

**Neurological and Biological Foundations of Children's Social and Emotional
Development: An Integrated Literature Review.**

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Abstract

This paper provides an integrated review of the expert literature on developmental processes that combine social, biological and neurological pathways, and the mechanisms through which these pathways may influence school success and health. It begins with a historical overview of the current understanding of how attachment relationships and social environments influence brain development and plasticity and are, therefore, central to the physical and mental health of individuals and populations. It then expands on the effect of plasticity in relation to behavior and learning at school. This paper concludes with a discussion of the role the school nurse may play in supporting health and learning by recognizing signs of relational stress and by advocating for prevention strategies.

Key words: Literature Review, Plasticity, Relationship, Development, Mental Health, Bullying, School Nurse.

Introduction

Children have innate and inherited characteristics that direct the course of their biological, psychological, and social development. In addition, children's social and emotional experiences influence brain development and are therefore central to outcomes of behavior, learning, and health. Relationships with adults and other children play a central role in the development of social and emotional regulation. Nurturing relationships generally support appropriate regulation and lead to the formation of brain pathways and neuro-endocrine systems that are prerequisites to learning and good health. Non-responsive or

abusive relationships, on the other hand, can lead to social and emotional dysregulation and sub-optimal brain development that has negative consequences for learning and health.

At school entry, children vary in their capacity for appropriate social and emotional regulation. While many children slip into the classroom routine and school environment very easily, many do not. Those who struggle with social and emotional regulation usually come to the attention of their teacher. Social and emotional dysregulation is also associated with symptoms that give reason for many children to present to the school nurse (Shannon, Bergren, & Matthews, 2010). Increasingly, school nurses work with teachers and parents to enhance children's social and emotional development, so as to advance well-being, academic success, and lifelong achievement (Council on School Health Services, 2008).

Great advances have been made in the understanding of the development of the human brain in the last decade due in the main to Functional Magnetic Resonance Imaging (fMRI) and other innovations in human neuroscience (Almas et al., 2012). For the first time, scientists have been able to begin to understand the complex processes whereby people's thoughts and feelings which are intimately related to their social experiences, influence interactions between neurological, endocrine, immune, and metabolic systems. This paper reviews the recent evidence-based literature on children's social and emotional development and its effect on health, behavior, and learning. It is anticipated that this knowledge and understanding of child development will enhance the capacity of nurses, teachers, and other professionals in the school community to work together to encourage positive development in all children, promoting learning and life-long patterns of health (Council on School Health Services, 2008).

Literature Review

Using a range of relevant search terms, a database search was conducted, including

PsychInfo, ScienceDirect, CINAHL, Medline, and ProQuest. Search terms included various combinations of the following terms: child, development, social, emotion, plasticity, attachment, allostasis, social gradient, school nurse, somatization, learning, behavior, aggression, and bullying. The grey literature, or literature that is not readily available was also reviewed. Documents were retrieved from the Australian Research Alliance for Children and Youth, a clearinghouse for published material on children's health and development (Australian Research Alliance for Children & Youth, n.d.). A manual reference list search was also conducted to locate original articles where relevant.

To understand the effect of social and emotional development on health, it is necessary to first understand the biological, psychological and social processes by which development is shaped. Section One of this paper explains why and how children's social environments influence brain development and are, therefore, central to the health of individuals and populations. Section Two expands on the effect of these developmental pathways in relation to behavior and learning at school. Section Three addresses the role of the school nurse in supporting social and emotional development.

Pathways of development.

The environment, brain plasticity, and biological embedding.

Bronfenbrenner (1979) first proposed that children's understanding, perception, and motivation are shaped by their own experience within their environment. Beyond the physical surround, the *environment* includes children's relationships with others, beginning with family, and extending out in broadening circles to school and neighbourhood, and the influences of society, including government policies and overarching beliefs and values (Bronfenbrenner, 1995). Developmental systems theory is now the dominant paradigm in understanding children's development and it is also now well established that the early

experiences of children become *biologically embedded*, that is, experiences influence biological development (Hertzman, 2012). In this way, early experience lays the foundation for life-long behavior, cognition, learning, and physical and mental health (McEwen, 2012; Shonkoff, 2012). There is a *plasticity* to brain pathways and associated flexibility in the development of endocrine, immune, and metabolic systems that allows them to be modelled and remodelled in response to each child's own environment (McEwen, 2012; OECD, 2007; Yirmiya & Goshen, 2011).

