a weight of 1 to the "risk to the individual" factor and to the "importance to society" factor and a weight of 3 to the "altered prognosis" factor. Applying these weights to the scaled scores, we then have the weighted, scaled scores for each screening test shown in table 3.

Having determined the total weighted, scaled score for each screening test, we can construct a formula for the screening index. The tuberculin test, having the highest weighted, scaled score, is assigned a factor of 1 and each of the other screening tests is assigned a smaller factor, determined by using its weighted, scaled score as the numerator and the weighted, scaled score for the tuberculin test as the denominator. The screening index formula then can be stated:

$$SI = a + 0.8b + 0.7c + 0.6d$$

a = tuberculin test, b = hematocrit value, c = PKU test, and d = urinalysis.

The values for a, b, c, and d (specific screening tests) are determined by the timing and frequency of each test, and so take into consideration the potential for early intervention and control of the disease screened. A full score of 10 indicates an optimum pattern of use of each screening test. The patterns which achieve a full score for each screening test are shown as follows:

Interval and disease	*Score*
Screening for tuberculosis, anemia, and bacteriuria (urinalysis):	
During 1st year	5
During 2d year at least 6 months after 1st screening.	5
Phenylketonuria test on blood during 1st 6 weeks of life	10

Application of these values to the screening index formula will yield an optimum score of 31 for a 2-year-old child.

$$\begin{aligned} \mathrm{SI} &= a + 0.8b + 0.7c + 0.6d \\ &= 10 + 0.8(10) + 0.7(10) + 0.6(10) \\ &= 10 + 8 + 7 + 6 \\ &= 31 \end{aligned}$$

The optimum screening index score for a 1-year-old child is 19:

$$\begin{aligned} \mathrm{SI} &= a + 0.8b + 0.7c + 0.6d \\ &= 5 + 0.8(5) + 0.7(10) + 0.6(5) \\ &= 5 + 4 + 7 + 3 \\ &= 19 \end{aligned}$$

The scaled score for each screening test on each relative value factor, the weighting applied to each relative value factor (table 3), and the scoring for the patterns of use of aforementioned screening tests can be altered by individual investigators should they not agree with the values we have assigned.

Health Supervision Index

Having determined the formulas for the WBVI, the II, and the SI, they can be combined to obtain the health supervision index. If the three component scores WBVI, II, and SI are just added, the proportion of the variance of the total score which would be attributable to each of the component scores would be proportional to the variances of these component scores. However, we desire the contribution of each component score to the total to be proportional to its importance in overall health supervision. The component scores, therefore, must be weighted by the appropriate factors to achieve the desired ratios among the variances. These factors must include both the variances, or standard deviations, of the component scores and the relative importance of these scores. The standard deviations we have used in calculating the HSI have been those found in population samples we have investigated (*14*). Further work, however, may lead to more established values for a broader population sample which could then generally be used.

We have arbitrarily assigned a relative importance of 1.0 to the WBVI, 0.8 to the II, and 0.6 to the SI, and the reader who takes issue with our judgment can adjust the weighting to his own satisfaction. The rationale for making these assignments can be individualized in accordance with local factors affecting the components of the health supervision index. Therefore, the weighting of the three measures can be varied by individual investigators in accordance with their own perception of the relative importance of each measure. There are situations where this must be done. For example, a health care program dealing with a predominantly black, indigent population with a relatively high incidence of iron deficiency anemia, sickle cell disease, and tuberculosis should weight the screening index higher.

The suggested factors for the importance of the three component scores results in the following formula for HSI:

$$\mathrm{HSI} = \mathrm{WBVI} + \frac{\sigma\mathrm{WBVI}}{\sigma\mathrm{II}} \sqrt{0.8}\,\mathrm{II} + \frac{\sigma\mathrm{WBVI}}{\sigma\mathrm{SI}} \sqrt{0.6}\,\mathrm{SI}$$

Note that $\sigma\mathrm{WBVI} = 14.4$, $\sigma\mathrm{II} = 8.5$, and $\sigma\mathrm{SI} = 2.7$. Obviously in using the HSI to compare health supervision provided in different health care programs and in different populations, the same weightings must be used. As long as each investigator reports his weighting factors, others may use the same ones for comparisons with his sample. It may be possible to compare health care programs by assigning different values to the WBVI of each setting, after careful assessment of the content of the well-baby care provided in each setting. This methodology is not exact, but may be necessary if comparisons are to be realistic.

