Applying the ICF-CY framework to examine biological and environmental factors in early childhood development

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Background/Purpose: Previous cohort studies for the general pediatric population had a limited focus on either environmental or biological influences, or a specific theoretical framework. The child’s development, however, is a composite of physical, mental, social, environmental, and personal factors. The framework of the International Classification of Functioning, Disability and Health—Children and Youth Version (ICF-CY) provides a comprehensive model for investigating the influential factors of child development within a biopsychosocial perspective.

Methods: A birth cohort study followed up 122 child-parent dyads at birth and when the children were 4 months, 6 months, and 2.5 years old. Structural equation modeling was conducted based on the concept and the definitions of ICF-CY.

Results: The path coefficients linking exposures and outcome variables were significant except for the paths from birth weight to general development of infants and toddlers. Home environment explained 59% of variance of infant developmental outcomes.

Conclusion: The proposed model based on ICF-CY showed acceptable fit to the data and provides support for the importance of the home environment on general development of infants and toddlers.

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Introduction

Evidence from birth cohort studies has demonstrated that early child development underpins later development under the assumption of developmental continuity.¹ The optimization of health promotion in primary care for each child’s general developmental potential from early childhood is the main trend.² Previous cohort studies for the general pediatric population have tended to focus only on environmental³ or biological influences,⁴ or on a specific theoretical framework.¹ As the child’s development is a composite of physical, mental, social, environmental, and personal factors, so using a biopsychosocial perspective is needed to investigate the important risk or protective factors on early childhood development.

The framework of International Classification of Functioning, Disability and Health (ICF)⁵ and it’s Children and Youth Version (ICF-CY)⁶ (Fig. 1) proposed by the World Health Organization (WHO) is derived from multiple views of human development, and reflects a biopsychosocial perspective acknowledging the interaction of Health Condition with Contextual Factors (Environmental and/or Personal Factors), Body Functions and Structures, and Activity and Participation. Although the ICF-CY was developed and published in 2007 after the ICF, it shares the same framework and concept with the ICF and has the same chapters (first level categories). The only difference between the two, is that the ICF-CY had additional or revised lower level categories, which were developed to be sensitive to changes associated with growth and development.⁶ According to the definitions of both ICF and ICF-CY, Health Condition refers to diseases or disorders classified by the International Statistical Classification of Diseases and Related Health Problems; Body Functions and Structures are the psychological and physiological functions of body systems and anatomical parts of the body such as organs, limbs and their components; Environmental Factors make up the physical, social and attitudinal environment in which people live and conduct their lives. There are classifications for these domains but not for Personal Factors including age, sex, and ethnicity. Activities are defined as the execution of a task or action by an individual, while Participation is involved in a life situation, and especially represents societal perspectives of functioning.⁵,⁶ However, the codes of Activities and Participation in the ICF and ICF-CY classification systems are given in a single list; any one code can be used to denote Activities or Participation.⁵,⁶

For young children, the outcomes of general development covering each domain of child development are considered as part of the component of Activities and Participation.⁷ In sum, Health Condition, Body Functions and Structures encompass most of the biological determinants for early childhood. The framework of ICF presented in Fig. 1 can help to model the relationships among multiple biological and environmental determinants and the general development for young children. Besides the Health Condition and Personal Factor in the ICF-CY system, the components of Body Functions and Structures and Environmental Factors consist of a large number of categories with specific code numbers and detailed definitions. For example, in the component of Body Functions and Structures, category b125 is named "dispositions and intra-personal functions". In the Environmental Factors, category e310 is named "immediate family" with definition "the amount of physical and emotional support provided by the immediate family."⁵,⁶ In clinics, the ICF-CY framework has been used at the conceptual level to assist the clinician in determining the prognosis, to set realistic goals, and to decide the intervention strategies for children with developmental delays.⁸ For example, if the relevant measures of categories in the ICF-CY are available, the results of measures can be displayed in the ICF framework for further decision making by professional teams. A collaborative service delivery incorporating the ICF model for children with movement disorders has been presented in a previous study.⁹