Plasticity is defined as the flexibility of neural cells and pathways to alter in their structure and function in response to stimulation from the environment (McEwen & Gianaros, 2011). The type and number of brain cells made, the formation of neural pathways, and the release and reception of neurotransmitters at synaptic connections, occur in response to children's experience (Kessels & Malinow, 2009; OECD, 2007). This is the cellular basis of plasticity, coordinating behavior and physiology (Hummel & Cohen, 2006; Yirmiya & Goshen, 2011). Plasticity is protective in early childhood, fitting neural and physical development to the environment each child experiences, first in their family, and then in new environments including school (McEwen, 2012). Neural development that protects children in environments of early adversity, however, may predispose them to poor outcomes of development and health over the life course (Shonkoff, 2012). Plasticity is most prolific during critical or sensitive periods, in which brain pathways specific to different areas of development are shaped and connected according to children's own experience (Sokolowski, Boyce, & McEwen, 2013). Based on a review of the most recent evidence in both animal and human research Hertzman (2012) considered that such sensitive periods begin prenatally, peak in the very early years of life, and lessen with increasing age.

A consistent finding is the importance of the social environment to plasticity, beginning with earliest attachment relationships (Hertzman, 2012; Hostinar, Stellern,

Schaefer, Carlson, & Gunnar, 2012). Animal and human studies have shown that social deprivation in early life can cause reduced plasticity creating vulnerability to disorders of emotion regulation, cognitive function, and mental health (Almas et al., 2012; Hostinar et al., 2012). In animal studies this is attributed to the direct effect of maternal care on the development of neural pathways that regulate the emotional, neuroendocrine, and cognitive response to stress (Champagne et al., 2008; de Kloet, Joëls, & Holsboer, 2005). Champagne et al. (2008), for example, found that in comparison to low maternal care, high maternal care of rat pups (licking and grooming) supported synaptic development ($p < 0.001$). This is consistent with findings from children whose earliest months of life were lived in an environment of emotional and physical deprivation in Romanian orphanages during the Soviet era, and who were later adopted into nurturing homes. Gunnar, Morison, Chisholm, and Schuder (2001), for example, found disrupted brain plasticity and low cognitive development in children adopted after eight months of age, present 6.5 years after adoption into stable homes. This effect was buffered by the secure attachment relationships of children who were placed into nurturing homes, with a higher protective effect the closer children were to eight months of age on adoption (Gunnar & Quevedo, 2007). It has been shown in animal and human studies that the primary facilitator of plasticity is the tactile and emotionally nurturing aspects of care rather than feeding (Beckett et al., 2006; de Kloet, Vreugdenhil, Oitzl, & Joëls, 1998; Walker, Chang, Powell, & Grantham-McGregor, 2005). In contrast to the poor outcomes reported in conditions of severe early social neglect, there can also be a cascading effect of mundane relational stress that leads to a feedback loop affecting the development of neural pathways over time, beginning in the home and increasing the risk for school failure (Hertzman, 2012).

At a population level, systematic differences in social experience lead to differential health and developmental outcomes for adults and children. Known as the *social gradient*, in

each society those of higher social class or socioeconomic status, live longer and are healthier than those below, in a step-wise pattern (Hertzman, 2012; Kendall, van Eekelen, Li, & Mattes, 2009; Marmot, 2005; McEwen & Gianaros, 2010). At a population level, compared with those who live in societies with steep social gradients, those who live in societies with flatter gradients where resources are distributed more evenly across the population experience better outcomes in health and well-being (Commission on Social Determinants of Health [CSDH], 2008; Marmot & Wilkinson, 1999). The social gradient in health was first highlighted in the Whitehall Studies of British Civil Servants conducted in the 1960s, 70s and 80s. Employment grade, or status, was found to predict risk of cardiovascular disease mortality after controlling for known risk factors, such as obesity and smoking (Marmot et al., 1991). Marmot and colleagues concluded that the gradient effect in health outcomes was due to social inequality, rather than poverty or material conditions, and that the mechanism was likely to be through physiological processes that regulate the human response to stress (Marmot et al. 1991). Later, Keating, Hertzman, and colleagues (Keating & Hertzman, 1999) synthesized evidence showing that the social gradient also applied to children's development, including emotional and behavioral adjustment, and literacy and numeracy. In a seminal publication, Keating and Hertzman (1999) coined the phrase "biological embedding" (p. 4), to describe the process whereby social environments influence the developing brain and the physiological regulation of stress; two important causal pathways by which early experience influences both health and developmental outcomes. While supporting the theory proposed by Marmot and colleagues that the experience of social stress is largely responsible for the social gradients seen in health outcomes, Hertzman went further by highlighting the role played by the early childhood experience in shaping the adult stress response (Kendall & Li, 2005).

