

# Pathways to child health, development and wellbeing: Optimal environments for orchids and dandelions

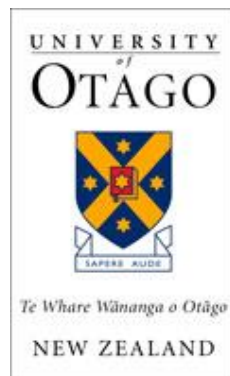
## An overview of the evidence

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Manatū Hauora

By

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# 1. Introduction and overview

This report discusses the findings of a rapid review of some of the latest evidence on the pathways to optimal health and wellbeing for children from birth to age 14 years, through the developmental periods of infancy, early and middle childhood and early adolescence. The information gained from this review is intended to inform future policy-development to promote optimal and equitable outcomes for all children in Aotearoa New Zealand. This section provides an overview of the aims, background, methods and scope of the review, and describes the structure used in this report.

## Aims of this review

The aims of this rapid review of the child health literature were:

1. To summarise the key influences and experiences that contribute to the development of health and wellbeing in children from conception to age fourteen inclusive.
2. To indicate findings from the literature in relation to the sequencing of influences and experiences identified (including life course epidemiology and/or other perspectives if appropriate).

## Overview of approach

This review takes a positive approach following the World Health Organization's lead in defining health as more than simply the absence of disease or infirmity (World Health Organization 1946) and is consistent with the holistic view of health expressed in Te Whare Tapa Wha model of Māori health (Durie 1994) and Pacific models of health (Suaalii-Sauni, Wheeler et al. 2009). For example, in Te Whare Tapa Wha model of health "four dimensions of health were seen as platforms for an integrated approach to the delivery of health services to Māori ... A spiritual dimension (taha wairua) recognized the importance of culture to identity as well as the significance of long-standing connections between people, ancestors, and the natural environment. A cognitive and emotional dimension (taha hinengaro) was based on Māori ways of thinking, feeling, and behaving and drew heavily on marae encounters. Taha tinana (physical wellbeing) encompassed the more familiar aspects of bodily health, while social wellbeing was reflected in taha whānau (family aspect). All four dimensions, acting in unison, were seen as foundations for health and relevant to the full range of health services" (Durie 2011 page 30).

Such positive framing also aligns with a shift in child health in recent years towards investigating factors that support and promote healthy development (Rutten, Hammels et al. 2013). This is an important change in academic thinking: previous child health research tended to focus on the factors that lead to or prevent vulnerability. Too great an emphasis on poor outcomes – often with little recognition of what constitutes a good outcome or the factors that might support it – can result in many missed opportunities to improve children's lives (Kvalsvig, O'Connor et al. 2014).

However, although the focus is on positive outcomes, considering only positive influences would not capture all of the issues relevant to New Zealand's children: it is also important to consider preventable threats to children's health and wellbeing, as these threats need to be minimised for children to flourish. Thus, this review will consider threats to healthy development as well as positive influences; but as much

as possible in terms of how they impede or promote the desired outcomes for children.

A positive frame is also consistent with the UN Convention on the Rights of the Child (UNCRC) (United Nations General Assembly 1989), which was ratified by the New Zealand Government in 1993. There is a growing appreciation of the implications of UNCRC for policy-makers, practitioners and researchers (American Academy of Pediatrics Council on Community Pediatrics and Committee on Native American Child Health 2010). UNCRC is grounded on basic human needs for life, growth and development, and applies to all children up to the age of 18 years (Waterston and Davies 2006, Reading 2009). UNCRC also empowers children as important members of society in their own right, acknowledging their evolving capacity and the importance of their own experiences of the world in which they live (Smith 2007). Indeed, some children may never reach adulthood. Concepts of health and wellbeing may have a different meaning for different children, and can still be experienced in the presence of illness or impairment.

### **The New Zealand context**

There has been extensive documentation about the state of child health and wellbeing in Aotearoa New Zealand. Many have highlighted concerns about childhood poverty, infectious diseases, family violence, inequities (particularly experienced by tamariki Māori and Pacific children) and the increased pressures facing many children, families and whanau, particularly children or parents/caregivers with disabilities or chronic conditions, low-income families, new migrants and refugees, and children of prisoners (Public Health Advisory Committee 2010, Baker, Barnard et al. 2012, Simpson, Oben et al. 2014).

There have been numerous inquiries, publications and reports, including during the period covered by this review. We do not seek to duplicate efforts, rather, we aim to complement and build on the existing substantial body of knowledge. In particular we acknowledge the recent reports from the Māori Affairs and Health Committees (Health Committee 2013, Māori Affairs Committee 2013), the Prime Minister's Chief Science Advisor (Office of the Prime Minister's Science Advisory Committee and Gluckman 2011), the Public Health Advisory Committee (Public Health Advisory Committee 2010), the Children's Action Plan (NZ Government 2012), the Office of the Children's Commissioner (Expert Advisory Group on Solutions to Child Poverty 2012), the UN Committee on the Rights of the Child (Committee on the Rights of the Child 2011), the mortality review committees ([www.hgsc.govt.nz/our-programmes/mrc/](http://www.hgsc.govt.nz/our-programmes/mrc/)), and reports from many other government and non-government organisations.

### **Biodevelopmental framework**

This review uses a “biodevelopmental framework”, an evidence-based approach to assist policy-makers in developing effective and equitable early childhood policies and programmes (Shonkoff 2010). Shonkoff (Shonkoff 2010) developed the biodevelopmental framework to prompt policy-makers to consider the causal pathways through which environments affect child development, linking child health and wellbeing outcomes and disparities to preceding events and conditions at societal and molecular levels. This framework has been developed relatively recently and is rapidly gaining currency because of its ability to capture the dynamic relationships between children and their environments. A benefit of the biodevelopmental framework is that it can provide a unified, science-based framework that can foster integrated interagency action to promote the health and wellbeing of children and reduce disparities.

## **Background and theory**

The biodevelopmental framework draws on decades of research and theorisation on human development and health (Shonkoff 2010). It is based on ecological theory, the concept that an individual's health and development is shaped by the complex and dynamic social and physical environments in which they live, encompassing the micro-level (such as family and peer relationships), the meso-level (such as neighbourhood or school), or the macro-level (societal factors) (Bronfenbrenner 1994). Like Te Whare Tapa Wha (Durie 1994) and UNCRC, it recognises the multi-dimensional nature of the foundations for wellbeing.

The biodevelopmental framework also draws on the now substantial body of work on the social determinants of health and health equity (Shonkoff 2010). The term "social determinants of health" refers to the wider social factors (the health-related resources, conditions, opportunities or risks) that affect overall population health (Appendix 1) (Graham 2004, Commission on Social Determinants of Health 2008). Health outcomes and their determinants are distributed unequally between population groups (Graham 2004). The term "social determinants of equity" refers to the complex societal "structures, policies, practices, norms, and values" that shape the distribution of resources, opportunities and risks in a society (Jones, Jones et al. 2009). The social determinants literature identifies early childhood as a key period during which upstream social factors exert their effect on health and equity (Irwin, Siddiqi et al. 2007). This evidence-based approach helps us to understand precisely how poverty influences child health outcomes, providing new opportunities to identify policies and interventions that can ameliorate current inequalities in child health and wellbeing.

## **Overview of the biodevelopmental framework**

In the past, one of the major limitations of research into child health and development was the lack of precise knowledge about how children's biology, experience, and environment, combine to shape child outcomes, sometimes characterised as a conflict of "Nature vs Nurture". We now know that to be an over-simplification (Wermter, Laucht et al. 2010). The limitations of that model made it difficult to identify several important modifiable pathways of child health and development, and this has led to missed opportunities for policymakers and health services.

What more recent research has shown is that even factors previously thought to be fixed characteristics, such as genes, can be modified by the child's environment. This understanding has rapidly evolved into a new field, epigenetics, which seeks to understand how genes and environments interact. (For more detail and a good introductory review of the topic, see a recent review by Groom et al (Beery and Francis 2011).