The US Centers for Disease Control and Prevention have advanced a national health promotion agenda, "Healthy People 2020", which is focused on promoting quality of life, healthy development and healthy behaviors in the population across life stages.¹⁰ The ICF⁵ and ICF-CY⁶ published by WHO, provide a universal focus which may be applied in the study of children without developmental delays (NDD). Previous research has described various factors and their impacts on mental and language development of children NDD under 3 years old¹¹ within a biopsychosocial perspective, yet no empirical data have been used to verify such biopsychosocial perspectives based on the ICF-CY model. The present study applied the ICF-CY to examine the role of biological and environmental factors on the development of children with NDD. At the time the study was designed in 2003, the ICF-CY⁶ was not published but the framework and the related categories used are the same with ICF, so this paper will refer to the ICF-CY. The purpose of this study was to apply an ICF-CY based model to depict the relationships among multiple factors influencing developmental outcomes of young children with NDD. Such a model showed the effects of the interaction between Environmental Factors and Health Condition on Activities and Participations and could be used for advocacy of health promotion for children with NDD.

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Figure 1  The framework of International Classification of Functioning (ICF) (Adopted from WHO, 2001 with permission).
Materials and methods

Participants

The participants in this study were drawn from the Taipei Birth Panel Study12 based on a longitudinal birth cohort study design. Three hundred and thirty-five infants who were born at the National Taiwan University Hospital between May and October in 2004, were the follow-up subjects, and were to be examined at the ages of 4 months, 6 months, and at around 2.5 years old. Because the purpose of the present study was to build an ICF based model for children with NDD, the criteria for recruiting the participants of the present study were families with children with NDD (developmental quotients ≥70 in all developmental domains). Of the 335 infants, contact was lost for 80 (24%) children because of incomplete information on self-report questionnaires at the age of 4 months. At the 6 months assessment, 97 (29%) cases did not receive the required tests or interviews due to multiple reasons, such as moving to other countries (n = 6), refusing to be interviewed at home (n = 21), losing contact (n = 7), and unspecified reasons (n = 63). The remaining 158 cases had met the criteria of NDD. At the third follow-up, when the children were around 2.5 years old (toddler stage), another 36 (10%) cases were lost because two moved to other countries, three were parental refusals, one lost contact, and 30 had other reasons. The rest of the 122 children met the selection criteria of NDD, although some of them presented minor biological risks at birth or post-natal stage (8 cases with Apgar scores 1 minute < 8, 1 case with Apgar scores 5 minutes < 8, 4 cases with congenital heart disease, and 1 case with seizure in infancy).

Given the high attrition rate (64%), we compared the available basic information of children and their family backgrounds for participants and lost cases (Table 1). The demographic data revealed no statistical differences between the two groups except for a higher proportion of preterm children for those lost to follow-up at toddler age (χ² = 4.36, p < 0.05). The proportion of low-birth-weight infants (birth weight < 2,500 g) in the present data (3%) was lower than the prevalence of the general population (6%–8%).

An outcome model based on the ICF-CY framework

Among the components of the ICF-CY, Activity and Participation is considered the most important outcome for young children.14 Young children’s general development was assessed with a comprehensive developmental test, designed to capture the ICF-CY component of Activity and Participation.8 Health Condition, Body Function and Structures, Environmental Factors, and Personal Factors were identified as the multiple predictors of children’s developmental outcomes.14

For measuring Health Condition in the NDD pediatric population, birth weight was identified as one of the indexes,15 and was found to be a predictor of later cognitive development.4 For Body Functions and Structures, many studies have demonstrated the impact of movement-related factors on developmental outcomes, such as Involuntary Movement Reaction Function (ICF category b755, such as sitting balance),13 Muscle Power Function (ICF b730), Muscle Tone Function (ICF b735),16 Seeing Function (ICF b210),17 Hearing Functions (ICF b230)18,19 and Attention (ICF b140).20,21 Dispositions and Intra-Personal Functions (such as infant temperament) (ICF b125) variables have also been found to be predictors of children’s cognitive and social behavior outcomes with variation among typical developed children.22,23 The pathway from child temperament to development would further be mediated by the effects of family functioning.22