Discussion

Most of the health indices that are used to evaluate the health of specific populations and nations use mortality and morbidity as their bases. These are negative measures of health and are endpoints of the health care delivered or not delivered. The use of positive health measures in assessing public health has been advocated by a work party of the American Public Health Association (*15*). The health supervision of infants, including well-baby visits, immunizations, and screening procedures, is an example of a positive health endeavor, and the extent to which such health supervision is conducted is a partial measure of the health of any population surveyed. The health supervision index described can be used to this end, as can each of its components, the well-baby visit index, the immunization index, and the screening index to the degree to which one is convinced that each of these health-care activities contributes to the health of the individual child and to the health of society.

There has been one previous effort to combine measures of both well-baby visits and immunizations into a single index. Mindlin and Densen (*16*) combined the Barron and Mindlin (*13*) index of well-baby visits with a simple two-category measure of immunization status. These two values were combined graphically to divide the sample into three ranked categories of total health supervision, roughly equivalent to good, fair, and poor health supervision. Considering the elaborate way in which the index of health supervision visits is calculated, it is unfortunate to lose this multiple category, ratio-scale index, and its accompanying advantages by combining it with such a raw measure of immunization status. We have recognized the importance of the basic work of Barron and Mindlin in developing a measure of well-baby visits and have developed more elaborate measures of both immunization status and screening for illness status. The three measures have been combined to preserve the quantification of each and weight them according to their relative importance in overall health supervision.

If the three component indexes are to be considered as different measures of the same underlying variable (health supervision), then they should correlate with each other. The three indexes do seem to correlate fairly well with each other. In one sample, we found correlations of 0.75, 0.69, and 0.63 among them *(14)*. Those who do better on one of the component indexes also tend to do better on the other two indexes; therefore, it is not unreasonable to combine them into one measure of health supervision.

Combining the component indexes into a weighted sum provides a numerical score which is about normally distributed, although slightly skewed toward low health supervision, and which divides the sample into many more than the three categories—good, fair, and poor. Such scores provide for easier presentation of the data and for statistical calculations on the data. Mindlin and Densen (*16*) used numerous bar graphs to present their data on the health supervision index as a function of the population characteristics on which it was obtained. With a more elaborately calculated measure of health supervision, such data can be presented numerically as means rather than figuratively as bar graphs. In addition, statistics such as the significance of the differences between groups can be calculated instead of depending on visual impressions, and smaller differences should be discernible. An essentially normally distributed, continuous measure of health supervision also allows for the use of many other statistical manipulations of the data in exploring the relationship of health supervision to other variables.

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Health supervision of children in the form of well-baby visits, administration of immunizations, and performance of screening tests is recognized as a positive health endeavor. It can be used as a partial indicator of the health of any given population group if it can be measured in a uniform fashion.

A health supervision index is described and the methodology for arriving at each of its three components, the well-baby visit index, the immunization index, and the screening index is detailed. The well-baby visit index reflects the number and timing of well-baby visits made; the immunization index reflects the specific immunizing agents administered, their number, and the timing of their administration; and the screening index reflects the specific screening tests administered and the timing of their administration. The three separate measures are weighted in accordance with their variances and their relative importance in health supervision to achieve the final health supervision index. The immunization index was believed to be only 80 percent as important as the well-baby visit index and the screening index only 60 percent as important, and therefore they were weighted accordingly in the final formula.

The health supervision index or any of its components can be used to compare interprogram and intraprogram health supervision in surveys of levels of health care of specific population groups and in evaluation of the health supervision provided for individual patients.