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Cognitive and health-related outcomes after exposure to early malnutrition: The Leiden longitudinal study of international adoptees

Christie Schoenmaker [a], Femmie Juffer [a,*], Marinus H. van IJzendoorn [a], Linda van den Dries [a,b], Mariëlle Linting [a], Anja van der Voort [a], Marian J. Bakermans-Kranenburg [a]

[a] Leiden University, Centre for Child and Family Studies, Leiden, The Netherlands
[b] Radboud University, Nijmegen, The Netherlands

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ABSTRACT

Background: We followed 190 internationally adopted children from infancy to young adulthood to examine the long-term consequences of early malnutrition on cognitive and health-related outcomes.
Method: We measured birth weight and physical condition in infancy, IQ and somatic problems in middle childhood, adolescence and young adulthood; in young adulthood, socioeconomic success was also assessed.
Results: Early malnutrition negatively affected IQ in middle childhood and to a lesser extent IQ in young adulthood, but a negative effect on socioeconomic success was absent. Higher levels of early malnutrition predicted more somatic problems in middle childhood.
Conclusions: Variation in early malnutrition explains differences in cognitive and health-related outcomes, with early malnutrition predicting lower IQs in middle childhood and in young adulthood. Early malnutrition did however not negatively affect the young adult's socioeconomic success, indicating that early malnutrition may be compensated by later experiences.

1. Introduction

International adoptees are often confronted with high risks at the beginning of their lives, for example adverse prenatal and/or postnatal rearing conditions in their birth countries, and the loss of their biological family (Brodzinsky, 1990; Grotevant & McDermott, 2014; Juffer et al., 2011; Palacios & Brodzinsky, 2010). After a period of adversity, the adoptees are placed with permanent substitute parents in a new enriched environment. Adoption can thus be characterized as a complex of risk (e.g., separations and early deprivation) and protective factors (e.g., being reared in usually nurturing adoptive families). According to the theory of risk and protective factors (Rutter, 1987; Werner, 1993), an accumulation of risk factors contributes to less optimal child development, whereas protective factors may buffer the negative effects of the risks, resulting in recovery and resilience. The drastic change in environment following adoption and its consequences for child adjustment have been widely discussed (e.g., Palacios, Román, Moreno, León, & Peñarrubia, 2014; Rutter & the English & Romanian Adoptees Study Team, 1998). The influence of adoption on the adoptees' development has been tested for the domains of physical growth, attachment, cognitive development and school achievement, self-esteem, and behavior problems, and meta-analytic findings have convincingly shown that adoption is a successful intervention (Van IJzendoorn & Juffer, 2006). Adoptees show remarkable catch-up in all domains of development, which demonstrates the human brain's capability of adapting to environmental influences. However, malnutrition may restrict the extent of catch-up in adopted children and result in persisting developmental delays in some areas. In the current study we followed international adoptees from infancy to young adulthood to examine possible consequences of early malnutrition on their later cognitive and health-related development.

1.1. Early malnutrition and cognition

Cognitive functioning is the result of dynamic processes that proceed well into adulthood (Gogtay et al., 2004), and that consist of complex interactions between genetic, biological and environmental factors (Fratiglioni & Wang, 2007). Early environmental adversities, such as institutional deprivation and malnutrition, may lead to biological programming effects in the brain (Rutter, O'Connor, & the English &

* Corresponding author at: Leiden University, Centre for Child and Family Studies, P.O. Box 9555, 2300 RB Leiden, The Netherlands. Tel.: +31 71 5273434; fax: +31 71 5273945.
E-mail addresses: c.schoenmaker@fsw.leidenuniv.nl (C. Schoenmaker), juffer@fsw.leidenuniv.nl (F. Juffer), vanijzen@fsw.leidenuniv.nl (M.H. van IJzendoorn), L.Dries@elg.umcn.nl (L. van den Dries), linting@fsw.leidenuniv.nl (M. Linting), avoort@fsw.leidenuniv.nl (A. van der Voort), bakermans@fsw.leidenuniv.nl (M.J. Bakermans-Kranenburg).

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Romanian Adoptees Study Team, 2004). Brain development starts a few weeks after conception and continues with important processes of cell migration (movement of cells), cell differentiation (specialization into a cell type), synaptogenesis (the formation of connections between nerve cells) and myelination (the formation of layers around the nerve fibers) (Fox, Levitt, & Nelson, 2010). Therefore, the brain is most sensitive to early adverse experiences, and negative experiences – such as the lack of sufficient nutrition – can hinder normal organization of pathways in the brain (Nelson, Bos, Gunnar, & Sonuga-Barke, 2011). As a consequence, cognitive processes such as sensory perception, executive control, and memory may be negatively affected. These cognitive processes play a crucial role in the cognitive experiences the child encounters, and are therefore associated with lower levels of cognitive functioning (Fox et al., 2010; Nelson & Jeste, 2008; Nelson et al., 2011). Duration of malnutrition seems to be crucial for cognitive outcome: The longer children are exposed to malnutrition, the more difficult it is to redirect their cognitive development to a normal trajectory (Nelson et al., 2011). Reversibility of the effects of malnutrition and the possible long-term consequences for cognitive development are even more important for adoptees, who are placed in a new enriched environment after having been exposed to early malnutrition.