Home environment has been found to be a very influential factor of infant development based on the bioecological model,24 family system perspective,25 and empirical evidence,26 and represents a variable covered in Environmental Factors of ICF-CY. Physical stimulation and social stimulation24 provided for young children would be documented with codes in the Environment Factor domains (ICF e140: product and technology for personal use in daily living; ICF e120: product and technology for personal indoor and outdoor mobility and transportation; ICF e130: product and technology for education; ICF e310: immediate family; e410: outdoor mobility and transportation; ICF e120: product and technology for personal use in daily living; ICF e130: product and technology for education; ICF e310: immediate family; e410: individual attitudes of immediate family members) at home. Furthermore, an infant’s home environment has also been suggested to be related to infant temperament and developmental outcomes in Transactional Models,27 and the Process Model.28 The living environment would have a relatively larger effect on a child’s development at a younger age, and the developmental outcomes at an older age are mainly influenced by optimal development at a younger age.1
Age, gender, and ethnicity were not analyzed in the present study for several reasons. Firstly, the scores for child outcomes were adjusted by age because developmental quotients (DQs) were used; the impact of multiple factors on development showed no gender differences in young children. Secondly, there would also be minimal differences in racial considerations, since the parents in this study are all from Asia.

However, when ICF codes were identified as variables for analysis of the NDD children aged <2 years, two problems were encountered in this study. Firstly, most variables associated with small variance would limit statistical analyses. Secondly, the valid and reliable measures for some relevant categories were not available for very young children and some modified or self-developed measures would be needed. As a result, in the present study based on the ICF-CY framework, variables were selected which had adequate variation and for which measures were available for typically developing children. After a comprehensive literature review, an ICF-CY based model for general development in early childhood was proposed and is illustrated in Fig. 2.

**Procedures**

The study was as approved by the Human Subjects Review Committee at National Taiwan University Hospital (NTUH), Taiwan. Informed consent was obtained from all the participating mothers who had arranged to give birth to a child at NTUH in Taiwan. Data on children’s health conditions, including birth weight, gestational age, and sex, as well as social economic status (SES) of the parents was collected. The Revised Infant Temperament Questionnaire (RITQ)23 was mailed to the mothers when the children were 4 months of age. When the child was 6 months of age, the trained testers administered three measures at the infants’ home: the Sitting Balance Scale (SBS), the Comprehensive Developmental Inventory for Infants and Toddlers (CDIIT), and the Home Observation for Measurement of the Environment- Infant/Toddler version (IT-HOME). Test summary reports were mailed to parents within 2 weeks after the home visit, in order to remind the parents to continue the follow-up. When the children were around 2.5 years old, the parents were informed to arrange a follow up with CDIIT at the laboratory. Testers and interviewers visiting the children’s homes at the three specified ages were blind to the assessment made in the laboratory. In the following sections describing measures and constructs, the information is organized within the four domains of the ICF-CY.

**Measures and constructs**

**Activity and participation (general development) - The Comprehensive Developmental Inventory for Infants and Toddlers (CDIIT)**

The CDIIT is a developmental test commonly used to make a developmental diagnosis of infants and toddlers aged 3 to 71 months in Taiwan. The CDIIT has acceptable test-retest reliability ($r = 0.89–0.99, p < 0.001$), internal consistency (Cronbach $\alpha = 0.75–0.99$), content, concurrent and construct validity.30 The DQs of the two factors of the CDIIT in the infant stage and toddler stage (Perceptual-motor and Social-adaptive)32 were defined as the outcome variables in this study.

**Body Function and Structures (biological determinants) - Muscle Power Function and Muscle Tone Function test**

The test was modified from de Groot et al.,33 including three items for shoulder, trunk and legs. For shoulder, the
amount of power generated in the arms and shoulders (during traction test), trunk (active extension in ventral suspension), and legs (Bauer reaction by abducting the legs with extended knee while measuring the degree of the adductors’ angle) were scored. Each item contained three response options: weakness, normal, and abnormal. Weakness referred to inadequate muscle power, while abnormal represented hypertonicity in these body parts.

Body Function and Structures (biological determinants) - Seeing Function test

The test item of seeing function was modified from Battelle Developmental Inventory for detecting the ability to see in 6-month-old infants. The item tests the infant’s looking downward immediately after a red object was dropped in front of the infant’s eye level in the supported sitting position. The infant’s seeing function is scored 0 (the infant look downward successfully in 2/3 repetitions), 1 (successfully in 1/3 repetitions), or 2 (no successful trial).

