



# Development and Validation of Age-Specific Resilience Instruments for Early Childhood Assessment: A Taiwan Birth Cohort Study

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## ABSTRACT

**BACKGROUND:** We sought to develop and validate age-specific instruments for measuring early childhood resilience at ages 3, 5 and 8 in the Taiwan Birth Cohort Study, a national longitudinal study.

**METHODS:** Using data from 18,553 mother-infant pairs, we conducted exploratory factor analysis (EFA) on a simple random half of our sample. We then used the remaining half of these data for confirmatory factor analysis (CFA) to further assess the fit of 3 CFA models (ie, first-order, second-order, and bifactor). Psychometric properties, distributions, and inter-item and inter-factor correlations of each instrument were also evaluated.

**RESULTS:** EFA and CFA showed that the bifactor model of resilience (which included a general resilience factor and 5 specific factors) had the best fit for all 3 resilience scales, with 19 items at year 3, 18 items at year 5, and 19 items at year 8. All 3 resilience scales showed good psychometric properties,

including construct validity, internal consistency, and normal distributions. For predictive validity, we found that in the face of adversity (measured by the High Risk Family Score), individuals with high resilience scores at age 3 had better general health scores at ages 3, 5, and 8 compared to those with low resilience scores.

**CONCLUSIONS:** We describe the development and validation of age-appropriate survey instruments to assess resilience in young children at the population level. These instruments can be used to better understand how resilience can impact child health over time, and to identify key factors that can foster resilience.

**KEYWORDS:** early childhood; general health; psychometric properties; resilience

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## WHAT'S NEW

Few instruments have assessed resilience during early childhood at the population level. Using a large, nationally representative cohort, we describe the development and validation of novel survey instruments to assess resilience at ages 3, 5, and 8.

PREVIOUS RESEARCH HAS characterized resilience as the capacity for an individual to successfully develop positive adaptations enabling one to thrive in the face of social adversity or environmental risks.<sup>1–3</sup> However, there is little consensus on defining resilience. Ann Masten and colleagues<sup>4</sup> define resilience as a “successful adaptation,” while Michael Rutter<sup>1</sup> considers it to be “psychologically doing relatively well compared to others in similar at-risk situations.” Luthar and Cicchetti, on the other hand, describe resilience as stemming from the interplay

between risk and protective factors, where protective factors can either compensate for the risk or buffer its effect.<sup>5,6</sup> Despite these varying definitions, there is recognition that resilience is not simply a personality trait; it is a dynamic process that continues to evolve throughout one's life course.<sup>7</sup>

Waves of resilience research since the 1970s have evolved from a psychopathology-based approach to a multi-disciplinary approach, such as in the context of stress response systems (eg, genetic factors, epigenetic factors, etc.)<sup>8,9</sup> and socio-ecological influences by age,<sup>10</sup> gender,<sup>10</sup> social context,<sup>11</sup> and cultural origin.<sup>12</sup> This trend allows for identifying factors modifiable to improve long-term outcomes for “at-risk” individuals, particularly young children.<sup>13</sup> Children who experience adversities early on are often considered at risk for failing, and yet some still succeed. Thus, better understandings of how to promote and foster resilience among young children are

imperative for their development, health, well-being, and success later in life.

Close parental attachment during early childhood is critical for regulating cognitive, physiological, and stress response states. Protective factors, such as supportive parenting styles<sup>14</sup> and positive school environments,<sup>12</sup> have been associated with increased resilience among children. Yet, it is unclear when certain factors begin to contribute to a child's resilience. Some internal factors, such as sense of self, are age dependent but may also be culturally and socially fostered.<sup>10,15,16</sup> Much resilience research to date has focused on older school-age children in Western populations, with few validations in Asian populations.<sup>17–19</sup> As global health crises and conflicts among nations increase, the need to understand how to build and foster resilience at a larger scale that also accounts for the child's age, culture, and social environment is evident.

In this study, we report on the development and validation of survey instruments that measure early childhood resilience at ages 3, 5, and 8, where early childhood refers to the period from birth to age 8.<sup>20</sup>

## METHODS

### STUDY PARTICIPANTS AND SAMPLING

We used datasets from the Taiwan Birth Cohort Study (TBCS), a prospective, nationally representative cohort study that aims to follow over 20,000 children from birth to adulthood, in order to provide information on health, developmental outcomes, and factors that affect them from the life course perspective.<sup>21</sup> Face-to-face interview surveys by trained researchers with mothers or primary caregivers were conducted when infants of the cohort were 6 months (baseline 21,248 mother-infant pairs), 18 months (response rate 94.9%), 3 years (93.7%), 5 years (92.8%), and 8 years (91.8%) of age. The resilience instruments were developed from the 3-year, 5-year, and 8-year follow-up surveys, which we will refer to as T1, T2, and T3, respectively here forward. Written informed consent was obtained from the mother and ethics approval was granted by relevant institutional review boards.

### CONCEPTUAL FRAMEWORK OF RESILIENCE

We adapted our conceptual framework of resilience (Fig. 1) from the Healthy Kids Resilience Assessment by Constantine and Benard, who proposed that internal factors are resilience-driving traits while external factors encompass influences from the child's home, school, community, and peer environments.<sup>18</sup> In our framework, we incorporated internal factors including Sense of Self, Adaptability to Surroundings, Social Competence, Problem Solving, and Empathy. We also retained 2 external factors, namely Caring Relationships in the Home and Meaningful Participation in the Home. Given that East Asian cultures place strong emphasis on familial relationships in the home,<sup>22</sup> we further built upon Constantine

and Benard's theory by hypothesizing that these 2 external factors would remain consistent across all time points, while other internal factors (eg, Problem Solving and Empathy) may be more relevant to resilience as a child gets older.