The knowledge that external influences affect health and wellbeing through different pathways, including altered gene expression, demonstrates the profound importance of **environments** on children's health and development. New research also continues to underline the importance of identifying **early influences**. Environments can have their impact before birth and even before conception (Kvalsvig 2014), and during sensitive periods their influence, whether positive or negative, may be lifelong (Korosi, Naninck et al. 2012, Wang, Walker et al. 2013). Although health and wellbeing are influenced by environments and experiences throughout life, early life is increasingly seen to be a time when many health trajectories are established (Wang, Walker et al. 2013). Early childhood development significantly influences subsequent life chances and health, and interventions in early childhood to promote optimal development have a high rate of social and economic return (Office of the Prime Minister's Science Advisory Committee and Gluckman 2011). Health benefits



of early childhood interventions persist into adulthood with lower prevalence of risk factors for cardiovascular and metabolic diseases (Campbell, Conti et al. 2014) (Adde, Alvarez et al. 2013), improved educational attainment and employment opportunities, and better mental health.(Mitchell, Wylie et al. 2008)

This has far-reaching implications for population health. An emerging body of evidence also demonstrates the phenomenon of **latent effects** of adverse environments during **sensitive periods** where adversity in early life can have little observable effect during childhood, but leads to poor health outcomes many years later (Shonkoff 2010). For example, suboptimal growth in utero resulting in low birthweight has little effect on cardiovascular outcomes in childhood but is strongly linked to coronary heart disease, diabetes, hypertension and stroke in adulthood (De Boo and Harding 2006). What this means in practice is that often, harmful early environments can be observed but their effects on health cannot, because these effects will only be detectable later on. This is a strong argument for measuring, monitoring, and intervening on high-risk environments in addition to child outcomes.

Another key concept in the biodevelopmental approach is **responsiveness**. The complex two-way interactions between genes and environments show us that early life is a time of constant, dynamic change, in which children are continuously responding to environmental influences and building on previous growth patterns. This responsiveness in young children (also known as 'developmental plasticity') (Shonkoff, Richter et al. 2012) presents an opportunity: even if a child has not had an optimal start, trajectories can be changed. The developmental plasticity of the early years is an important reason why earlier interventions tend to be more effective than later ones. However, the research also suggests why single, one-off interventions tend to be less successful: short-term interventions are not able to capitalise on the ongoing, iterative process by which children develop through engaging with their environments (Kuzawa and Thayer 2011).

### **Scope of this review**

The task of reviewing the many influences on child health, development, and wellbeing, from conception to early adolescence, is enormous and encompasses a vast literature. We have conducted a high-level, focused and selective review of this literature, with as much rigor as possible, in the highly condensed timeframe available (as described in the Methods section below). We aimed for a balance of sufficient breadth to provide an overview and the flexibility to start to explore important aspects in more detail, particularly important or emerging concepts and topics. A comprehensive review was not possible and not all important topics are included. However we hope that this report stimulates interest and further inquiry. A review of strategies for prevention and early intervention was outside the scope of this exercise.

We note that there is also a substantial body of work from Te Ao Māori that was beyond the scope of this project but is important in its own right. Kaupapa Māori theory, methods and knowledge (Durie 2007, Robson and Harris 2007), including current research on whānau ora (for example, see Boulton et al (Boulton, Gifford et al. 2010, Boulton and Gifford 2014)), offers different, but complementary, insights into positive influences on child development and wellbeing, grounded in a cultural and historical context. Similarly, there is much to be gained from incorporating knowledge based on Pacific world views, cultures and values (for example, see the Pacific Islands Families Study (Savila, Sundborn et al. 2011)).

The age range of interest for this review is from conception to 14 years. However, not all ages have been given equal weight. For most children the strongest influences on

child health and wellbeing occur in early life. There is mounting evidence that the single most influential determinant is the child's environment of relationships with caregivers during the early years. For that reason, this is a major focus of this review. A recent New-Zealand-focused literature review about preconception and pregnancy factors that influence child health (Kvalsvig 2014) will be referenced where relevant.

## **Methods**

We conducted a focused and high-level review of the international and New Zealand child health, child development and neuroscience literature. With assistance from the Ministry of Health librarians, we searched the PsycInfo, Scopus, ERIC and Google Scholar databases using search terms and syntax as appropriate for the database, such as (child\* OR adoles\*) AND (devel\*) AND ("Health status" OR "quality of life" OR "optimal development" OR wellbeing OR "integrated child development" OR "positive development" OR resilience OR "well being"). We applied search filters to limit the results to: review articles, the age range of conception to 14 years inclusive, the period from 2005 to current, and the English language. We identified 3876 articles and created an EndNote library database which was searched using specific key words and phrases, titles and abstracts were scanned to identify papers of interest, and full texts were acquired. For example, key words for the period of early childhood included: attachment; resilience; wellbeing; epigenetic; biodevelopmental framework; positive stress; sensitive periods; executive function; built environment; and metabolic programming. Articles were also identified through the research teams' knowledge of key papers in the literature and through manually searching the reference lists of key review papers and the website of the Center on the Developing Child at Harvard University ([developingchild.harvard.edu](http://developingchild.harvard.edu)). Where possible we have given preference to the New Zealand experience.

## **Structure of this report**

This report discusses the foundations or influences required that support optimal child health and development under three major biodevelopmentally-oriented headings (Shonkoff 2010):

- 1) The environment of relationships in which a child develops.
- 2) The physical, chemical and built environments in which the child and family live.
- 3) Nutrition for health.

## 2. The environment of relationships

There is now extensive and well-established evidence that the environment of relationships is of critical importance for children (National Scientific Council on the Developing Child 2004). The Center on the Developing Child observes that “establishing successful relationships with adults and other children provides a foundation of capacities that children will use for a lifetime” (National Scientific Council on the Developing Child 2004 page 1). In a review of family influences on child development, Belsky (2008) reported that sensitive-responsive parenting leads to:

- attachment security
- higher levels of linguistic functioning
- greater social skills
- better peer relations, and
- more executive control.

These facets of child development and their importance for child health and wellbeing are discussed in more detail in the sections that follow. Although the paper by Belsky quoted above focuses on relationships with parents, these are not the only important relationships in children’s lives: “The environment of relationships in which a young child develops ... includes both family and non-family members as important sources of stable and growth-promoting relationships as well as critical buffers against significant threats to healthy development” (Shonkoff 2010 page 359). The environment of relationships aligns with taha whānau and taha wairua in Te Whare Tapa Wha model. The effects of the environment of relationships on children is not limited to social and emotional outcomes (Belsky and Fearon 2002) but includes multiple other domains of child health and wellbeing such as safety, nutrition, health behaviours, puberty onset, academic attainment and cardiovascular health (Ellis, Shirtcliff et al. 2011). This observation highlights the underpinning philosophy of Te Whare Tapa Wha that all four dimensions act in unison and must all be included in consideration of the foundations of wellbeing (Durie 2011).

### Attachment

Attachment describes a child’s relationship with a specific, familiar caregiver. Secure attachment is seen when a young child is happy to explore their surroundings, but returns to the caregiver for reassurance and protection when alarmed or distressed (Zeanah, Berlin et al. 2011). Since Bowlby published his major works on this topic in the 1970s and 1980s, attachment has been well-researched, particularly with respect to documenting the severe social and emotional effects that are seen when this relationship is disrupted or absent (Bakermans-Kranenburg and Van Ijzendoorn 2007, Breidenstine, Bailey et al. 2011, Zeanah, Berlin et al. 2011).

More recent research has expanded this knowledge to give a clearer picture of what, exactly, it is that caregivers and children do to establish this relationship. This knowledge has led to further insights about how attachment acts as a foundation for child resilience (Cameron, Ungar et al. 2007, Rutten, Hammels et al. 2013), discussed in more detail in a later section. There is also increased understanding of how attachment is important in relationships that children have with people other than parents or primary caregivers. The current review will focus on these newer findings and their relevance for supporting children’s health and wellbeing.