Body Function and Structures (biological determinants) - Hearing Functions Test

The item for detecting the ability to hear in 6-month-old infants was also drawn from the Battelle Developmental Inventory. For this item, the tester stands behind the infant and makes a sound with the rattle from the infant’s left side and right side, respectively. The item was scored 0 if the infant oriented to both sides, 1 if to one of either side, and 2 for no orientation response.

Body Function and Structures (biological determinants) – Attention Function test

To assess attention, an item was designed to measure infants’ sustained and focused attention. This test was modified from Ruff et al’s study, with infants observed during the visit for sustained attention to any object, or people by looking or orienting toward them for 15 seconds. Focused visual attention was observed in terms of the gaze, facial expression, posture, and degree of bodily and vocal activity of the infant. The item was scored 0 with over 90% appropriate responses for the observation, 1 for 89%–50% appropriate responses, 2 for <50% appropriate responses.

Body Function and Structures (biological determinants) - Revised Infant Temperament Questionnaire (RITQ)

The RITQ is a 95-item parent response questionnaire and was standardized on 254 infants aged from 4 to 8 months in Taiwan, with acceptable test-retest reliability ($r = 0.67–0.90$, $p < 0.05$). The sub-domains of the RITQ include: activity level, rhythmicity, approach or withdrawal, adaptability, persistence and attention, threshold, intensity of reaction, quality of mood. Temperament types have been defined as easy, intermediate low, intermediate high, slow to warm up, difficult.

Body Function and Structures (biological determinants) - Sitting Balance Scale (SBS)

The SBS was developed in the present study for testing postural control in the sitting position at 6 months of age. The scores range from 0 to 7, with increasing capacity in sitting balance (0 = leaning body against the wall for 0–1.9 seconds; 1 = leaning body against the wall for ≥2 seconds; 2 = sitting without help for 0–9.9 seconds; 3 = sitting without help for 10–14.9 seconds; 4 = sitting without help for 15–29.9 seconds; 5 = sitting without help for 30 seconds or more; 6 = retrieving toy 10 cm in front of the child in the sitting position, without losing balance; 7 = retrieving toy 15 cm from both sides of the child without losing balance). The test-retest weighted kappa coefficients ($\kappa = 0.78$, 95% CI: 0.63–0.93) indicated good reliability in our pilot study.

Environmental Factors (environmental determinants)- Home Observation for Measurement of the Environment - Infant/Toddler version (IT-HOME)

The IT-HOME consists of 45 binary items clustered into 6 domains: Responsivity, Acceptance, Organization, Learning Materials, Involvement, and Variety. A 1-hour period is used by trained testers to complete the IT-HOME by interviewing the caregivers and observing the parent-child interaction.

The internal consistency was 0.44–0.89. The inter-rater reliability of ratings by 32 participants in this study sample was moderate to good. The convergent validity values SES were low to moderate. Four (Organization, Learning Material, Variety, and Involvement) of the six domains in the IT-HOME were selected as indicators for the infant home environment in the study, because of relevance to developmental outcomes for children younger than 3 years old.

Data analysis

Initial descriptive data analysis of the data indicated minimal variation for a number of variables. The item for Muscle Power Function and Muscle Tone Function tests showed that only five infants (4%) were scored for weakness on the traction test, and two (2%) infants were scored for weakness on the ventral suspension and Bauer reaction test. No infants were scored abnormal on the three tests. More than 95% of the infants in the sample had optimal scores on Seeing, Hearing, and Attention Functions. Only a small portion of infants were partially successful in the performance of Seeing Function (2%), Hearing Function (5%) and Attention Function (5%). Consequently, these variables (indicated by dashed circles and arrows in Fig. 2) were removed and not included for further statistical analyses. However, the sitting balance function defined by ICF-CY code b755 Involuntary Movement Reaction Function was retained, as it was found to predict motor-related functions in a previous study.

To examine the ICF-CY based model illustrated in Fig. 2, structural equation modeling was used removing variables with minimal variation. The final model defined three latent variables (Fig. 3) with 11 related measurable variables (Table 2) used to analyze the longitudinal follow-up data. Univariate distributions for all the 11 measurable variables were examined for normality and
outliers with the Statistical Package for Social Science version 13.0 (SPSS, Inc., Chicago, IL, USA, 2004). Structural equation modeling was conducted with EQS 6.1 (Multivariate Software, Inc., Encino, CA, USA, 2004) on the covariance matrix of the 11 variables. The method of maximum likelihood was applied considering the distributions of the variables. The proposed model was evaluated by Chi-square statistic and other fit indexes.