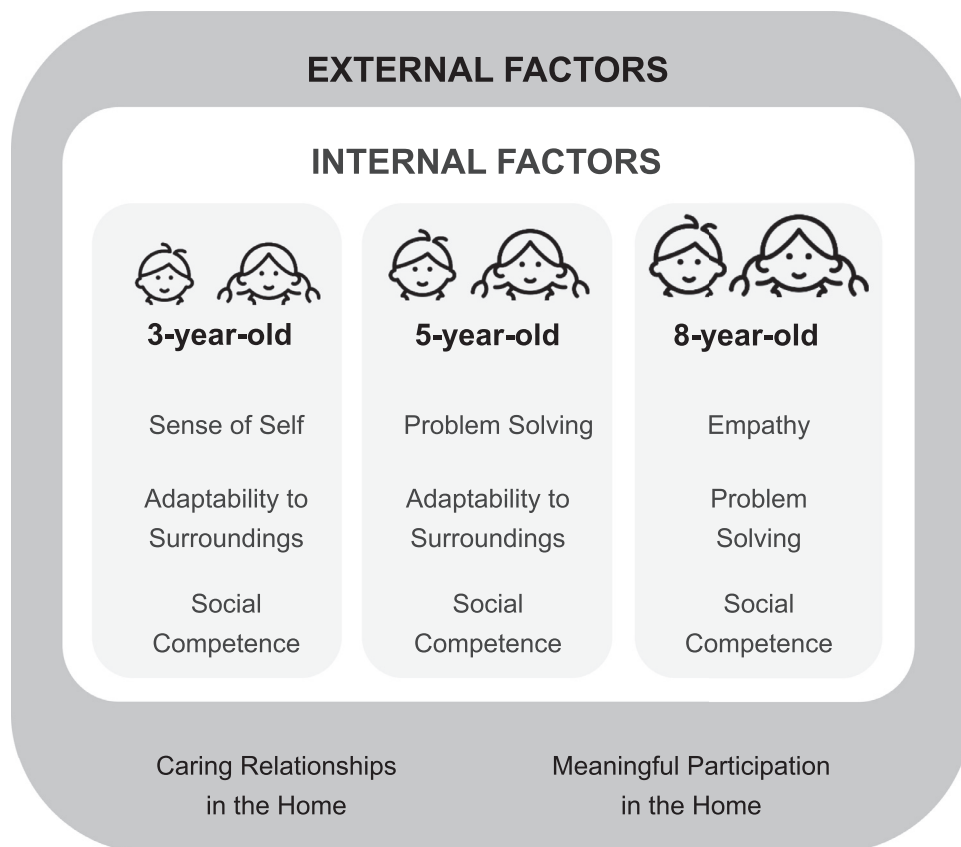
### DEVELOPMENT OF THE TAIWAN BIRTH COHORT STUDY RESILIENCE INSTRUMENT

We pulled T1, T2, and T3 resilience items from the respective TBCS questionnaires, some of which were specifically designed to assess resilience; other related items were also considered based on our conceptual model. In our initial selection, there were 25 total items for T1, 58 items for T2, and 38 items for T3. All items were carefully reviewed by child development experts to ensure content validity; expert opinion confirmed that items adequately represented the content of their domains. Items were also compared to resilience items found in the literature<sup>17,18,23–31</sup>; they were assessed for harmonization, cultural sensitivity, and age appropriateness. Both Chinese and English translations and back translations of each survey were examined by an independent reviewer fluent in both languages.

Exploratory factor analysis (EFA) was used to further reduce the initial selection of items and explore the underlying factor structure. We then used confirmatory factor analysis (CFA) to assess the model fit of the factor structure. To create a composite resilience score, 5-point Likert scales were assigned a score between 0 and 100. For instance, when parents were asked "*In the past month, the child has asked for help when [they] had questions or faced difficulties,*" always = 100, often = 75, sometimes = 50, occasionally = 25, and never = 0. Likewise, 7-point Likert scales (eg, Does the child's behavior fit the following description? 1 = completely doesn't fit; 7 = completely fits) were converted into a score between 0 and 100 as shown in [Supplemental Table 1](#). Responses that were either "don't know," "not applicable," or "unknown" were treated as missing. Resilience scores at the instrument and factor levels were calculated by averaging the scores of all items within an instrument or factor; total distributions were then plotted for the cohort.

### STATISTICAL ANALYSIS

Exploratory factor analysis (EFA) using Promax rotation was used to reduce the initial selection of items into their simplest factor structure. We assessed the factorability of items by using a Kaiser-Meyer-Olkin (KMO) index  $\geq 0.6$  and a Bartlett's Test of Sphericity significance  $\leq 0.05$ .<sup>32</sup> To determine the number of factors to extract, we followed the Kaiser-Guttman criterion<sup>33,34</sup> of retaining factors with an eigenvalue  $> 1$  and the scree test. Items with loading values  $< 0.4$  were dropped before re-running the EFA with retained items. This process was iterated until all items loaded significantly onto a factor and the rotated factor pattern reached its simplest structure with no cross-loadings. Model fit adequacy of first-order,



**Figure 1.** Conceptual framework of resilience for the Taiwan Birth Cohort Study. Age-appropriate internal and external factors for the 3-year, 5-year, and 8-year-old instruments were adapted from Constantine et al's Healthy Kids Resilience Assessment. Internal factors include resilience-driving traits while external factors encompass influences from the child's home environment. Some domain names remained consistent throughout the 3 time points (ie, social competence, caring relationships in the home, and meaningful participation in the home), while others were specific to the child's biological age (ie, Sense of Self for age 3, Adaptability to Surroundings for ages 3 and 5, Problem Solving for ages 5 and 8, and Empathy for age 8). Sense of Self refers to the child's sense of personal identity, Adaptability to Surroundings refers to the child's reactivity to external stimuli in their direct environment, Social Competence refers to the child's ability to communicate effectively in social settings, Problem Solving refers to the child's ability to think critically and examine multiple perspectives before taking action, and Empathy refers to the child's understanding and caring about another's experiences and feelings.