A summary and timeline of the development of attachment behaviour is shown in Table 1 of Zeanah, Berlin et al. (2011). This table focuses on child behaviour, but increasingly attachment is seen as a function of the *interaction* between the child and the attachment figure, rather than the behaviour of either in isolation. This interaction has been described as “serve and return” (National Scientific Council on the Developing Child 2004). Adults respond to a baby’s smiles and vocalisations with smiles and vocalisations of their own; this stimulates neuronal activity in the baby’s brain and causes new connections to be laid down, leading to more complex behaviours, which in turn elicit more complex responses from adults. These constantly evolving interactions quite literally build babies brains, establishing the architecture for all future learning (McEwen 2000).

In view of the fundamental importance of attachment for future outcomes, several authors (Zeanah, Berlin et al. 2011) have called for assessment of attachment (formal or informal) to be a routine component of all clinical encounters with children. It is also increasingly recognised that attachment should be assessed and taken into account in major decisions about children’s care, for example in determining child custody arrangements (Byrne, O’Connor et al. 2005) and in child protection interventions (Zeanah, Berlin et al. 2011). Children in out of home care are a particular group whose capacity for wellbeing may need particular attention and support. There is a need to identify the influences that will improve the chances of healthy development for children in foster care and to ensure that all children who cannot be raised by their own parents enjoy relationships that promote their wellbeing (Goemans, van Geel et al. 2015) (Winokur, Holtan et al. 2009, Jones, Everson-Hock et al. 2011).

Caregiver-child relationships can be assessed and reported at different stages; see Byrne, O’Connor et al. (2005) for a review and discussion of approaches to measuring attachment. More recently, scales have been developed for assessing the mother-fetus relationship (van den Bergh and Simons 2009) which may be an opportunity to identify vulnerable mothers even before birth. It is especially important to recognise postpartum depression (in fathers as well as mothers) as this can have a strongly adverse effect on attachment (McPeak, Sandrock et al. 2015). Another prevention approach is to assess parents’ own experience and beliefs about attachment (Zeanah, Berlin et al. 2011) as parents’ own experience of attachment is a strong predictor of the sensitivity of their relationships with their children (Bakermans-Kranenburg and Van Ijzendoorn 2007).

It is important to note that attachment is not only relevant to a child’s relationship with one primary carer: Bretherton (2010) has reviewed the literature on fathers and attachment, an emerging area of interest with some evidence to suggest that fathers and mothers may have complementary roles as attachment figures. Educators are also attachment figures and the quality of the attachment relationship is an important determinant of children’s learning outcomes; while attachment may determine the quality of relationships with health professionals and of health outcomes (see Education settings page 10).

### **Linguistic functioning**

There are both innate and social components to language. However, language acquisition in young children is almost inevitable as long as these components are present to some degree (Hammer, Hoff et al. 2014). What is not universal is the timing and process of acquiring language, resulting in wide variations in children’s language skills at any given age.

Language is understood to evolve out of attachment behaviour: the 'serve and return' process is clearly seen in the language learning of infants (National Scientific Council on the Developing Child 2004). The security of the attachment relationship is a predictor of language skills (Belsky and Fearon 2002), and language acquisition can be seen to shape neural development in the growing brain (Jasinska and Petitto 2013).

This new evidence about the way in which neural pathways are laid down when children communicate provides the biological basis for what has been known for many years: language is crucial to child development. In a landmark study in the USA over 20 years ago, Hart and Risley analysed the conversations of parents and young toddlers in their homes over a period of two and a half years (Hart and Risley 1995). They reported that the children in more advantaged households heard tens or even hundreds of thousands more words each week than the children in disadvantaged circumstances. Hart and Risley estimated that by the age of three, these differences translated into a 30 million word gap. When follow-up studies of the same children revealed the pervasive and significant long-term consequences of poorer early language environments, the authors came to view this gap as a 'catastrophe' for children and for society (Hart and Risley 2003).

Impoverished early linguistic environments are now understood to be responsible for much of the relationship between poverty and later outcomes (Locke, Ginsborg et al. 2002), particularly with regard to education. Oral language skills set the foundations for emerging literacy (Reese, Sparks et al. 2010) and are also essential for developing social competence in relationships with peers (Hebert-Myers, Guttentag et al. 2006) and with teachers (Moritz Rudasill, Rimm-Kaufman et al. 2006).

There is a large literature but little consensus on the precise extent to which bilingualism confers cognitive advantages (examined recently by Barac, Bialystok et al. (2014) and in a systematic review and meta-analysis by Adesope, Lavin et al. (2010). Overall it seems that children have much to gain from bilingualism, both cognitively and socially. Where children speak a minority language at home, it is strongly recommended that families maintain this language as this can help to support cultural identity as well as enhancing self-esteem and strengthening parent-child relationships (Han and Huang 2010, Tessel and Danesh 2015).

A different situation arises in places where an indigenous culture has been disadvantaged, resulting in attrition of language and cultural capital. In New Zealand, the re-emergence of support structures for Te Reo Māori is a positive step for new generations of Te Reo speakers (Chrisp 2005, Campbell 2012).

Language continues to develop throughout childhood. Adolescents require increasingly complex language skills to manage peer relationships (Durkin and Conti-Ramsden 2007), access academic curricula (Conti - Ramsden, Durkin et al. 2009), and exercise their right to express their views as fully participating members of society (Lansdown and Karkara 2006).

The understanding that language has a key mediating role in a number of outcomes has led to increased efforts to view language development as an important target for public health intervention (Cesaro, Campos et al. 2013) with the dual aims of improving outcomes for individual children and reducing population-level inequalities (Sirin 2005, Reese, Sparks et al. 2010).

## **Executive function and self-regulation**

Executive function has been described as the brain's "air traffic control system" (Center on the Developing Child at Harvard University 2011). The capacity of a child or young person to delay gratification, control impulses and regulate emotions is an important developmental task that correlates strongly with health and well-being through adolescence and adulthood (Poulson 2011). Executive function is important both for learning and for social development (Center on the Developing Child at Harvard University 2011, Kapa and Colombo 2014).

By the age of three, children are beginning to develop the key executive function skills of inhibitory control, working memory and mental flexibility (Center on the Developing Child at Harvard University 2011) that will be the foundation of a range of life skills and competencies. After a dramatic growth in executive function skills between the ages of 3 and 5 years, individuals continue to build on this learning through childhood and adolescence and on into adulthood. For a detailed timeline, see the working paper referenced above (Center on the Developing Child at Harvard University 2011). Interventions are effective in improving self-control at least up until age 10 years (Piquero, Jennings et al. 2010, Blair and Raver 2014). There are likely to be population benefits for all children from enhancing self-control (Poulson 2011).

## **Parenting and family support**

After hundreds of hours spent observing children and parents at home for the longitudinal study of language mentioned above, Hart and Risley observed that: "By the time the children were 3 years old, trends in amount of talk, vocabulary growth, and style of interaction were well established and clearly suggested widening gaps to come. Even patterns of parenting were already observable among the children. When we listened to the children, we seemed to hear their parents speaking; when we watched the children play at parenting their dolls, we seemed to see the futures of their own children" (Hart and Risley 2003).

Families and communities have primary responsibility for the provision of the kind of supportive relationships and positive learning experiences required for healthy child development (Public Health Advisory Committee 2010, Shonkoff 2010). Governments also have a duty to support the caregiving capacity of parents (United Nations General Assembly 1989). The transmission of parenting behaviours across generations may be a source of tremendous resilience and stability in families (Roehlkepartain and Syvertsen 2014); but some parents and carers require additional support to break harmful cycles and develop more positive and responsive patterns of interaction.

Parents who are provided with support and information that enables them to be optimally responsive to their infants and young children are better able to support healthy child development (Fergusson, McNaughton et al. 2011). There is also a clear need to provide parents and caregivers of older children with skills and resources to help them set effective limits on risky behaviour in adolescence (Office of the Prime Minister's Science Advisory Committee and Gluckman 2011). While parenting support is important for all families, those with a history of interpersonal conflict or family violence have a need for additional support and their children may benefit from a variety of evidence-based intervention programmes (Armstrong, Birnie-Lefcovitch et al. 2005, Fergusson, McNaughton et al. 2011). Young parents may also need additional support to provide a nurturing relationship environment where their children can flourish (McDermott and Graham 2005).

