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REPORT OF THE INFORMAL MEETING OF THE INVESTIGATORS  
ON SECONDARY ANALYSIS OF LONGITUDINAL DATA  
ON GROWTH AND DEVELOPMENT  
Geneva, 13 - 15 October 1988

Programme of Maternal and Child Health  
including Family Planning  
Division of Family Health  
World Health Organization  
Geneva, 1989

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## 1. INTRODUCTION

The WHO collaborative study at eight centres in six countries on Development and Field Testing of Techniques for Monitoring Physical Growth and Psychosocial Development aims:

- (i) to identify simple, reliable and culture-appropriate measures of psychosocial development and physical growth of children;
- (ii) to develop a framework within which a country can devise a means of enquiring about environmental factors which influence growth and development, and to establish factors which are the most powerful indicators in each culture, and
- (iii) to prepare a locally acceptable home-based monitoring record of growth and development which can be used by family and primary health workers.

Concurrently, the WHO supported the secondary analysis of data of longitudinal studies on physical growth and psychosocial development to supplement the available information, particularly on the above-mentioned second objective. The analysis aimed to look at predictive powers of the environmental factors, and also at developmental milestones. It also studied the inter-relationship between growth and development and between individual milestones of development.

An Informal Meeting of the Investigators on Secondary Analysis of Longitudinal Data on Growth and Development was held in Geneva on 13-15 October 1988. The objectives, agenda, expected outcome of the meeting, and list of participants are given in annexes I-IV.

The meeting opened with an introduction by Dr P M Shah, Medical Officer, Programme of Maternal and Child Health including Family Planning, to the WHO project on developmental indicators. He explained that eight centres in six countries (Argentina, China, India, Pakistan, Senegal and Thailand) have undertaken the work of identifying culture-appropriate milestones of development in children up to the age of 6 years and are also developing locally based norms for these indicators and for growth. The aim is for each centre to add a small number of indicators to the Child's Home-Based Record (CHBR). It is hoped that the work will lead on to a further project on intervention. Throughout, the overall strategy is to empower family members and community health workers to carry out as much of the monitoring of psychosocial development as possible and also to disseminate research and data analysis skills to colleagues in each study centre. So far data have been collected and partly analysed in China and Thailand and it is hoped that other centres will have completed their work by the middle of 1989.

The next step will be to incorporate findings in the Child's Home-Based Record. It will be helpful at this stage to examine what is known of the predictive value of anthropometric and developmental data and the association between the two from longitudinal studies.

## 2. DEVELOPMENTAL CONTINUITY IN THE FIRST SIX YEARS OF LIFE

Before presenting data from the Bogota study, Dr Christiansen discussed the concept of continuity in development. One view is that development is discontinuous, that a knowledge of children now will tell us little of value about their subsequent development.

Supporting the argument against continuity is the frequently reported finding that the correlation between infant test results and later IQ is very low except at the extremes of the distribution. The Denver Developmental Screening Test has been shown to be a poor predictor of mild delay and of school failure.

On the other hand there are weaknesses in using a single variable like developmental and intelligence test quotients for a complex topic. Socioeconomic factors account for 50% of the variance in childhood IQ and if we are to look at development in a sophisticated way we should adopt a view of children which sees them developing not in isolation from their environment but rather as people who interact with the environment.

This interactionist model sees children being affected by their families and the culture in which they grew up and, in turn, affecting the families as well, so there is a two-way, continuous process. The family at time B is different from the family at time A, and therefore has a different influence on the child, partly as a response to the child's behaviour in the period intervening between the two times.

In more detail, Dr Christiansen noted that continuity can be conceptualised in forms of

1. Separating out continuities of behaviour, developmental status and underlying processes related to behaviour. (An example of an underlying process is the ability to regulate one's own behaviour.) These three are often lumped together when they should be perceived as separate.
2. Explanatory continuity: We should not imagine that causal factors will operate in the same way throughout a child's life. For example: socioeconomic status is associated with more skills as children get older; it makes relatively little difference which class a child comes from when one is interested in how old they are when they sit up; it makes a big difference when one looks at reading.
3. Tests tap different skills at different ages. Infant tests are heavily weighted with motor skills for obvious reasons. On the other hand there is some evidence to support the idea that there are certain underlying skills which can be measured and which provide good predictions of later IQ, measures of attention being an example.
5. Genetic potential should always be borne in mind when discussing an interactionist model.