second-order, and bifactor CFAs was evaluated by the chi-square test, Akaike Information Criterion (AIC), Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA). CFI compares fit of the specified model to that of a null model. Normally, a value  $>0.9$  but preferably  $\geq 0.95$  indicates good fit.<sup>35</sup> Finally, RMSEA assesses residuals in the specified model, where a value  $<0.06$  with a  $P$  value  $>.05$  indicates good fit.<sup>36</sup>

We then conducted descriptive statistics on the finalized items and plotted the population distribution of resilience scores at each time point. Internal consistency for factors and instruments was determined by Cronbach's alpha. We considered an alpha between .7 and .9 acceptable as alpha values  $<.7$  may suggest a lack of homogeneity, while  $>0.9$  may suggest redundancies.<sup>37,38</sup> Although Cronbach's alpha does not specifically measure homogeneity as it is susceptible to the number of items (ie, greater numbers of items yield higher alpha values), it is still an important concept in evaluating instruments for further adding validity and accuracy to the interpretation of

our data besides factor analysis, which identifies dimensionality.<sup>38</sup>

Predictive validity was assessed by examining the association of resilience with general health in the context of High Risk Family (HRF) scores among individuals at 3, 5, and 8 years of age. We assessed general health using the item, "Generally speaking, how would you rate [their] health status?" as reported by the child's mother/primary caregiver. The variable was coded into 3 groups: poor/fair (very poor, poor, fair), good, and very good health. The HRF score is a composite of 6 risk factors: poverty (parental monthly income of  $\leq$  NT\$30,000 or US \$1000), both parents having poor general health, low family APGAR score ( $\leq 3$ ), both parents having less than a senior high school education, parents not being married, and both parents being unemployed.<sup>39</sup> We used Student's  $t$ -tests to compare the significant difference in general health scores between individuals with high resilience ( $\geq 90$ th percentile) and those with low resilience ( $\leq 10$ th percentile).

All  $P$  values were 2-tailed, calculated at the 95% confidence interval. Statistical analyses were performed using R version 4.1.2 (R Core Team, 2021).

## RESULTS

### STUDY PARTICIPANTS

Among the 24,200 mother-infant pairs who were sampled, 21,248 (87.8%) completed the first follow-up interview when the infants were 6 months old. About 2952 (12.2%) were lost to follow-up due to incorrect addresses (358/2952; 12.1%), refusal to be interviewed (1734/2952; 58.7%), having moved abroad (351/2952; 11.9%), no one being at home on multiple visits (104/2952; 3.5%), death of the infant (67/2952; 2.3%), and other reasons (338/2952; 11.4%). A total of 19,910 mother-infant pairs remained at the 3-year follow-up (T1), 19,721 at the 5-year (T2), and 19,519 at the 8-year (T3). In our final analysis, we included 18,553 (93.2%) mother-infant pairs who completed follow-up surveys at T1, T2, and T3 to ensure that we assessed resilience among the same individuals over time. Of the 18,553 mother-infant pairs, 8820 (47.5%) children were female and the proportion of parents living in poverty (average monthly salary income of NT\$30,000/~US\$1000 or less) was consistently around 13% for each time point.

### CONSTRUCT VALIDITY AND RELIABILITY

#### EXPLORATORY FACTOR ANALYSIS

We randomly selected half of the participants ( $N = 9276$ ) for exploratory factor analysis to explore the underlying factor structure and further reduce the number of items. Factorability was favorable at all time points (T1:  $KMO = 0.87$ , Bartlett's test of sphericity:  $\chi^2(300) = 72891.74$ ,  $P < .0001$ ; T2:  $0.90$ ,  $\chi^2(1653) = 122,699.78$ ,  $P < .0001$ ; T3:  $0.91$ ,  $\chi^2(703) = 98,919.65$ ,  $P < .0001$ ).

For T1, 2 iterations of EFA resulted in a 5-factor structure that explained 64% of the variance. Since all items loaded significantly onto a single factor (ie, no cross-loadings) with at least 3 items in each factor, we concluded that the 5-factor model was the most parsimonious factor structure. A total of 19 items remained in the final factor structure, with 7 items in Caring Relationships in the Home, 3 in Sense of Self, 3 in Meaningful Participation in the Home, 3 in Adaptability to Surroundings, and 3 in Social Competence. For T2, after 6 rounds of EFA, the simplest factor structure resulted in a 5-factor model (explaining 62% of total variance) of 18 items: 4 in Caring Relationships in the Home, 3 in Meaningful Participation in the Home, 5 in Adaptability to Surroundings, 3 in Social Competence, and 3 in Problem Solving. For T3, 19 items were removed after 2 rounds of EFA. The final list of 19 items suggested a 5-factor model (explaining 61% of total variance), with 4 in Caring Relationships in the Home, 5 in Meaningful Participation in the Home, 4 in Social Competence, 3 in Problem Solving, and 3 in

Empathy. The final TBCS resilience instruments are summarized in [Table 1](#).

Internal consistency was examined using Cronbach's alpha. The alpha value for each instrument was high:  $\alpha = .83$  for T1,  $\alpha = .82$  for T2, and  $\alpha = .83$  for T3, as was that for each factor. For T1,  $\alpha = .86$  for Caring Relationships in the Home,  $\alpha = .76$  for Sense of Self,  $\alpha = .76$  for Meaningful Participation in the Home,  $\alpha = .76$  for Adaptability to Surroundings, and  $\alpha = .77$  for Social Competence. For T2,  $\alpha = .81$  for Caring Relationships in the Home,  $\alpha = .82$  for Meaningful Participation in the Home,  $\alpha = .71$  for Adaptability to Surroundings,  $\alpha = .77$  for Social Competence, and  $\alpha = .68$  for Problem Solving. For T3,  $\alpha = .83$  for Caring Relationships in the Home,  $\alpha = .75$  for Meaningful Participation in the Home,  $\alpha = .75$  for Social Competence,  $\alpha = .74$  for Problem Solving, and  $\alpha = .74$  for Empathy.