## **Peer relationships**

Peer relationships are an important, sometimes critical, influence on the health, development and wellbeing of children and young people, positively or negatively affecting a range of physical and mental health outcomes and health-related behaviours such as tobacco or drug use, physical activity, safe sex, or violence (Hay 2004, Greenberg and Lippold 2013). Children first develop peer relationships during the preschool years. Peer relationships develop as part of an ongoing iterative and reciprocal process of social skill development and emotional self-regulation, building on earlier attachment and peer relationships (Hay 2004, Farley and Kim-Spoon 2014, Groh, Fearon et al. 2014). Peer relationships are especially powerful during adolescence, a key developmental period of increasing independence during which young people spend more time with their peers than with their families (Fitzgerald, Fitzgerald et al. 2012, Platt, Kadosh et al. 2013).

Peer relationships can affect health through pathways such as peer support, peer norms, peer acceptance or rejection, peer crowd affiliation, and peer victimisation or bullying (Fitzgerald, Fitzgerald et al. 2012). Bullying, peer victimisation and peer rejection are important sources of stress for young people (Platt, Kadosh et al. 2013). Traditional bullying is more prevalent than cyberbullying but both are highly correlated (Modecki, Minchin et al. 2014).

## **Online environments**

Social media have far-ranging effects on the social environment for children and young people with the nature of peer pressure and role models now very different to those experienced by previous generations (Office of the Prime Minister's Science Advisory Committee and Gluckman 2011). Online communication and social media have both positive and negative effects on adolescent wellbeing, for example social networking sites can increase social capital, broaden social networks and enhance identity development, yet can also lead to internet addiction or increased exposure to cyber-bullying, exploitation, and marketing of unhealthy products such as tobacco, junk food or alcohol (Clifton, Goodall et al. 2013, Allen, Ryan et al. 2014, Bailin, Milanaik et al. 2014, Best, Manktelow et al. 2014). Parental involvement in children's use of the internet, together with internet safety education in educational settings, seem to have a positive and protective effect for adolescents in the online environment (Whittle, Hamilton-Giachritsis et al. 2013).

## **Education settings**

Early childhood education has a powerful impact on child outcomes. This has been reviewed in detail by Mitchell et al. (Mitchell, Wylie et al. 2008). One of the major findings of the review was the importance of quality of service provision, reflected in the quality of staff-child interaction and the establishment of a supportive environment for children to work together. This is consistent with results from a more recent study showing that in early childhood education settings, the quality of the caregiver-child relationship influences child development more than other markers of quality (Gialamas, Mittinty et al. 2015). Similarly, in school-age children the quality of the teacher-child relationship is a strong predictor of later outcomes (O'Connor and McCartney 2007).

## **Health and healthcare settings**

Children interact with professionals in the health and healthcare environment in several ways, including as patients and as relatives of patients. Having a stable relationship with a healthcare provider (a "medical home") has a positive effect on child wellbeing (Hadland and Long 2014). There is a now considerable body of literature on the beneficial impact for children and their families of child-friendly and family-centred healthcare services (Clarke and Nicholson 2007, Dunst and Trivette

2009, AAP Committee On Hospital Care and Institute For Patient- Family-Centered Care 2012). One aspect of child-friendly healthcare is the need to provide developmentally appropriate information to children and to consider their views in decision-making process (Gu and Zhang 2012). In the literature there are a number of discussions about the child's voice in healthcare settings in relation to specific health conditions (McConachie, Colver et al. 2006) (Varni, Limbers et al. 2007) (Hinds, Menard et al. 2012) and to measuring health-related quality of life (HRQOL) or patient related outcome measures (Fayed, De Camargo et al. 2012) (Janssens, Coon et al. 2015). Children as young as five years of age can reliably and validly report their HRQOL using an appropriate instrument (Varni, Limbers et al. 2007, Arbuckle and Abetz-Webb 2013).

### ***Long-term health conditions***

Living with a long-term health condition can affect quality of life and children with health problems may need additional resources to maintain and enjoy optimal development. For some children with long-term health problems long-term treatment may be an important component of attaining and maintaining wellbeing (Sawyer, Afifi et al. , Hanghøj and Boisen 2014). Specific health service environments for children with chronic conditions need to be considered so that they enjoy the best possible outcomes (Taylor, Gibson et al. 2008, Abbott 2009). In keeping with the multidimensional nature of wellbeing the educational needs of children with chronic illness are also important (Jackson 2013).

As children with long-term health problems move into adolescence, it is important that the healthcare environment enables appropriate transition from child to adolescent to adult health services (Steinbeck, Brodie et al. 2007). The nature of healthcare environments that enable transitions that promote wellbeing requires further exploration and research.

### ***Young carers***

Health issues within the family can affect the environment of relationships. “Young carers” are children who perform care tasks for a parent, sibling or other family member who has a physical or intellectual disability, mental illness or substance problem. Such caregiving is associated with both positive and negative effects on wellbeing (Ireland and Pakenham 2010). Siblings of children with chronic physical illness can also experience reduced quality of life, and are a group for whom additional support and resources may be required (Limbers and Skipper 2014).

### ***Adverse relationship environments***

While the focus of this section has been on positive requirements for healthy child development, there clearly are some adverse relationship environments that are severely detrimental and pose serious threats to children's health and wellbeing. Adverse relationship environments impact on health and wellbeing through different pathways. Because of the multi-faceted impact of some of these adverse relationship environments, there is some overlap between sections of this report. Relationship environments that are associated with toxic stress are discussed in this section. The physiological impact on the fetus of maternal stress is discussed in the chemical environment section.

The physiological response to what is known as “toxic stress” is particularly damaging to the developing fetus, child and early adolescent. An interesting and relatively recent development is the understanding that not all stress is harmful. Instead, child development researchers now distinguish between “positive” or at least “tolerable” stress – challenges that the child can overcome and that build a sense of mastery over their life circumstances especially – and “toxic stress”, in which the



child's stress responses are overwhelmed (National Scientific Council on the Developing Child 2015). These three categories of stress refer to the "physiological expression of the stress response and not to the specific stressors themselves" (Shonkoff 2010 page 359). Toxic stress, when it is prolonged, has multiple adverse effects.

Relationship environments that are associated with toxic stress include violence, child maltreatment, parental addictions and substance misuse, and serious parental mental illness. These relationship environments can also adversely affect children through other pathways in addition to causing a physiological stress response. For example, alcohol misuse by parents or caregivers can affect the different aspects of parenting capacity (such as the ability to meet a child's basic needs, protect them from harm, and nurture and guide them) and family functioning (Bijttebier, Goethals et al. 2006, Girling, Huakau et al. 2006, Harwin, Madge et al. 2010). Parental alcohol misuse is associated with a range of adverse outcomes such as death, maltreatment, unintentional injury, and poor physical and psychological health (Girling, Huakau et al. 2006, Damashek, Williams et al. 2009).

It is important to consider that these potentially damaging relationship environments are complex in nature, and in keeping with the ecological model, are shaped by factors at different causal levels. For example, in the case of alcohol-related harm, adult and youth drinking patterns are powerfully shaped by wider factors such as marketing and sponsorship practices of the alcohol industry, alcohol pricing and availability, drink-driving counter-measures and social norms (Anderson, de Bruijn et al. 2009, Beaglehole and Bonita 2009, Casswell and Thamarangsi 2009, Babor, Caetano et al. 2010, Law Commission 2010).

Such developmental threats must be addressed to promote the wellbeing and caregiving capacity of parents and prevent severe adverse outcomes for children (Bair-Merritt, Blackstone et al. 2006, AAP Committee on Psychosocial Aspects of Child Family Health, Committee on Early Childhood et al. 2012, Johnson, Riley et al. 2013). The increasing understanding of the importance of stress in child health has led the American Academy of Pediatrics to produce a policy statement with recommendations for child health professionals regarding managing stress in early life, and in particular, reducing and preventing toxic stress (Garner, Shonkoff et al. 2012).

#### *Allostatic load*

Allostatic load (AL) is the term used to describe the cumulative effect of stress over a long period (McEwen 2000). Beckie (2012) conducted a systematic review of allostatic load research and concluded that although variability in how this was measured sometimes made it difficult to compare studies, there were clear links between allostatic challenges such as child poverty, measured AL and a wide range of subsequent health outcomes. The author concluded that "targeting the antecedents of AL during key developmental periods is essential for improving public health" (Beckie 2012 Abstract, page 311).