In a pioneering study by Winick, Meyer, and Harris (1975), the development of malnourished and well-nourished Korean children was examined after their adoptive placement in the USA, mostly before the age of two years. In elementary school, the malnourished children had significantly lower IQ scores and lower levels of school achievement than the well-nourished children, although all three groups (severely malnourished, moderately nourished and well-nourished) reached the American standard (Winick et al., 1975). A comparable design has been used to examine the adjustment of Romanian children adopted into the UK. At age 11, a cognitive deficit remained for children who had suffered from severe early deprivation for more than six months, whereas the group of children placed before 6 months of age showed cognitive outcomes comparable to non-deprived samples (Beckett et al., 2006; Rutter & the English & Romanian Adoptees Study Team, 1998; Sonuga-Barke, Schlotz, & Rutter, 2010). In children exposed to malnutrition for a shorter period of time, later experiences may alter the neural effects of early deprivation, and compensatory psychological strategies could also be involved (Beckett et al., 2006). As Huttenlocher (2002) stated, neural plasticity is not restricted to the infancy period, and even continues into adolescence and adulthood.

In two other studies, the effects of early deprivation on adopted children's adjustment in later life have been examined. In the first study, girls from Hong Kong were internationally adopted into the UK in the 1960s after an average stay of 20 months in orphanage care, with 55% of the girls slightly or moderately malnourished at adoption (British Chinese Adoption Study; Feast, Grant, Rushton, & Simmonds, 2013). In a follow-up study in midlife (mean age 48 years) the women showed relatively high educational attainment, and they were found to be well adjusted and physically healthy (Feast et al., 2013; Rushton, Grant, Feast, & Simmonds, 2013). These positive outcomes confirm the meta-analytical evidence on the catch-up of adopted children (Van IJzendoorn & Juffer, 2006), and point to compensatory factors after adoptive placement. In the second study, children who spent their infancy in Greek orphanage care (Metera), were domestically adopted in Greece and followed into adolescence (13 years) (Vorria, Ntouma, & Rutter, 2014, 2015). Although the cognitive scores of the adopted adolescents still lagged behind those of their non-adopted Greek peers, an overall rise in cognitive outcomes of the adoptees from infancy to preschool and then to adolescence suggested increasing cognitive catch-up and narrowing of the gap (Vorria et al., 2015).

The current study may shed light on the effects of relatively brief exposure to early malnutrition on cognitive outcomes extended to young adulthood. In adulthood, educational and occupational attainment become of major importance for young adults' integration into the labor market and into society (Dalen et al., 2008), and therefore socioeconomic success can be considered as an important adaptational outcome in this life stage.

1.2. Early malnutrition, health, and cognition

Children reared in early adverse conditions including malnutrition often show retarded physical growth and impaired health (Johnson & Gunnar, 2011; Miller, 2005), but behavior and mental health outcomes can also be affected (Miller, 2005; Van der Vegt, Van der Ende, Ferdinand, Verhulst, & Tiemeier, 2009). In the present study, we examined effects of early malnutrition on internationally adopted children's health-related outcomes extended to young adulthood. Medically unexplained physical symptoms, or somatic problems, were included as indicators of health condition over time. These symptoms are commonly reported in both children and adolescents, and consist of recurrent complaints such as headache, stomach aches and fatigue (Campo, Jansen-McWilliams, Comer, & Kelleher, 1999). Multiple studies have shown that somatic problems adversely affect cognitive performance (e.g., Flaherty et al., 2009; Hughes, Lourea-Waddell, & Kendall, 2008). Children with high levels of somatic problems may experience pain, and this pain could result in a negative affective state that demands much of their attention. As a consequence, fewer resources are available for competing tasks, for example memory tasks (Kuhajda, Thorn, Klinger, & Rubin, 2002). Also, children with somatic problems may spend less time in school and more time in medical care facilities such as a nurse's office than other children of their age (Deary, Chalder, & Sharpe, 2007; Hughes et al., 2008). An important question is whether all children are equally vulnerable to early adversities such as malnutrition. Individual variation in vulnerability to adversities might be linked to child-related resilience mechanisms and some children might even escape completely damage from early adverse influences (Van IJzendoorn et al., 2011).

Measures of cognitive ability (intelligence) were included to represent the construct of cognition in our research design, but in young adulthood a cognitive performance measure (socioeconomic success) was also part of the construct to get a completer view on the adoptees' cognitive adjustment in this phase of life. It has been meta-analytically shown that intelligence at previous ages can be considered as a powerful predictor of socioeconomic success (Strenze, 2007). Evidence has also been found for poor health in childhood as a negative predictor of educational attainment, and indirectly a negative predictor of occupational attainment (Haas, 2006). Besides these predictive pathways towards socioeconomic success, both health and intelligence at early ages seem to predict the same construct at later ages. Stability of intelligence is partly due to heritability of some of its aspects (e.g., Miller, 2005).

1.3. The present study

In this longitudinal study, we examined long-term consequences of early malnutrition on cognitive and health-related outcomes in international adoptees. The adoption design provided an opportunity to investigate the development of children reared outside their biological family, and as a consequence possible associations are not confounded by the parents' and children's shared genetic make-up. First, we hypothesized that the risk factor of early malnutrition negatively affects IQ, health and socioeconomic success, but these effects may become less profound at later developmental stages (Feast et al., 2013; Rushton et al., 2013) based on possible recovery processes after adoptive placement. Our second hypothesis concerns the interdependence of intelligence and somatic problems; we expect higher levels of somatic problems to be associated with lower IQs. Third, we hypothesized that IQ and somatic problems would be direct and indirect predictors of socioeconomic success in young adulthood.