#### CONFIRMATORY FACTOR ANALYSIS

Using the remaining random half of the dataset ( $N = 9,277$ ), we conducted CFAs to compare the model fit indices of 3 factor models: first-order, second-order, and bifactor ([Table 2](#)). All 3 models provided good fit based on their chi-square, CFI, and RMSEA values; however, the bifactor model showed the best fit for all time points and thus was retained: (T1:  $\chi^2(133) = 1611.54$ ; CFI = 0.976; RMSEA (90% CI) = 0.035 (0.033–0.036); T2:  $\chi^2(117) = 1811.49$ ; CFI = 0.968; RMSEA (90% CI) = 0.040 (0.038–0.041); T3:  $\chi^2(133) = 2367.25$ ; CFI = 0.960; RMSEA (90% CI) = 0.043 (0.041–0.044)). At T3, the first-order factor model showed marginally lower AIC, higher CFI, and lower RMSEA values than the bifactor model, yet results from an ANOVA analysis showed that the first-order model did not fit these data statistically better than the bifactor model.

#### COMPOSITE RESILIENCE SCORES

Composite scores were calculated for each instrument based on the average of all items. Higher scores indicated greater resilience. Participants had an average resilience score of 76.3 (standard deviation [SD] = 9.9; interquartile range [IQR] 69.7–82.9) at T1, 75.1 (SD = 10.4; IQR 68.5–81.9) at T2, and 70.9 (SD = 11.6; IQR 63.2–78.9) at T3. A summary of the descriptive statistics for each instrument and resilience factor is shown in [Table 3](#). Mean resilience scores for participants at all 3 time points were normally distributed, following a relatively even bell-curve shape ([Fig. 2](#)).

#### CONVERGENT AND DIVERGENT VALIDITY

We assessed item-item and factor-factor correlations within and across all 3 time points ([Table 4](#), [Supplemental Tables 2–4](#), and [Supplemental Figure 1](#)). Within time points, items showed stronger correlations with items in their respective factor ( $r = 0.30$ – $0.76$ ) than with those of other factors, suggesting good convergent validity. All correlations between the same factors across 2

**Table 1.** Exploratory Factor Analysis Factor Loadings, Item-Total Correlations, and Internal Consistency for the 19-Item, 18-Item, and 19-Item TBCS Resilience Instruments (TBCS-RI) (N = 9276)

Item Wording	Factor Loading With Promax Rotation	Item-Total Correlation
T1: 3-year Instrument ( $\alpha = .83$ )*		
Factor 1: Caring Relationships in the Home ( $\alpha = .86$ )		
1. You care about the safety of the child's play environment	0.56	0.49
2. You hug or kiss the child	0.59	0.51
3. You attentively watch the child while busying in the house	0.77	0.54
4. You talk to the child while busying in the house	0.75	0.46
5. You respond to the child's requests or questions	0.78	0.56
6. You usually praise the child proactively	0.76	0.60
7. You usually talk to the child happily	0.69	0.55
Factor 2: Sense of Self ( $\alpha = .76$ )		
8. In the past month, the child has been energetic	0.87	.36
9. In the past month, the child has been able to be immersed in or enjoy playing	0.84	0.44
10. In the past month, the child has been in a good mood	0.47	0.47
Factor 3: Meaningful Participation in the Home ( $\alpha = .76$ )		
11. You take the child to the park or out of town for fun	0.46	0.39
12. You read books and tell stories to the child	0.87	0.41
13. You draw pictures and play games with the child	0.83	0.40
Factor 4: Adaptability to Surroundings ( $\alpha = .76$ )		
14. Is your child able to play outside on their own as long as you are around or they can hear your voice?	0.60	0.27
15. At home when you are not present, is your child able to play on their own as long as relatives they are familiar with are around or can be heard?	0.73	0.31
16. Outside when you are not present, is your child able to play on their own as long as relatives they are familiar with are around or can be heard?	0.86	0.25
Factor 5: Social Competence ( $\alpha = .77$ )		
17. In the past month, has the child hit others spontaneously?	0.79	0.23
18. In the past month, has the child bitten or kicked others?	0.67	0.23
19. In the past month, has the child fought or scuffled with others?	0.72	0.25
T2: 5-year Instrument ( $\alpha = .82$ )		
Factor 1: Caring Relationships in the Home ( $\alpha = .81$ )		
1. You use a gentle and happy tone to speak with your child	0.55	0.44
2. You hug or kiss your child	0.84	0.48
3. You compliment your child proactively	0.94	0.55
4. You use verbal responses for your child's requests and questions	0.69	0.52
Factor 2: Meaningful Participation in the Home ( $\alpha = .82$ )		
5. You encourage your child to play with toys or games that require fine motor skills (eg, coloring, stickers, puzzles, etc.)	0.44	0.53
6. You encourage your child to learn the Chinese phonetic alphabet or the English alphabet	0.97	0.48
7. You encourage your child to learn numbers or math	0.86	0.47
Factor 3: Adaptability to Surroundings ( $\alpha = .71$ )		
8. Can your child focus on one task without being distracted by the environment or are they easily distracted?	0.55	0.43
9. Does your child insist on completing tasks, persevering through obstacles and difficulties, or do they give up easily?	0.59	0.44
10. In the past 6 months, your child has been able to concentrate when drawing or coloring	0.66	0.41
11. In the past 6 months, your child has been able to be immersed in building or assembling things and stick to it for a long time	0.61	0.38
12. In the past 6 months, your child has been deeply attracted by a story book and read it for a long time	0.51	0.44
Factor 4: Social Competence ( $\alpha = .77$ )		
13. In the past month, your child has hit others spontaneously (including family members)	0.69	0.25
14. In the past month, your child has bitten or kicked others (including family members)	0.88	0.24
15. In the past month, your child has fought or scuffled with others (including family members)	0.41	0.26
Factor 5: Problem Solving ( $\alpha = .68$ )		
16. In general, your child would bravely speak up for themselves	0.82	0.39
17. In general, your child knows whom to seek help from in times of difficulty	0.67	0.46
18. In general, your child would talk about the problem when trying to solve it	0.68	0.29
T3: 8-year Instrument ( $\alpha = .83$ )		
Factor 1: Caring Relationships in the Home ( $\alpha = .83$ )		
1. You usually talk happily with the child	0.78	0.55
2. You usually praise the child proactively	0.84	0.59
3. You respond to the child's requests and questions	0.62	0.56
4. You use body language to express love to the child (eg, hugging, holding hands, putting your arm around their shoulder, etc.)	0.64	0.53