#### **Differential susceptibility: Dandelions and orchids**

During the last ten years, evidence has been accumulating for a powerful role of gene-environment interactions in determining a range of social-emotional outcomes in children. This is known as 'differential susceptibility'. In a landmark paper, Boyce and Ellis (2005) characterised these differently-susceptible individuals as "dandelion children" - who are less sensitive both to positive and negative influences - and "orchid children" - who flourish in a supportive environment but can be overwhelmed by adversity. This model (and the genetic mechanisms that underpin it) has proven to

be robust and to explain a number of empirical observations about the impact of environments and interventions on children.

For example, differential susceptibility offers one explanation for why children can respond so differently to adversity. Bakermans-Kranenburg and Van Ijzendoorn (2007), in their review of the evidence regarding differential susceptibility and attachment, highlight the importance of secure attachment in supporting “orchid children”.

Another key finding of recent research is that biological sensitivity to context does not end in infancy and is not only relevant to parents and primary caregivers. This effect of differential susceptibility to relationship quality is also seen in the early childhood education context and later on, with primary school teachers (Essex, Armstrong et al. 2011). This emphasises the importance of *all* relationships experienced by the child.

### **3. Physical, chemical and built environments**

The second target area in a biodevelopmental framework is that of the physical, chemical and built environments in which the child and family live and includes safe sleep environments in infancy, protection from neurotoxic exposures such as lead, mercury, and organophosphate insecticides, safeguards against injury and availability of safe neighbourhoods (Shonkoff 2010).

#### **Physical environments**

##### **Sleep environment in infancy**

It is essential that the sleep environment of infants, particularly newborns, is as safe as possible to reduce the risk of sudden, unexpected death. Sudden unexpected death in infancy (SUDI) is by far the commonest cause of post-neonatal mortality in Aotearoa New Zealand. Of all high-income nations, New Zealand has the highest rate of Sudden Infant Death Syndrome (SIDS), a subset of SUDI that refers to those deaths unexplained despite a post-mortem and an investigation of the clinical history and circumstances of death (Moon, Horne et al. 2007). Just under half of all SUDI deaths are associated with strangulation or suffocation in bed (NZ Mortality Review Data Group University of Otago 2013). Hence, the importance of promoting safe sleep environments for all infants (Task Force on Sudden Infant Death Syndrome 2011).

Understanding of key aspects of the causal pathways involved in SUDI is incomplete, however, there is a large body of evidence on risk-factors (such as prone and side infant sleep positions, smoke exposure, parental alcohol and drug use, bed-sharing, soft bedding and sleep surfaces, and overheating) and protective factors (protecting infants from second-hand smoke, supine sleep position, firm sleep surfaces, room-sharing without bed-sharing, avoiding soft bedding, pacifier use, breastfeeding and immunisation) (Moon, Horne et al. 2007, Task Force on Sudden Infant Death Syndrome 2011, Cleminson, Oddie et al. 2015).

The context of bed-sharing has been of particular interest in recent years. Carpenter and colleagues combined individual data from five case-control studies to explore the relationship of bed-sharing and SIDS (Carpenter, McGarvey et al. 2013). They found that parental alcohol use and smoking was especially hazardous, however there was also a five-fold higher risk of SIDS from bed-sharing for breast-fed babies whose parents do not smoke or use alcohol or drugs (Carpenter, McGarvey et al. 2013).

However other work has shown that maternal presence during infant sleep has benefits for attachment and may contribute positively to a regulatory role in the way that infants' sleep patterns mature (Adams, Stoops et al. 2014). Ball and Volpe (2013) note that bed-sharing is not reduced by simple recommendations about risk. This is particularly the case in families where bed-sharing is connected with traditional cultural practices and identity. For these families, advice not to co-sleep with a young baby may be seen as setting up a conflict between "safeguarding" and "wellbeing" (Adams, Stoops et al. 2014). Researchers in New Zealand are contributing to the evidence-base around culturally-appropriate and safe sleeping environments for infants that reduce risk and enable parental presence such as through the use of wahakura (Tipene-Leach 2010) (Abel and Tipene-Leach 2013).

##### **Injury**

Injury of children aged under 15 years is a significant contributor to disability adjusted life years (DALYs) lost to premature death and to impairment or disability (Schwebel

and Gaines 2007). In their review of child injury trends in the USA and globally, Johnston and Ebel (2013) note the challenges in reducing injury while not stopping children from leading active lives. The built environment contributes significantly to the observed social gradient in child injury deaths (Shaw, Blakely et al. 2005, Orton, Kendrick et al. 2012) with differential exposure of children to health damaging environments (Roberts 1997). A safe environment that protects children from unintentional injury will include mandatory use of seatbelts and appropriate child restraints, fencing of swimming pools, legislation and policy to reduce alcohol-related harm, but also requires an understanding of contextual factors such as parental supervision and the impact of poverty on injury risk (Schwebel and Gaines 2007). Mandatory child-resistant closures for medicines have also been shown to contribute to a safe physical environment (De Ramirez, Hyder et al. 2012). While these regulatory measures are of some benefit, events which result in child injury do not occur in isolation. Upstream factors including employment and income distribution, the changing nature of neighbourhoods and families, work-life balance and the value of children in society must also be addressed to create physical environments where children can live safely (Simpson, Fougere et al. 2013).

### **Chemical environments**

In this review chemical environments are considered to include influences that act on physiological processes in the body of which the most important are stress, and toxins delivered via the placenta such as tobacco, alcohol, and other drugs, together with emerging research about physiological changes around puberty. An earlier review examined the literature on the influence of maternal factors, including maternal stress and smoking, alcohol and drug use during pregnancy (Kvalsvig 2014). The current review will focus on influences occurring after birth.

### **Maternal stress response**

Maternal stress during pregnancy has been shown to have a strong association with a number of child outcomes, including preterm delivery and behaviour, language and generalised developmental problems (Sandman and Davis 2012, Graignic-Philippe, Dayan et al. 2014, Kvalsvig 2014). These effects are mediated through hormonal physiology, communicated to the fetus through the placenta. The stress environment experienced by the fetus programmes that individual's stress responses, a process that continues after birth. Early stress experiences have been shown to influence adult health over many decades, including age-related cognitive decline (Korosi, Naninck et al. 2012) and cardiovascular risk, probably as a result of stress-induced activation of inflammatory pathways (Rohleder 2014) (Ruiz and Avant 2005).

### **Alcohol and other drugs**

In utero exposure to alcohol has well-described and lasting effects on development, increasing the risk of congenital malformations and developmental and psychosocial problems (Kvalsvig 2014). When they occur together, these effects are known as Fetal Alcohol Spectrum Disorder (Riley, Infante et al. 2011). For more detail on the effects of antenatal exposure to alcohol and other drugs on child health, see our previous review (Kvalsvig 2014).

### **Physiology of adolescent development**

There is a significant body of emerging research around opportunities to provide optimal environments for adolescents accompanied by a call to place adolescent years at centre stage (Richter 2006, Anderson, de Bruijn et al. 2009, Auxemery 2010, Roberts, Sanci et al. 2012, Sawyer, Afifi et al. 2012, Baer, Gottlieb et al. 2013, Barankin 2013, Allen, Ryan et al. 2014, Asarnow and Miranda 2014, Bailin, Milanaik et al. 2014, Baker and Steinkraus 2015). "Health in adolescence is the result of interactions between prenatal and early childhood development and the specific

biological and social-role changes that accompany puberty, shaped by social determinants and risk and protective factors that affect the uptake of health-related behaviours” (Sawyer, Afifi et al. 2012 page 1630).

## **Built environments**

In this section we have considered built environments in terms of housing and the broader communities in which children live and play. There is some overlap with previous sections, for example over half of the injury-related deaths and hospitalisations of young children in New Zealand result from injuries that occur at home (Simpson, Fougere et al. 2013), and protection from environmental tobacco smoke is very relevant in the home environment (Weitzman, Kavanaugh et al. 2005).