Figure 3 Parameter estimates of the ICF-CY based model for developmental outcomes of infants and toddlers. DQ: developmental quotient; PM, Perceptual-motor; SA, Social-adaptive; OR, Organization; MA, Material; VA, Variety; IN, Involvement. Standardized coefficients are presented along with solid arrows. Dashed arrows indicate non-significant paths *

Table 2 Descriptive statistics of 11 variables in the final model.

<table>
<thead>
<tr>
<th>Type of variables</th>
<th>ICF components</th>
<th>Measures</th>
<th>Variable names</th>
<th>Mean</th>
<th>SD</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td>Health Condition</td>
<td>Birth weight</td>
<td>3201.1</td>
<td>427.5</td>
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<td>0.92</td>
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<tr>
<td>determinants</td>
<td>Body Function</td>
<td>RITQ</td>
<td>Temperament type</td>
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<td>0.5</td>
<td>-0.22</td>
<td>-0.31</td>
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<td></td>
<td>SBS</td>
<td>Sitting balance</td>
<td>2.6</td>
<td>1.8</td>
<td>0.81</td>
<td>-0.68</td>
<td></td>
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<td>Environmental</td>
<td>Environment</td>
<td>IT- HOME</td>
<td>HOME-Organization</td>
<td>5.1</td>
<td>0.9</td>
<td>-0.27</td>
<td>-1.25</td>
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<td>determinants</td>
<td></td>
<td>HOME-Material</td>
<td>7.3</td>
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<td>0.7</td>
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<td></td>
<td></td>
<td>HOME-Involvement</td>
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<td>1.0</td>
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<td>Developmental</td>
<td>Activity and Participation</td>
<td>CDIIT at infant stage</td>
<td>Infant Perceptual-motor DQs</td>
<td>95.1</td>
<td>5.6</td>
<td>0.39</td>
<td>1.57</td>
</tr>
<tr>
<td>outcomes</td>
<td></td>
<td>CDIIT at toddler stage</td>
<td>Infant Social-adaptive DQs</td>
<td>103.8</td>
<td>8.6</td>
<td>-0.11</td>
<td>-0.29</td>
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<td></td>
<td></td>
<td></td>
<td>Toddler Social-adaptive DQs</td>
<td>100.9</td>
<td>9.0</td>
<td>-0.46</td>
<td>0.39</td>
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</table>

CDIIT = The Comprehensive Developmental Inventory for Infants and Toddlers; DQ = Development quotient; IT- HOME = Home Observation for Measurement of the Environment - Infant/Toddler version; RITQ = Revised Infant Temperament Questionnaire; SBS = Sitting Balance Scale.
The fit indexes are developed to indicate whether the theoretical model is a good fit to the data. Acceptable models usually show a low Chi-square value given the number of degrees of freedom and an insignificant $p$ value, high goodness-of-fit indexes, such as Bollen’s Fit Index (IFI), Relative Noncentrality Index (RNI), Comparative Fit Index (CFI), etc., and low standardized root mean squared residual (SRMR). Hu and Bentler proposed a 2-index strategy for model evaluation with the Maximum Likelihood method, assessing model fit with SRMR supplemented by either the Tucker-Lewis Index (TLI), IFI, RNI, CFI, Gamma Hat, McDonald’s Centrality Index (MFI), or root mean square error of approximation (RMSEA). Regarding the fit indexes (that is, SRMR, TLI, IFI, CFI, MFI, and RMSEA) provided by EQS 6.1, a cutoff value of 0.08 for SRMR, 0.95 for TLI, 0.95 for IFI, 0.95 for CFI, 0.90 for MFI, and RMSEA) were identified.

Results

Descriptive statistics and intercorrelations

The descriptive statistics of the 11 variables are listed in Table 2. All variables had skewness and kurtosis in the range between $\pm 2$. Table 3 presents the correlations among the variables. The variables under the constructs of Health Condition (birth weight), Body Functions (temperament type, sitting balance), and part of Environment Factors (IT-HOME-Organization, Material, Involvement) correlated to at least one factor of general development (CDIIT-Perceptual-motor DQ, Social-adaptive DQ) at the infant stage, while only part of the Environment Factors (HOME-Material, Variety, Involvement) were related to general development at the toddler stage. The DQs of general development for both ages were correlated with each other except Perceptual-motor DQ at the toddler stage.