(Continued)



**Table 1.** (Continued)

Item Wording	Factor Loading With Promax Rotation	Item-Total Correlation
Factor 2: Meaningful Participation in the Home ( $\alpha = .75$ )		
5. You encourage your child to read extracurricular books	0.64	0.48
6. You take your child to performances or exhibits	0.51	0.37
7. You accompany your child to do their homework	0.51	0.36
8. You encourage your child to develop interests and hobbies	0.82	0.57
9. In general, you spend a lot of time helping your child find their own thoughts, interests, and talents	0.59	0.50
Factor 3: Social Competence ( $\alpha = .75$ )		
10. In the past month, your child has argued and disputed with others	0.51	0.23
11. In the past month, your child when angry has ferociously cursed or retorted others	0.53	0.23
12. In the past month, your child has hit others spontaneously (including family members)	0.78	0.28
13. In the past month, your child has fought or scuffled with others	0.86	0.30
Factor 4: Problem Solving ( $\alpha = .74$ )		
14. Generally speaking, your child knows whom to seek help from when they encounter problems or difficulties	0.71	0.42
15. Generally speaking, when trying to solve a problem, your child would talk about it	0.87	0.48
16. Generally speaking, when wronged, your child would appropriately express their feelings	0.51	0.34
Factor 5: Empathy ( $\alpha = .74$ )		
17. Generally speaking, your child feels sad when someone else gets hurt	0.68	0.48
18. Generally speaking, your child is sensitive to others' emotions	0.66	0.37
19. Generally speaking, your child has same-age friends who care about them	0.75	0.47

TBCS indicates Taiwan Birth Cohort Study.

\*Cronbach's alpha coefficients.

time points, except for Adaptability to Surroundings at T1 and T2, ranged from 0.30 to 0.49, demonstrating factor stability. Caring Relationships in the Home also had strongest correlations with Meaningful Participation in the Home at all 3 time points (T1:  $r = 0.43$ ,  $P < .001$ ; T2:  $r = 0.48$ ,  $P < .001$ ; T3:  $r = 0.52$ ,  $P < .001$ ), but otherwise showed discriminant validity with other factors, including Adaptability to Surroundings (T1:  $r = 0.19$ ,  $P < .001$ ; T2:  $r = 0.32$ ,  $P < .001$ ) and Social Competence (T1:  $r = 0.10$ ,  $P < .001$ ; T2:  $r = 0.17$ ,  $P < .001$ ; T3:  $r = 0.18$ ,  $P < .001$ ). Sense of Self was not strongly correlated with Meaningful Participation in the Home (T1:  $r = 0.2$ ,  $P < .001$ ), Adaptability to Surroundings (T1:  $r = 0.29$ ,  $P < .001$ ), and Social Competence (T1:  $r = 0.03$ ,  $P < .001$ ), although it showed moderate correlation with Caring Relationships in the Home (T1:  $r = 0.44$ ,  $P < .001$ ). Meaningful Participation in the Home was not strongly correlated with Adaptability to Surroundings (T1:  $r = 0.07$ ,  $P < .001$ ; T2:  $r = 0.31$ ,  $P < .001$ ),

Social Competence (T1:  $r = 0.15$ ,  $P < .001$ ; T2:  $r = 0.11$ ,  $P < .001$ ; T3:  $r = 0.11$ ,  $P < .001$ ). Adaptability to Surroundings and Social Competence were not well correlated either (T1:  $r = 0.01$ ,  $P < .001$ ; T2:  $r = 0.15$ ,  $P < .001$ ).

#### PREDICTIVE VALIDITY

Overall, resilience scores were significantly correlated with general health scores both within and across time points as shown in Table 5. We also investigated the association of high resilience (defined as  $\geq 90$ th percentile or about 2 standard deviations above the mean) at T1 with higher levels of general health in later years (Fig. 3). There were significant differences in general health scores at all 3 time points (T1:  $t(3839) = 20.8$ , 95% CI 0.46–0.55; T2:  $t(3939) = 15.1$ , 95% CI 0.33–0.44; T3:  $t(3875) = 16.7$ , 95% CI 0.35–0.44), although these effect sizes were small. Overall, 3-year-old children with a resilience score in the  $\geq 90$ th percentile had