## **Healthy housing**

There is a large body of research describing the profound impact of housing quality on child health. This is not surprising, given that young children spend most of their time at home and are particularly susceptible to features of that environment (Weitzman, Kavanaugh et al. 2005, Baker, Keall et al. 2007, Ormandy 2014). A healthy home provides protection from the elements – extreme heat and cold; from communicable disease and from injury (Keall, Baker et al. 2008), and promotes social and emotional wellbeing (Krieger and Higgins 2002).

Household crowding and exposure to dampness, cold temperatures, and second-hand smoke (Thomson, Wilson et al. 2005) have all been implicated as drivers of the inequalities in hospitalisations due to infectious diseases in New Zealand (Baker, Barnard et al. 2012). In community-based trials, improving housing quality has had a measurable positive effect on child health (Free, Howden-Chapman et al. 2010, Howden-Chapman, Crane et al. 2011).

There are a number of further references about built environments that promote wellbeing (Committee on Environmental Health 2009, Bult, Verschuren et al. 2011, van Loon and Frank 2011, Dahan-Oliel, Mazer et al. 2012, Ager, Metzler et al. 2013, Christian, Zubrick et al. 2015, D’Haese, De Meester et al. 2015).

Given the importance of a safe and healthy home environment to child health and wellbeing, it is clear that children, families and youth who are homeless are extremely vulnerable (Grant, Shapiro et al. 2007, Altena, Brilleslijper-Kater et al. 2010, Perlman, Cowan et al. 2012, Spinney, Australian Housing Urban Research Institute et al. 2012, Henwood, Cabassa et al. 2013, Stablein and Appleton 2013, Medlow, Klineberg et al. 2014, Narayan 2015). New Zealand Census data from 2001 and 2006 indicate that there were approximately 34,000 people who did not have access to housing that met a minimum adequacy standard. Children aged under 15 years made up more than a quarter of the severely housing deprived population (Amore, Viggers et al. 2013).

## **Safe neighbourhoods**

Children are currently more sedentary than they have ever been (Dollman, Norton et al. 2005). The reduced opportunities for both physical activity and socialising has led researchers to consider neighbourhood characteristics like walkability and perceived safety, and how the built environment might be shaping child development (Goldfeld, Woolcock et al. 2015).

A social context that promotes wellbeing for adolescent children will include access to education, age and stage appropriate health services, and provide opportunities for autonomy, decision-making, employment and enjoyment of human rights (Sawyer, Afifi et al.). Community engagement is also an important aspect of

wellbeing for children living with disability or long-term health condition (Andrews, Falkmer et al. 2015).

## 4. Nutrition

Within the biodevelopmental model the target area of appropriate versus poor nutrition “requires attention to the availability and affordability of nutritious food; parent knowledge about age-appropriate meal planning for young children that assures adequate intake of both macronutrients (e.g., protein, carbohydrates, and fat) and micronutrients (e.g., vitamins and minerals); and effective controls against the growing problem of excess caloric consumption and early obesity” (Shonkoff 2010 page 360). A full discussion of the large and extensively-researched topic of nutrition is outside the scope of the current review, which instead highlights topics of recent or emerging interest and factors known to be strongly influential on child health and wellbeing.

### **Micronutrient level**

We have previously reviewed the role of maternally-derived micronutrients such as folate, vitamin D and iodine in child health, and the evidence about individual- and population-level interventions to promote adequate levels of these nutrients (Kvalsvig 2014). Folic acid supplementation is estimated to prevent 69% of neural tube defects (Dean, Lassi et al. 2014). Other micronutrients of interest currently are iodine and selenium (Shukri, Coad et al. 2014). There is increasing concern about low Vitamin D levels, with rickets re-emerging in some populations in recent years (Dawodu and Wagner 2007).

Children’s micronutrient needs are not uniform. Recent research indicates that consideration also needs to be given to the needs of children with chronic health conditions and disabilities, particularly with regard to Vitamin D (Andrew and Sullivan 2010, Abrams, Coss-Bu et al. 2013).

### **Macronutrient level**

Macronutrient intake in pregnancy has been reviewed previously. That review found that although the literature is still evolving and findings are sometimes contradictory, there is increasingly strong evidence that maternal weight (even pre-pregnancy weight) and – as a separate consideration – maternal weight gain during pregnancy, have a metabolic programming effect on offspring (Kvalsvig 2014). In the current review, we describe evidence about childhood aspects of macronutrition - the appropriate intake of healthy food leading to optimal growth for that individual and a healthy weight.

### **Breastfeeding**

The evidence for health effects of breastfeeding is not reviewed in detail here as it has been thoroughly reviewed elsewhere (Oddy 2001, Horta and World Health 2007, Cleminson, Oddie et al. 2015). In recent years research effort has shifted from the “why” (i.e. reasons to breastfeed) to the “how” (i.e. approaches to breastfeeding promotion). Women in disadvantaged communities in New Zealand have lower breastfeeding rates (Craig, Adams et al. 2012). The reasons for this are complex, but lack of support for women who are breastfeeding - whether from health professionals, family or the wider community - is a commonly-cited reason for cessation (Scott and Colin 2002). Clearly, an important strategy for promoting breastfeeding is to ensure a supportive environment for new mothers and babies to develop this skill (Cleminson, Oddie et al. 2015).

Also, researchers are moving from a simple consideration of breastfeeding versus not breastfeeding to a more nuanced approach. This has led to evidence showing that duration (Harder, Bergmann et al. 2005) and exclusivity (Quigley, Kelly et al.

2007) are important dimensions of breastfeeding with independent effects on child health, particularly obesity and infection risk.

### **Introduction to solid foods**

The World Health Organization recommends that babies who are exclusively breastfed do not need solid foods before 6 months of age (Kramer and Kakuma 2004). Determining a recommended age for solid foods is more challenging. Because of obvious difficulties in randomising infants to be introduced to solids at different ages, there is a lack of high-quality evidence regarding the optimal age for starting solids and how to judge when an individual child is ready.

One interesting empirical approach in dealing with this question is baby-led weaning, which has been widely adopted by new parents in recent years (Brown and Lee 2011). The principle of baby-led weaning is that the infant self-feeds (Rapley 2011, Rowan and Harris 2012). Thus, they begin solids when they are developmentally ready to sit upright and eat, rather than at a predetermined age. They are also in control of the quantity they eat. This is a promising approach given the evidence on the importance of satiety in supporting healthy eating: babies who eat when hungry and stop when they feel full have a higher chance of maintaining a healthy weight as they grow (Lindsay, Sussner et al. 2006). It has been suggested that one of the ways in which breastfeeding protects from obesity is that it promotes satiety responsiveness (Brown and Lee 2012); baby-led weaning can be seen as a continuation of this pathway.

This is a new evolving area of research with interesting implications for early interventions to promote a healthy eating environment for children.

### **Flavour and exposure**

A relatively new line of enquiry is to consider the factors that encourage children to eat a wide variety of foods, particularly vegetables. There appears to be an early sensitive period in which babies rapidly become accustomed to some flavours, particularly bitter tastes; this occurs during the first 3 months of life. This has implications for formula-fed babies who are not exposed to different flavours in the way that breastfed babies are (Rohlf's Domínguez 2011). At older ages exposure is still important and children can be induced to accept new flavours if they are given multiple opportunities to try them (Cooke 2007).

### **Breakfast**

Breakfast has been identified as an important meal for children, particularly before the school day begins. Children who eat breakfast are more likely to be a healthy weight and to have adequate micronutrient intake (Rampersaud, Pereira et al. 2005, Szajewska and Ruszczyński 2010, Fulford, Varley-Campbell et al. 2015). In New Zealand, as elsewhere, eating breakfast is socially patterned and children who are more advantaged are more likely to eat breakfast (Utter, Scragg et al.). It is estimated that 55,000 children in New Zealand do not eat breakfast on any given day (Ni Mhurchu, Turley et al. 2010) which is concerning.

### **Resilience to adverse nutritional conditions**

Resilience to adverse nutritional conditions has been identified as a promising area of research (Yousafzai, Rasheed et al. 2013); a better understanding of these pathways can inform strategies for supporting children whose nutritional environment has been poor.