Structural equation modeling

Fig. 3 illustrates the parameter estimates of the proposed hypothetical model. The fit indexes ($\chi^2/df = 44.2, p = 0.34$, SRMR = 0.07, TLI = 0.96, IFI = 0.98, CFI = 0.97, MFI = 0.99, RMSEA = 0.03 with a 95% CI of 0.00–0.07) indicate acceptable model fit according to differing combinations in the 2-index strategy. Part of the standardized estimates are presented in Fig. 3. The paths from birth weight to infant CDIIT and from birth weight to toddler CDIIT were not statistically significant. The temperament type at 4 months affected the developmental outcomes at 6 months through home environment factor in infancy. Sitting balance had an effect on Perceptual-motor DQ at 6 months. In addition, the findings pointed out the continuous effect of developmental outcomes from infancy to toddler ages.

Discussion

Biological factors

Birth weight predicting general development
There was no direct impact of birth weight on the developmental outcomes at either the infants or toddlers stage in the present study. In previous studies, differences in developmental outcomes between low birth weight children and those with normal birth weight have been found to be minimal or trivial in infancy. However, the developmental differences were more significant when the children reached ages 12 months to 3 years. Moreover, a study has shown that even among infants born within a normal weight range (2500 g–4000 g), those with a heavier weight had a better cognitive outcomes than those with a lighter weight at age 7 and later through adulthood. The lack of predictability of birth weight for general development found in this present study may contradict the previous findings. The possible reason might be that there were only 3% low-birth-weight infants (birth weight $< 2, 500$ g) in the present data.

Sitting balance and general development
Sitting balance was selectively related to Perceptual-motor DQ at the infant stage in the present findings. Other studies have found basic postural control ability in early infancy to affect later motor development. From a theoretical perspective, sitting balance should affect general development in that better balance in the sitting position allows a child to sit independently without other

Table 3 Correlation matrix of the 11 measurable variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight</td>
<td>1.00</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperament type</td>
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<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting balance</td>
<td>0.08</td>
<td>-0.01</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HOME-Organization</td>
<td>0.07</td>
<td>-0.17</td>
<td>0.02</td>
<td>1.00</td>
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<td>HOME-Material</td>
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<tr>
<td>HOME-Variety</td>
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<td>-0.15</td>
<td>-0.04</td>
<td>0.12</td>
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<td>HOME-Involvement</td>
<td>0.241</td>
<td>-0.06</td>
<td>0.16</td>
<td>0.201</td>
<td>0.241</td>
<td>0.221</td>
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<td></td>
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<tr>
<td>Infant Perceptual-motor DQs</td>
<td>0.16</td>
<td>-0.15</td>
<td>0.491</td>
<td>0.23*</td>
<td>0.19*</td>
<td>0.02</td>
<td>0.271</td>
<td>1.00</td>
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<tr>
<td>Infant Social-adaptive DQs</td>
<td>0.19*</td>
<td>-0.18*</td>
<td>-0.07</td>
<td>0.231</td>
<td>0.05</td>
<td>0.09</td>
<td>0.16</td>
<td>0.18*</td>
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</tr>
<tr>
<td>Toddler Perceptual-motor DQs</td>
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<td>0.09</td>
<td>0.06</td>
<td>0.201</td>
<td>0.10</td>
<td>0.21*</td>
<td>0.17</td>
<td>0.09</td>
<td>1.00</td>
</tr>
<tr>
<td>Toddler Social-adaptive DQs</td>
<td>0.16</td>
<td>-0.14</td>
<td>0.04</td>
<td>0.16</td>
<td>0.13</td>
<td>0.21*</td>
<td>0.20*</td>
<td>0.23*</td>
<td>0.251</td>
<td>0.431</td>
</tr>
</tbody>
</table>

*p < 0.05; *p < 0.01.