**Table 2.** Comparison of Confirmatory Factor Analysis Fit Indices for Each TBCS-RI (N = 9277)

Model	df	$\chi^2$	AIC	CFI	RMSEA (90% CI)
3-year (T1) Instrument					
First-order factor model	142	2801.82	360922	0.957	0.045 (0.044–0.046)
Second-order factor model	147	3377.97	361488	0.947	0.049 (0.047–0.050)
Bifactor model	133	1611.54	359750	0.976	0.035 (0.033–0.036)
5-year (T2) Instrument					
First-order factor model	125	2735.16	395402	0.951	0.047 (0.046–0.049)
Second-order factor model	130	2993.57	395650	0.947	0.049 (0.047–0.050)
Bifactor model	117	1811.49	394494	0.968	0.040 (0.038–0.041)
8-year (T3) Instrument					
First-order factor model	142	2091.52	412472	0.965	0.039 (0.037–0.040)
Second-order factor model	147	2557.67	412928	0.957	0.042 (0.041–0.044)
Bifactor model	133	2367.25	412766	0.960	0.043 (0.041–0.044)

$\chi^2$  indicates chi-square; df, degrees of freedom; AIC, Akaike information criterion; CFI, comparative fit index; RMSEA, root mean square error of approximation; CI, confidence interval; and TBCS-RI, Taiwan Birth Cohort Study Resilience Instrument.

**Table 3.** Descriptive Statistics of Resilience Instruments and Domains at Each Time Point (N = 18,553)

Resilience Domains by Instrument	# of Items	Resilience Score		
		Mean	SD	IQR
3-year (T1)	19	76.3	9.9	69.7–82.9
Caring Relationships in the Home	7	80.6	13.4	71–93
Sense of Self	3	87.2	12.2	75–100
Meaningful Participation in the Home	3	58.3	20.4	42–75
Adaptability to Surroundings	3	75.8	17.6	67–92
Social Competence	3	74.0	21.9	58–92
5-year (T2)	18	75.1	10.4	68.5–81.9
Caring Relationships in the Home	4	73.8	15.5	62–81
Meaningful Participation in the Home	3	70.7	19.2	58–83
Adaptability to Surroundings	5	73.7	14.3	63–83
Social Competence	3	75.7	18.5	67–83
Problem Solving	3	82.9	15.1	75–100
8-year (T3)	19	70.9	11.6	63.2–78.9
Caring Relationships in the Home	4	76.3	16.8	69–88
Meaningful Participation in the Home	5	59.2	19.1	45–75
Social Competence	4	76.5	18.5	69–88
Problem Solving	3	76.1	16.9	67–92
Empathy	3	70.6	16.6	58–75

SD indicates standard deviation; IQR, interquartile range.

good to very good general health scores at T1 (Mean = 4.29, SD = 0.73), T2 (Mean = 4.12, SD = 0.80), and T3 (Mean = 4.31, SD = 0.72) while those with a resilience score in the  $\leq 10$ th percentile had good or below general health scores (T1: Mean = 3.79, SD = 0.80; T2: Mean = 3.73, SD = 0.83; T3: Mean = 3.91, SD = 0.77). Among participants with a high HRF score, those with high resilience at T1 had significantly better general health at T1, T2, and T3 (95% CIs did not overlap) compared to those with low resilience. Similar patterns were also observed among those with low and medium HRF scores.

## DISCUSSION

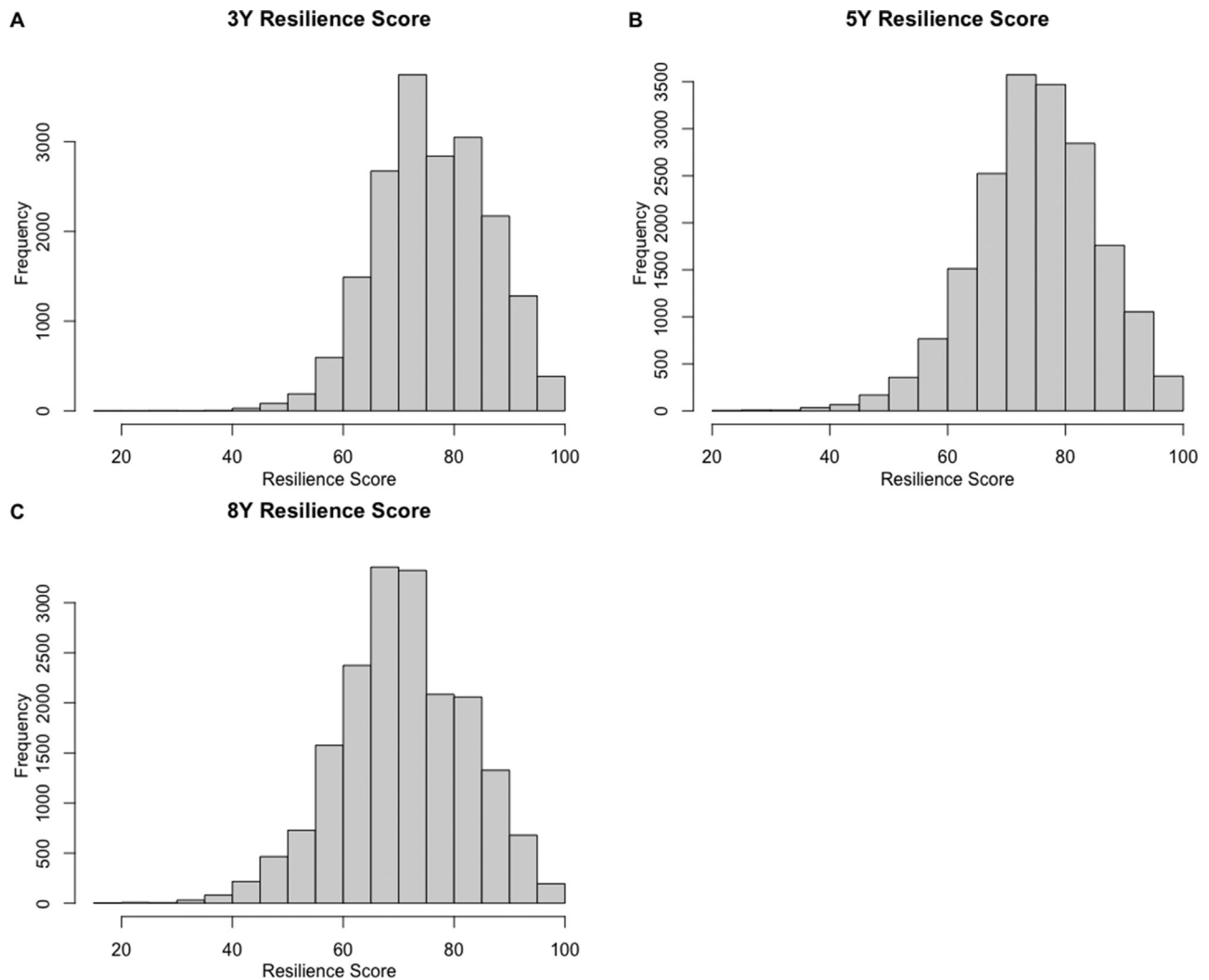
In this paper, we describe the development and validation of population-based instruments for assessing children's resilience at ages 3, 5, and 8. These instruments have good psychometric properties, showing strong construct validity, internal consistency, convergent and divergent validity, predictive validity, and normally-distributed resilience scores over time. Our findings suggest that these instruments, which include domains of Caring Relationships in the Home, Sense of Self, Meaningful Participation in the Home, Adaptability to Surroundings, Social Competence, Problem Solving, and Empathy, can be used as good measures to assess resilience in young children at the population level.