## **5. Putting the pieces together: sequencing and interactions**

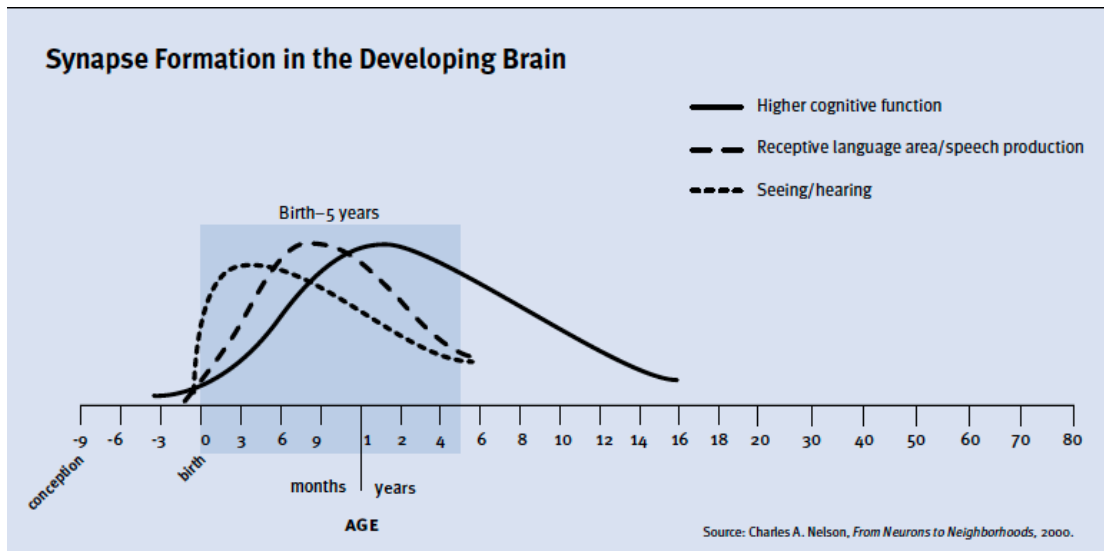
### **Sequencing of influences**

Effective health promotion planning requires an understanding of the sequencing of the key influences in children's lives. This includes identifying critical earlier factors on which later influences depend, and being aware of sensitive windows of time which should be utilised while the potential for change is highest.

The National Scientific Council on the Developing Child have produced a working paper, "The Timing and Quality of Early Experiences Combine to Shape Brain Architecture: Working Paper 5" (National Scientific Council on the Developing Child 2004) which summarises current thinking on this topic by linking the evidence on basic science research on brain development to the child development literature. This paper is highly recommended as a non-technical introduction to the science of child development. In particular, it shows how critical sensitive-responsive relationships are as the foundation for numerous later competencies and skills.

### **Sensitive periods**

It is now well established that the most sensitive time for brain development is the earliest part of life. Before and shortly after birth (see Figure 1) is the time in which neural development is happening very rapidly and is particularly sensitive to environmental impacts such as toxins or responsive interactions with caregivers. However, research from different disciplines is indicating that within that time range the sensitive period of different aspects of development is variable. For example, maternal alcohol ingestion has an important effect on fetal growth and development during the first trimester of pregnancy, and there appears to be a sensitive period for stress which occurs at 12–20 weeks of pregnancy (Kvalsvig 2014). The sensitive period for processing basic sensory information ends soon after birth (National Scientific Council on the Developing Child 2007), while the sensitive period for language occurs later (National Scientific Council on the Developing Child 2007). Not all sensitive periods occur in early childhood: adolescence has been proposed as sensitive period for sociocultural processing (Blakemore and Mills 2014).



**Figure 1. Timing and sequence of neural connections in early life brain development. Source: National Scientific Council on the Developing Child (2007)**

Knowledge about sensitive periods can inform strategies for intervention. For example, if a hearing intervention such as cochlear implantation is under consideration, this should occur early to have maximal effect on hearing as a sensory function, and similarly, will need to occur before the most sensitive period of language acquisition to have a maximal effect on speech (Kral and Sharma 2012). At a population level, the results of a large prospective cohort study from the UK suggest that infants who had participated in a universal newborn hearing screening programme (where hearing problems had been identified before nine months of age) had better reading comprehension as teenagers (Pimperton, Blythe et al. 2014).

This has also led to the concept of “age-appropriate experience”: children need basic sensory and emotional experiences shortly after birth, when sensory systems are actively developing; they need more complex experiences later on, to match the complexity of the skills that are then evolving (National Scientific Council on the Developing Child 2007 page 5). The need for experiences to be matched to the specific needs of the child at that time is one reason why a responsive environment is so important for children, and suggests that guidance on age-appropriate experiences would be useful information for parenting programmes to deliver.

The literature on sensitive periods appears fragmented, consisting mostly of studies reporting on one developmental process at one life stage. A recent paper in *Nature Reviews Neuroscience* has taken this a step further by discussing the different effects of stress on the brain and cognition at different times during the lifecourse (Lupien, McEwen et al. 2009).

What is now needed is a synthesis of the literature on sensitive periods that encompasses all domains of child health and development, with the aim of producing a timeline for population monitoring and support through childhood. In this way, the effectiveness of services and programmes could be maximised by aiming to deliver them at the time of greatest developmental plasticity.

However it should also be noted that there is considerable lack of agreement in defining precise sensitivity periods, and that these periods are not an all-or-nothing phenomenon. As the authors of the working paper cited above note: “For most

functions, the window of opportunity remains open well beyond age three” (National Scientific Council on the Developing Child 2007 page 5). There is some evidence that environment can influence developmental plasticity such that sensitive periods are extended in situations of under-stimulation (Thomas and Johnson 2008). This is an encouraging possibility for agencies supporting children who have had a difficult start in life. The emerging research about the neurophysiology of puberty may lead to new opportunities to support positive development and wellbeing in later childhood (see Physiology of adolescent development page 15).

### **Resilience**

Resilience can be defined as a “dynamic process encompassing positive adaptation within the context of significant adversity” (Luthar 2006). Resilience has been of interest to researchers for many years, with interest arising from the observation that some children emerge from experiences of extreme adversity without the poor outcomes that one might expect. However in the past, research on resilience has been hampered by a lack of strong concepts of resilience, sometimes leading to circular reasoning - i.e. a child is defined as resilient because they have shown resilience – which sheds no light on how the child arrived at this point, or what could be learned in terms of supporting other children.

While the term “resilience” is often used in the context of social-emotional development, newer research into the biological mechanisms of resilience has shown that the same processes are relevant to all domains of child health and development: earlier influences shape the individual’s response and vulnerability to later influences, and this is as true of nutrition as it is of social competence. The developmental concept of skills building on skills has been well-described in a number of developmental domains (Fischer 1980). However, there is now evidence that social-emotional development is a primary determinant of subsequent development across a number of domains, suggesting that this is a good starting point in examining the sequencing of child health and wellbeing.

The definition by Luthar (2006) quoted above emphasises the fact that until recently adversity was an essential requirement for investigating resilience: under this definition, one could only observe resilience in children who were experiencing adversity. More recent research into the mechanisms underlying resilience has led to an appreciation that the contexts and behaviours that establish the foundations of health and wellbeing are the same as the context and behaviours that support the development of resilience (Panter-Brick and Leckman 2013). This allows us to integrate what is known about resilience into strategies for promoting health and wellbeing for all children and vice versa.

Both secure early attachment (Rutten, Hammels et al. 2013) and executive function (Beeghly and Tronick 2011) have been described as foundational capacities for resilience, with the complex skills of executive function building on the earlier learning work of attachment. This suggests that secure attachment and executive function should be high-priority targets for child health promotion.

How can we actively promote resilience? For their consensus document on resilience, authors from the National Council on the Developing Child concluded that the single most important predictor of resilience was the availability to the child of at least one stable, caring supportive relationship with an adult in their life (often, but not necessarily a parent) (National Scientific Council on the Developing Child 2015). This responsive relationship helps create the right conditions for the child to develop executive function and self-regulation skills, competencies which in turn allow them to overcome challenges and develop a sense of mastery. Finally, the authors

recognised the protection that is given by supportive cultural contexts. The requirement to be responsive to each child includes a need to consider differential susceptibility causing children to have varying responses to interventions. It is also important to take into account the child's cultural environment: this has been found to influence many aspects of resilience, including how children experience stressors and the sociocultural support available to them (Clauss-Ehlers 2008).