Infant DQ = Developmental Quotient of the Comprehensive Developmental Inventory for Infants and Toddlers at 6 months.
assistance, freeing the child’s hands to manipulate objects, with implications for stimulating motor development and enhancing the child’s cognitive development.\(^{46}\)

Temperament type and general development

A difficult temperament in the infant stage was hypothesized to impair early child outcomes in this study, based on various theories of child development theory.\(^{47}\) The common description in these theories reveals two potential pathways that may predict a child’s developmental outcomes through his/her temperament. One is that the early temperament will directly affect the later outcomes; the other is that the environmental factors, such as parenting style, would mediate the relationship between the child’s temperament and his/her developmental outcomes.\(^{22}\) However, for the direct pathway, most empirical findings on the relationship between the child’s temperament and his/her development outcomes have been inconclusive.\(^{22}\) On the other hand, the findings of the indirect pathway in this study were consistent with findings of previous studies.\(^{22}\)

Our findings also revealed that environmental factors do mediate the impact of temperament on general development in infancy. These findings also imply that an easy-tempered child would facilitate his/her parents in providing a better environment, while a child with a difficult temperament might induce a less favored home environment within Taiwan’s cultural context. In other words, infant temperament might affect home environment, which might in turn affect infant development.

Environmental factors

Home environment at infant stage and general development

An early home environment providing social and physical stimulation in infancy, accounts for variations in later developmental outcomes.\(^{29}\) When home environment and birth weight were both considered as the predictors of general development under the ICF-CY based model, home environment could explain 59\% (calculated by the square of path coefficient of 0.77 from HOME to Infant DQ in Fig. 3) of the variance of infant outcomes, whereas birth weight did not. Previous studies have demonstrated the importance of the early home environment for child development beginning at very young ages.\(^{48}\) However, most previous studies focused on children in an adverse home environment, and their HOME scores were below the cut-off point for risk in the home environment.\(^{31}\) The HOME scores of this present sample were all above the suggested cut-off point. Therefore, even for infants in a non-risk home environment, the quality of home environment could still be one of the determinants of optimal development. Moreover, the home environment would serve as a mediator between temperament and general development in infancy, in that the effect of early environment on toddler development was relatively indirect (Fig. 3). This finding was consistent with previous research showing that the home environment has a relatively larger effect on the child’s development at a younger age.\(^{3}\) According to this derived model, some of the multiple biological and environmental determinants in this study would affect children’s development throughout infancy till toddler age.

Limitations

This study began in 2003 when the ICF-CY\(^{6}\) was not available; it was not published until 2007. Therefore, only the categories available in the ICF were selected for data collection and analysis of the present study. In this study, developmental outcomes were represented by codes from the Activities and Participation domain with the influence of multiple factors on early childhood development simultaneously estimated using the SEM technique. Although some environmental factors in the ICF-CY could be of importance as possible determinants of developmental outcome, they were not entered in the model because their addition would decrease the statistical power of the analysis. Further, it was assumed that variation would be minimal for factors such as the natural environment (ICF category e2) and food and drugs (ICF category e1) in that under the National Health Insurance System and Child Welfare Act in Taiwan, nearly all children in the study would receive food, drug and health care services as needed. In addition, environmental factors other than immediate family would be expected to have little effect on the results of this study. As the ICF-CY includes four new second level categories in Body Function and 14 new categories in Activities and Participation,\(^{49}\) it may be useful to add them as variables in the future for the ICF-CY based models examining developmental outcomes of young children.

Further, although the most important factors were retrieved from literature review and used in this study, some distal influential factors such as parental education, stress or SES, and other personal factors on infants and toddlers may also be useful to examine in future research.

Conclusions

The use of the ICF-CY as a multi-dimensional model to examine the nature of early childhood development was supported by the findings of this study. The definitions of categories in the ICF-CY/ICF components facilitated the search for measurable variables in the multi-dimensional model. Objective measures of biological or environmental determinants used in this study predicted developmental outcomes in early childhood for children without developmental delays. Those measures which are available and easily used in Taiwan, such as Sitting Balance Scale, Home Observation for Measurement of the Environment - Infant/Toddler version, Temperament Questionnaire, can be used as potential tools for monitoring the Body Functions and Environment for children in early life. The model based on the ICF-CY framework represented a useful approach for explaining the direct and indirect impact of multiple biological and environmental determinants on general development in early childhood. In addition, the use of the derived model offers implications for promoting early child development. The potential intervention strategies include facilitating infants’ postural control and enriching the home environment through the parents’ education and training.

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References