## 3. THE LONGITUDINAL STUDIES

### 3.1 The Bogota Study

Dr Christiansen then presented results of a dual prospective/

intervention study using random assignments to food supplement and home based stimulation groups over a period from 1973 to 1980.

The families concerned were poor (e.g. there was an average mattress occupancy of 3.8 persons) with a high proportion of prematurity and low birth weight. The original number was 433, out of 456 possible; by the end of the study the number had reduced to 220. Full data are not available on all since some had not started school. There were no demographic differences between those children lost and those remaining in the study but the former tended to have lowered measured intelligence.

The children's developmental quotients, based on a local adaptation of the Griffiths Scales, began above the mean but dropped steadily as the study progressed. Outcome measures included the Griffiths score at 66 months, the Raven's Progressive Matrices score, a school readiness test and school performance. The latter was felt to be unreliable since it depended so much on teachers' opinions. Children were tested throughout the study on Griffiths items, language comprehension, the Guatemala vocabulary test (naming and recognition) and motor milestones were also observed. Data were also collected on the demographic variables, child-caretaker interactions, anthropometric characteristics, morbidity and pre- and perinatal variables.

When results were analysed there were no group or sex effects, suggesting that neither food supplementation nor attention to childhood stimulation made any difference to the outcome variables. Analyses were carried out on the total sample in several stages, leading up to a hierarchical multiple regression analysis where the milestones were entered first.

Griffiths scores at 66 months were the easiest to predict, the Raven scores being the hardest. In particular the Griffiths score at 37 months was the best predictor of final Griffiths scores.

Social items: mother's literacy, her attitude to pregnancy, whether mother taught children their letters and whether the mother was the child's caretaker explained, uniquely, 10% of the variance.

Height-for-age explained uniquely only 1% of the variance.

Morbidity had a high predictive value, explaining 14% of the variance uniquely.

No culturally specific items, apart from the Guatemala test, were included in the study.

The best single item predicting the Griffiths score at 66 months was building a tower of three bricks. (See below for a discussion of other items.)

Data from the study are now clean and on tape and may be available for further analysis.

### 3.2 The Cali Study

Dr McKay presented data from this work, also undertaken in Colombia. It began in 1967 when the children were three years old. The number originally was 500; by the end of the study, eight years later, it was

approximately 350. Data were collected on demographic details, physical growth, the Guatemala test, Raven's Progressive Matrices, Wechsler Scales and school success.

A group of 50 elite children have been followed to provide reference values.

Interventions were carried out during the 7 to 8 year period of the study and had some positive effects lasting into school age.

The data are available for analysis but so far there have been few publications forthcoming.

### 3.3 The Guatemala Six Village Study

Professor Pollitt reported on this work which began in 1967 and is ongoing. The original design involved six villages with an allocation to food supplement, placebo supplement and no treatment. After baseline data were collected, the no-treatment villagers were dropped from the study for financial reasons.

The baseline data included demographic information, an infant developmental scale, a pre-school battery of up to 30 psychological tests, anthropometric measures and information on morbidity. Ongoing information was obtained between 1972-1982 on school performance; supplementation ended in 1977. In 1987 a new investigating team began collecting data on reproductive competence, educational levels, social competence, intelligence, growth, nutritional status, physical performance and neuro-psychological measures. Of the original number of 3670, 82% are available for follow-up. It was hoped to complete data collection by April 1989 and the information will probably be available for further analysis. Very little has so far been published on this study, only one paper having appeared in a referred journal.

### 3.4 The Jerusalem Study

Dr Palti introduced their work which was carried out with a heterogenous, Jewish population in West Jerusalem. The families were mainly middle and lower middle class with a very low level of unemployment. There was no malnutrition, although some mild anaemia was common. Infant mortality was 15-18 per thousand.