These factors - stable, supportive relationship with an adult, attachment, executive function, sense of mastery, and supportive cultural contexts - are all potentially modifiable. This suggests the exciting possibility of future intervention programmes that can effectively support all children to develop a healthy resilience to adversity.

## **Interactions**

The previous section described how earlier influences set the foundations for later processes in a continuous process of skills building on skills. However, it is also useful to understand how these factors interact and modify each other. As a way of illustrating this, we will discuss the way environments bring together multiple influences on child health and development, using the example of nutrition.

### **Nutrition and the leptogenic environment**

We have discussed nutrition in terms of micro- and macronutrition in a previous section. But promoting good nutrition to support child health and wellbeing is not only about the narrowest sense of providing appropriate types and amounts of nutrients for growth. Increasingly, translational research is exploring the effect of environments on children's eating patterns. Concern about the increased availability of foods that are energy-rich and nutrient-poor (Lobstein, Jackson-Leach et al. 2015) and the role this plays in obesity has led to discussion of the "obesogenic environment", an extremely useful concept in obesity prevention.

But what about positive pathways? In 1999 Boyd Swinburn and colleagues coined the term "leptogenic environment" from the Greek word *leptos* (meaning thin) to help conceptualise environments that encourage children to be lean. These environments have physical, sociocultural, economic, and political dimensions (Swinburn, Egger et al. 1999).

Earlier in this review, we discussed the importance of secure and responsive relationships for social and emotional wellbeing, and for resilience. But responsive relationships are also extremely important for nutrition (National Scientific Council on the Developing Child 2004). Responsive feeding arises from responsive parenting (Black and Aboud 2011). Thus, food itself is not the only determinant of health: the responsiveness of caregivers may also be strongly influential. Parenting style is linked to children's weight profiles both as a cause and effect (Gross, Fierman et al. 2010, Skouteris, Hill et al. 2015).

We have earlier discussed the built environment and its role in promoting or preventing physical activity. A developing area of research is emerging in relation to junk food promotion to children and the effect the food environment has on their eating habits (Dixon, Scully et al. 2007, Barr, Signal et al. 2015).

## 6. Conclusions

### Environments

A major theme in current research is to consider environments as powerful influences in children's lives, altering not only children's physical and emotional development but also their genes. This phenomenon is seen in topics as diverse as infant attachment, nutrition and early childhood education, underlining the importance of coordination between agencies. This is challenging, as Jack Shonkoff states: "...ministries of health prioritize child survival and physical well-being, ministries of education focus on schooling, ministries of finance promote economic development, and ministries of welfare address breakdowns across multiple domains of function" (Shonkoff, Richter et al. 2012 Abstract page e460). A focus on environments as targets for intervention would require a more coordinated approach, bringing these agencies together.

### Resilience and positive pathways

As research continues to identify the specific pathways between environments, physiological processes and health throughout the lifecourse, new light is shed on the opportunities and challenges for supporting children in positive trajectories of health and wellbeing.

"A lens on resilience shifts the focus of attention - from concerted efforts to appraise risk or vulnerability, towards concerted efforts to enhance strength or capability. It also shifts the focus of analysis - from asking relatively limited questions regarding health outcomes, such as what are the linkages between risk exposures and functional deficits, to asking more complex questions regarding wellbeing, such as when, how, why and for whom do resources truly matter" (Panter-Brick and Leckman 2013 page 333).

The quality of early relationships (in particular attachment), programming of the stress response, and healthy nutritional environments are foundational experiences. Influences occurring in sensitive periods during early life have enduring effects across multiple domains of health and wellbeing throughout the lifecourse.

Evidence from basic science fields shows that promoting environments for children that optimise these critical early processes is the most promising strategy for supporting resilience. Conversely, the realisation that adverse environments experienced by children living in poverty are actively shaping physical processes such as cognitive development (National Scientific Council on the Developing Child 2014) (a process known as 'embedding') is of great concern.

Hart and Risley, in summing up the findings of their research on language development, highlight how much more difficult it is to undo the damage of an adverse environment than it is to get things right from the beginning. "So much is happening to children during their first three years at home, at a time when they are especially malleable and uniquely dependent on the family for virtually all their experience, that by age three, an intervention must address not just a lack of knowledge or skill, but an entire general approach to experience" (Hart and Risley 2003).

## **Responsiveness**

Research on biological sensitivity to context shows us why individual children may respond differently to the same environmental influences: a “one size fits all” approach that is not responsive to individuals is unlikely to succeed. This research also shows us why adverse conditions such as poverty can have devastating effects for some children (the “orchids”), who are highly sensitive to their environments. This is a strong argument against the individual responsibility model of resilience in which children succeed or endure through “grit” and “willpower” (National Scientific Council on the Developing Child 2015). Instead, the evidence shows that resilience evolves most effectively when children are kept safe and supported by those around them.

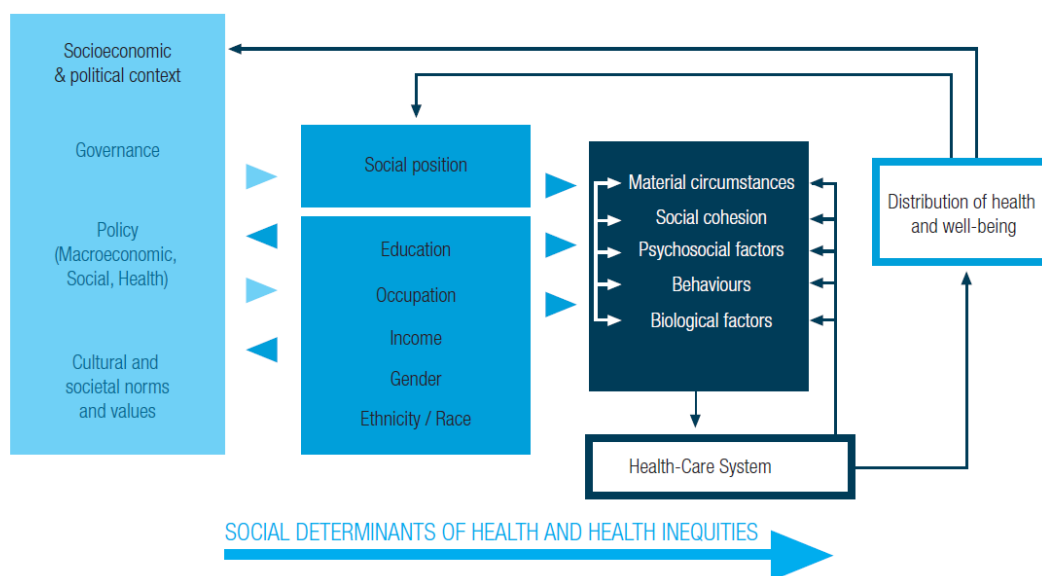
In a responsive, supportive environment both the “dandelion” and “orchid” children will do well; the “orchid” children will have the environment they need to thrive; and all will have the opportunity to realise their full potential. This is a developing area of work and we can expect to see more insights in the future.

## Abbreviations

AL	Allostatic Load
ECE	Early childhood education
HRQOL	Health-related quality of life
SIDS	Sudden Infant Death Syndrome
SUDI	Sudden Unexpected Death in Infancy
UNCRC	The United Nations Convention on the Rights of the Child
WHO	The World Health Organization

## Appendix 1 Social determinants of health conceptual framework

WHO Commission on the Social Determinants of Health conceptual framework for the social determinants of health



Source: Amended from Solar & Irwin, 2007

Source: Commission on the Social Determinants of Health, World Health Organization 2008. Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health. (based on Solar O & Irwin A. A conceptual framework for action on the social determinants of health. Discussion paper for the Commission on Social Determinants of Health. Geneva, World Health Organization, 2007) (Commission on Social Determinants of Health 2008)



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