To our knowledge, this is the first study to measure resilience in a large population of children under 8. Most validated resilience instruments to date have been conducted in sample sizes of <2000 young adults or adults, with little focus on young children in early to middle childhood.<sup>19</sup> Our 3-year, 5-year, and 8-year instruments showed strong internal consistency, providing support that our age-specific items for measuring resilience were internally consistent and reliable indicators of resilience.

The Problem Solving domain at T2 had a marginally lower alpha value of .68 compared to other domains, but this is likely due to the alpha being both a function of the number of items and the covariance among items. The Resilience Scale for Adults, a previously validated widely used scale, reported a Cronbach's alpha greater than .7 for the whole instrument while those of its subscales ranged from .3 to .7.<sup>40</sup> Across all factors, we did not find any substantial increases in alpha by eliminating more items.

Our findings show evidence that resilience is a multi-dimensional construct strongly affected by both internal and external factors, as previously theorized.<sup>5,18</sup> Not only were individual traits, such as Social Competence, Empathy, and Problem Solving important, but equal emphasis was also placed on positive relationships in the child's home. Culturally, this is consistent with how family relationships and support are emphasized in Taiwan. Families in Taiwan are described as close-knit units, often manifested in 3-generational households; families remain the main pillar of social support. Studies have suggested that positive relationships in the school and community, in addition to the family, may also be important for school-age children when coping with stress or facing challenges.<sup>10,17</sup> However, our study did not have data on caring relationships or meaningful participation in the school. We initially included items on caring relationships and meaningful participation in the community for the 5-year and 8-year EFAs but were subsequently removed due to low loading values.

From a socio-developmental standpoint, we show that measuring resilience using age-specific items and domains is essential. Across all time points, Caring Relationships in the Home was the strongest factor contributing to resilience, while Meaningful Participation in the Home became a strong factor once the child turned 5 and 8. This is consistent with the fact that children can take on more responsibility without supervision when they reach



**Figure 2.** Frequency distribution of resilience composite scores at (A) 3 years of age (T1), (B) 5 years of age (T2), and (C) 8 years of age (T3). T1 resilience scores consist of 5 resilience domains: Caring Relationships in the Home, Sense of Self, Meaningful Participation in the Home, Adaptability to Surroundings, and Social Competence. T2 resilience scores consist of 5 resilience domains: Caring Relationships in the Home, Meaningful Participation in the Home, Adaptability to Surroundings, Social Competence, and Problem Solving. T3 resilience scores consist of 5 resilience domains: Caring Relationships in the Home, Meaningful Participation in the Home, Social Competence, Problem Solving, and Empathy.

**Table 4.** Factor-Factor Correlations for the 3-Year, 5-Year, and 8-Year TBCS Resilience Instruments (N = 18,553)

Time	Factor	T1					T2					T3				
		CR	SS	MP	AS	SC	CR	MP	AS	SC	PS	CR	MP	SC	PS	E
T1	CR	1														
	SS	0.44	1													
	MP	0.43	0.20	1												
	AS	0.19	0.29	0.07	1											
	SC	0.1	0.03	0.15	0.01	1										
T2	CR	0.42	0.23	0.35	0.06	0.12	1									
	MP	0.29	0.17	0.34	0.03	0.09	0.48	1								
	AS	0.23	0.16	0.24	0.06	0.12	0.32	0.31	1							
	SC	0.09	0.05	0.13	0.01	0.38	0.17	0.11	0.15	1						
	PS	0.25	0.22	0.16	0.11	0.03	0.37	0.31	0.33	0.06	1					
T3	CR	0.35	0.20	0.30	0.05	0.12	0.49	0.30	0.25	0.13	0.26	1				
	MP	0.29	0.15	0.44	0.04	0.14	0.35	0.39	0.28	0.12	0.19	0.52	1			
	SC	0.08	0.04	0.08	0.01	0.30	0.15	0.07	0.11	0.41	0.05	0.18	0.11	1		
	PS	0.21	0.19	0.15	0.1	0.04	0.25	0.22	0.23	0.06	0.39	0.40	0.30	0.06	1	
	E	0.22	0.15	0.17	0.05	0.07	0.27	0.23	0.23	0.11	0.27	0.38	0.35	0.12	0.42	1

T1 indicates 3-year Instrument; T2, 5-year Instrument; T3, 8-year Instrument; CR, Caring Relationships in the Home; SS, Sense of Self; MP, Meaningful Participation in the Home; AS, Adaptability to Surroundings; SC, Social Competence; PS, Problem Solving; E, Empathy. Underlined data represent correlations between same factors across 2 time points.