The work consisted of monitoring a community health programme; it was not set up as a research study as such. Data were collected when resources were available in children's development using the Brunet Lezine Scale (based on the Gesell tests), the MILLI (based on the Stanford Binet) and an Israeli adaptation of the Wechsler Infant Scale. Anthropometric measures were taken as a routine. Non-compliance was low but there was a 15% mobility rate during the ten year period of data collection, from 1972 to 1982.

Analysis of the data has produced a pattern of correlations very similar to that reported from Bogota, i.e. the closer in time between two measures of DQ the greater the correlation. By 36 months the predictive value of the DQ had reached between 0.4 and 0.5. Demographic variables had

a much greater predictive value over the period 9 to 36 months than was found by using developmental tests. Correlations between height and developmental scores varied between 0.04 and 0.32, between weight and test scores the correlations were 0.02 to 0.17 (0.15 is statistically significant for this number). Multiple regressions entering demographic data first indicated that adding anthropometric data contributed very little in explaining the variance in outcome scores, not surprising given that this was a uniformly well nourished group.

The single item with the most predictive value among the developmental tests was the child's response to a nappy placed over the face. The educational level of the mother, even in a population of this nature, was a good predictor of developmental scores, less so of growth status.

### 3.5 The Sri Lankan Study

Dr Nikapota presented work done in Sri Lanka which has to be seen against a background of educational and health care provision that has been developed over 40 years leading to a literacy rate of 82% and a lower infant mortality rate than many others in the region.

There has been a child mental health programme integrated with child health services in primary health care since 1982. Developmental monitoring has been chosen as a strategy to increase awareness of the potency of caretakers to influence children's development as well as to identify children at risk. Nine milestones are used (all selected on the advice of a Sri Lankan paediatrician). Home risk factors are also regularly rated by health workers as part of this monitoring (e.g. organisation of the home, abject poverty, neglectful mother). Monitoring has continued in the field since 1984. During this period high risk factors such as abject poverty have remained constant but the number of children delayed by 4 or more months on successive milestones has declined from 12% to 7%. During this time the number of mothers displaying an understanding of developmental sequences has risen from 16% to 55%.

The main content of the presentation related to data from a cross sectional study where 1620 families were visited. The sample included the range of socioeconomic groups in the country excluding the upper 5%. Seventy percent of the final sample came from rural areas.

The objectives of the study were to identify (a) culture-appropriate indicators of development to expand the developmental monitoring being done routinely and (b) optimal and risk factors for development.

Developmental tests used included culture specific items (for example picking up grains of rice, rolling a sleeping mat). Data on family backgrounds was also collected and home risk factors rated.

The major discriminators of poor developmental status were the level of organization in the home, economic status and most powerful, opportunities for play provided by the mother.

Children of very poor families were better at the culture specific items than at some others, i.e. they were more advanced in skills like rolling up a mat than copying a square. On the other hand, children known to be mentally retarded were unable to perform well on the culture specific tests either.

It was found that up to 24 months motor tests were the best discriminators, but language tests were better between 24 and 40 months, whereas cognitive tests were better for the ages between 40 and 72 months.

#### 4. SELECTION OF MILESTONES FROM THE DATA AVAILABLE

It was agreed that the selection of milestones depended on the outcome measure that is to be predicted. What is more, predictive value may not be the only criterion for selection of a milestone; there may be some here and now advantage in including some items. As discussed, the general framework for item selection was:

1. Select outcome measure.
2. Eliminate those items at a given age range not passed by between 30%-70%.
3. Select from those that correlate well with the outcome measure.

There was considerable discussion about point 2 above and it was felt that further consideration to alternative criteria should be given.

It is recognised that each centre will probably arrive at a unique set of milestones and that taken alone milestones have a low level of predictability during the first three years of a child's life. However, there is some support from the data presented at this meeting for the idea of some milestones having more general applicability than others. A list of such items is included in Annex V.

#### 5. DISCUSSION ON OTHER ISSUES OF IMPORTANCE

##### 5.1 A note on risk groups

It was noted that the concept of risk groups came from medicine where there is a discrete disease to be identified. In psychology there has to be a move towards continuous measures with a need to identify not whether a child has a disease or not but whereabouts on a defined scale that child's score lies. Thus we deal with continuous outcomes rather than clear cut yes/no questions.

#### 5.2 A note on measurement intervals

There is no value in taking measures at fixed intervals in a child's life, e.g. at 3, 6, 12 months of age, since information on what happens in the intervening period is not available. It is much more fruitful in a longitudinal study to take a group of children and measure them at intervals to cover the whole age range.

#### 5.3 A note on sampling

It was agreed that there is value in gathering information on all children within a family to allow examination of family differences.

#### 5.4 Intervention

The draft protocol for Study on Pre-school Child Stimulation Intervention Programmes (4th version) was considered. The following points were made:

1. Note should be made of the interactive effects of certain variables like nutrition and health care which are more than simply additive.
2. Vitamin A should be added to the list of nutritional supplements.
3. DQ should not be regarded as an essential outcome measure although some form of developmental assessment should remain.
4. Greater emphasis should be given to the notion of monitoring input being part of a regular health care programme.

#### 5.5 Recording and analysing data

With the spread in the availability of computers, it is possible that in some developing countries, after a few years, referral centres operating at a secondary level may be able to use more complex data analysis approaches than is possible when all analysis is done by hand.

It will be advisable to move from a pass/fail classification approach to one in which the developmental function and trajectory of each child is recorded and considered.

Missing data will always present a serious problem: some resources should be held in reserve to allow some of the missing information to be collected.

It would be desirable to bring data from different studies together for a common analysis. There may be difficulties in this but they could in part be overcome if centres could be on a common computer network allowing collaboration at a distance. The idea of one centre holding a data archive was supported.

### 5.6 Statistical Packages

Professor Goldstein introduced and, with Mr Gorstein's help, demonstrated GRANDSTAT, a package which allows for the recording of growth and development data and the subsequent analysis of such data. It has a number of features relevant to all centres collaborating in growth and development work, the most prominent being:

It is user friendly and can be learnt by anyone with an understanding of basic statistics. Although previous experience with a computer is useful, it is not essential.

There are in-built checks at the time of data entry which help to ensure that data are clean.

Locally derived norms can be derived rapidly, the print-outs being usable as growth and development charts as they stand.

He also discussed multi-level models for analysing hierarchical data, for example children within a family, where the families are within a community where the community is within a village. Longitudinal data are a special kind of hierarchy. Measurements within an individual over time will be more similar than those between individuals. One of the problems of the analysis of longitudinal data so far has been the need to measure at fixed intervals; this is not necessary using a multi-level model. The model can be used to arrive at more precise predictions of outcomes from existing data.

## 6. RECOMMENDATIONS

During the deliberations the following recommendations were put forward:

1. That a data archive be created in a collaborating centre with suitable facilities.
2. That some common analysis be carried out.
3. That centres join a common computer network to facilitate communication and cooperate analysis of data.
4. That a meeting of investigators and statisticians be held to plan jointly the design of intervention studies and the analysis of data derived from such studies.

ANNEX I

Informal Meeting of the Investigators on  
Secondary Analysis of Longitudinal Data on Growth and Development  
Geneva, 13-15 October 1988

Objectives

1. To discuss reports of the Bogota, (Colombia), the Cali (Colombia), The Guatemala Six Villages (Guatemala), the Jerusalem (Israel) and Sri Lankan studies and decide on inter-relationship between growth and development and significance and predictive power of the milestones of psychosocial development;
2. To review the reports and abstract useful information and data for the development of (a) child's growth and development home-based record and (b) formulation of guidelines on intervention programme;
3. To outline updated procedures and scheme for analysis of longitudinal data on growth and development;
4. To review and discuss the longitudinal data on growth and development analysis scheme in conjunction with GRANDSTAT.