**Table 5.** Correlations Between Total Resilience and General Health Within and Across Time Points (N = 18,553)

	3-Year General Health (T1)	5-Year General Health (T2)	8-Year General Health (T3)
3-year Resilience (T1)	0.17	0.12	0.15
5-year Resilience (T2)		0.20	0.19
8-year Resilience (T3)			0.24

All correlations had  $P$  values  $<.0001$ .

primary school age. Early attention towards fostering a child's sense of self and adaptability to surroundings may also be critical for their resilience later in life. Although an individual's sense of identity is continuously shaped over one's life course, early enrichment activities (eg, encouraging a child to make their own decisions, taking the child on outings, reading with the child, etc.) that help a child gain confidence as early as age 3 may have long-term benefits on their resilience and health.<sup>13</sup>

While the scope of this study was to develop and validate population-based resilience instruments for children, we provide preliminary evidence that our 3-year resilience scale predicted better general health at ages 5 and 8. More complex analyses, such as mixed-effects models and longitudinal regression analyses that adjust for time-varying factors are needed to clarify the true relationship among resilience, general health, and high risk family score. Future TBCS work aims to tackle such questions, but other population-based research in young children should also be conducted to clarify the mechanisms linking resilience and health.

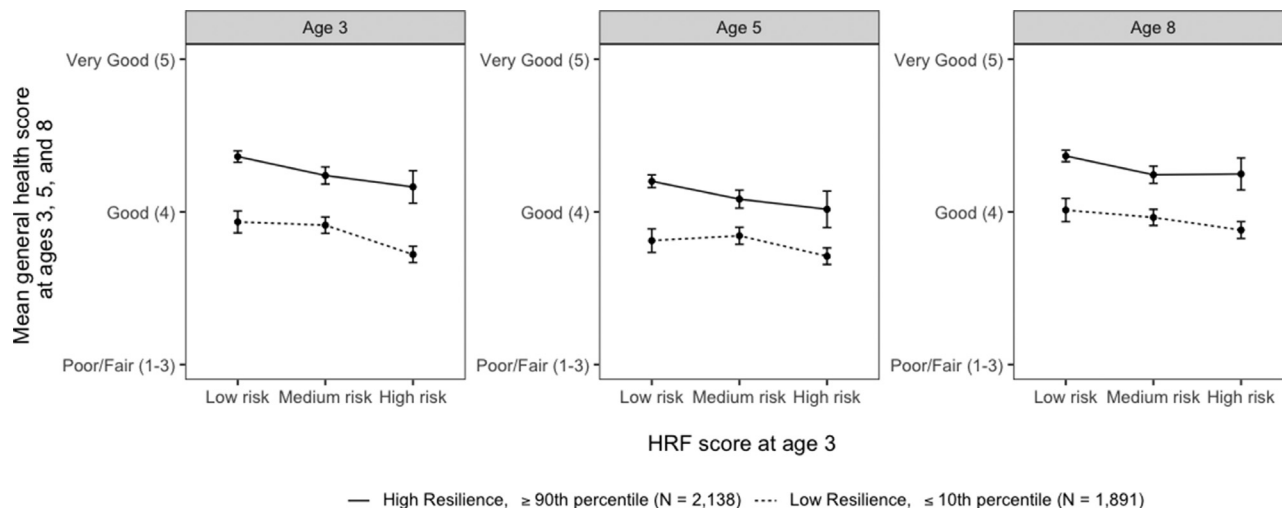
This study has several strengths. First, we used data from a large, nationally representative, longitudinal birth cohort study in Taiwan as a substrate to study resilience over time. Second, we used resilience domains previously theorized in the literature for Western populations and further built and developed validated measures that were culturally specific for Asian populations. Third, this study

uniquely reports on the robust measurement of resilience in an age-dependent manner. The results of each instrument follow a normal distribution, suggesting that each instrument does not skew towards either high or low resilience scores. The distribution's standard deviations also remained relatively consistent across time.

Limitations of this study should be mentioned. First, survey data used to assess resilience are self-reported by parents and may be subject to recall error. Second, the impact of items should be interpreted in the context of cultural acceptance and social desirability bias of parenting ideals in Taiwan. We suspect, however, that this effect would be minimal, as we adapted survey items used in Western cultures to ensure that questions in our instruments were similar. Finally, it was not possible to retain identical items at each time point assessed as some items were more applicable to one age group over another. However, we made efforts to harmonize the domains and items across the measured time points through a combination of subject matter input and quantitative analyses.

## CONCLUSION

In this paper, we describe the development and validation of age-appropriate survey instruments to assess resilience in children at ages 3, 5, and 8 at the population level. These instruments can be used to better understand how resilience can impact child health over time, and to



**Figure 3.** Predictive validity of 3-year-olds' resilience scores on general health scores at 3, 5, and 8 years of age. Average general health scores for each resilience group are plotted. High resilience (solid line) included individuals with a resilience score at the 90th percentile and above. Low resilience (dotted line) included individuals with a resilience score at the 10th percentile and below. Individuals in each resilience group were further categorized by their high risk family (HRF) score into 3 groups: low risk (HRF score = 0), medium risk (HRF score = 1), and high risk (HRF score  $\geq 2$ ). Error bars show the 95% confidence interval.

identify key factors that can foster resilience. Future studies should evaluate these instruments in other Asian populations to assess their generalizability.

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## SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at <https://doi.org/10.1016/j.acap.2022.06.002>.

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