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ANNEX II

Informal Meeting of the Investigators on  
Secondary Analysis of Longitudinal Data on Growth and Development

Geneva, 13-15 October 1988

Agenda

Thursday 13 October

9 a.m.  
Morning Inter-relationship between growth and development and use of longitudinal data for prediction

Afternoon The Bogota study, Dr Lea Vuori Christiansen  
The Cali study, Dr Harrison McKay  
The Guatemala Six Villages study, Dr Ernesto Pollitt

Friday 14 October

Morning The Jerusalem Study, Dr Hava Palti  
The Sri Lankan study, Dr A. Nikapota

Afternoon Abstract from reports useful for the formulation of guidelines on growth and development intervention programme and development of home-based record

Saturday 15 October

Morning Problems of sampling and longitudinal data management  
Use of the programme GRANDSTAT

Afternoon Updating the statistical analysis procedures and scheme for longitudinal data on growth and development

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ANNEX III

Informal Meeting of the Investigators on  
Secondary Analysis of Longitudinal Data on Growth and Development  
Geneva, 13-15 October 1988

Expected outcome

1. Information on inter-relationship between physical growth and psychosocial development;
2. Decision on the significance and predictive power of the milestones of psychosocial development;
3. Information and data for the development of
  - (a) child's growth and development home-based record;
  - (b) guidelines on intervention programmes.
4. Updated procedures and scheme for analysis of longitudinal data on growth and development;
5. Generation of ideas on incorporation of longitudinal data in the software programme - GRANDSTAT.

\* \* \*

ANNEX IV  
Report of the  
Informal Meeting of the Investigators on  
Secondary Analysis of Longitudinal Data on Growth and Development  
Geneva, 13-15 October 1988

List of participants

Dr Lea Vuori Christiansen  
4022 Iva Lane  
Annandale  
Virginia 22003  
USA

Dr Harvey Goldstein  
Professor, Department of Mathematics, Statistics and Computing  
University of London  
Institute of Education  
20 Bedford Way  
London WC1H 0AL  
United Kingdom

Mr Jonathan Gorstein  
Department of Epidemiology and Biostatistics  
Tulane University  
School of Public Health  
1430 Tulane Avenue  
New Orleans, AL 70112  
USA

Dr Richard Lansdown  
Chief, Psychologist, Department of Psychological Medicine  
The Hospitals for Sick Children  
Great Ormond Street  
London WC1N 3JH  
United Kingdom

Dr Harrison McKay  
PO Box 12715  
Research Triangle Park  
North Carolina 27709  
USA

Dr Anula Nikapota  
90 Abbots Rd  
Abbots Langley  
Watford, Herts, WD5 0BH  
United Kingdom

Dr Hava Palti  
Head, Maternal and Child Health Unit  
School of Public Health and Community Medicine  
Hebrew University-Hadassah Medical School  
P.O. Box 1172  
Jerusalem 9100  
Israel

Dr Ernesto Pollitt  
Professor of Human Development  
Department of Applied Behavioural Sciences  
University of California  
Davis, California, 95616  
USA

WHO Secretariat

Dr Heli Bathija, HRP/HRD  
Dr Igor Briazgounov, FHE/MCH  
Dr John Orley, MNH  
Dr P.M. Shah, FHE/MCH

ANNEX VDevelopmental items found to be predictive of later DQ or IQ and/or  
to discriminate disadvantaged children

Age range	Predictive of later scores	Discriminative
<u>0-12 months</u>		
Lifts head	+	+
Rolls from stomach	+	-
Sits alone	+	+
Stands	+	+
Walks	+	+
Babbles	+	-
Non verbal gesture	+	+
Turns head	+	-
Reaches to be picked up	+	-
<u>12-24 months</u>		
Walks	+	+
Pinches	+	-
Picks block	+	-
Puts pebbles in a cup	-	+
Says 1 - 3 words	+	+
Understands command (not more than two actions)	+	+
Names objects	+	+
<u>24-36 months</u>		
Motor skills with coordination (rides tricycle, rolls up mat)	+	+
Expressive vocabulary	+	+
Understands more complex commands	+	+
Dressing	+	+
Washing	+	+
Eating	+	+
Folds paper	+	+
Picks up grain of rice	+	-
Scribbles	+	+
Copies drawing	+	+
Knows name/age	+	+
Cooperates in play	+	+
Knows bigger/smaller	+	+

An analysis of these items suggests that different areas emerge as important at different ages in terms of predictive power.

In the first year: gross motor skills and an indication of interpersonal orientation (an interest in people) and in communicating.

In the second year: verbal items and fine motor skills involving a sequence of skills like folding paper.

In the third year: gross motor skills involving increasing coordination, self help skills.

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