An increasing body of evidence supports these earlier findings of the effect of the

social environment on learning, behavior, and health (Boyce et al., 2012; Kendall et al., 2009; Shonkoff, 2012). Lower social class or socioeconomic status is associated with an increased risk of adverse health and developmental outcomes, including: coronary heart disease, type 2 diabetes, cancer, anxiety and depression, dementia, school failure, teen pregnancy, and criminality (McEwen & Gianaros, 2011; Sokolowski et al., 2013). Furthermore, in egalitarian societies that have policies of social inclusion rather than social dominance, and where people are supportive of each other and cohesive at each level of the social hierarchy, people have better overall health and well-being (Marmot & Wilkinson, 1999; Sapolsky, 2005). Similarly, supportive families and schools, positive peer relationships, and neighbourhoods with high levels of social cohesion are environments that are protective of children's health and development (Currie et al., 2012). The American Academy of Pediatrics has recently called for an integrated approach between departments of health, education, and finance to support healthy development based on a scientific understanding of plasticity and the effect that social relationships have on the biology of the developing brain (Shonkoff, Richter, van der Gaag, & Bhutta, 2012). The following section explains the effect of relationships and emotions on brain development.

How relationships and emotions effect brain development.

A large body of research has now shown that the developing brain is particularly sensitive to elevated levels of hormones associated with environments of excessive stress (Hertzman, 2012; McEwen, 2012; National Scientific Council on the Developing Child, 2010; Yirmiya & Goshen, 2011). This has largely been attributed to the processing of emotion within the hippocampus and amygdala, structures of the limbic system that show high plasticity (Thompson, Lewis, & Calkins, 2008; Yirmiya & Goshen, 2011). The neural substrates of emotionally loaded events are stored in the amygdala, while the context of the emotion is processed in the hippocampus. These limbic structures communicate with the

prefrontal cortex (PFC), which helps to interpret the emotional experience. Previous experience shapes these structures and influences patterns of neurotransmitter release and the body's physical and mental preparation for each situation (McEwen & Gianaros, 2011). The experience of chronic stress is associated with changes in the structure and function of areas of the brain leading to problems with the regulation of emotions as well as cognitive difficulties in information processing and memory (McEwen & Gianaros, 2010).

The hypothalamic-pituitary-adrenal (HPA) axis and the sympatho-adrenal medulla (SAM) pathway are highlighted in the literature with regard to the plasticity of the limbic system and the response to emotion (Hertzman, 2012; McEwen, 2012; Repetti, Robles, & Reynolds, 2011; Yirmiya & Goshen, 2011). At the SAM pathway, catecholamine's act quickly to set the fight or flight response in motion; while the HPA axis releases cortisol and other glucocorticoid hormones that play a key role in the maintenance and control of resting and stress-induced metabolic functions. Overexposure to catecholamines and cortisol has a negative effect on the brain as well as metabolic and immune function. As antagonists of the hormone insulin, they mobilize energy reserves by raising blood glucose and promoting fatty acid release from fat tissues (Brunner & Marmot, 2006; Sokolowski et al., 2013).

Glucocorticoid hormones also suppress or dysregulate immune responses by altering the Type 1-Type 2 cytokine balance, inducing increases in proinflammatory factors, and suppressing numbers, trafficking, and function of immuno-protective cells (Dhabhar, 2013). The activity of these pathways is regulated by several feedback loops, providing a balance to the levels of hormones circulating in the body at any one time in a process named *allostasis* (McEwen 1998). Allostasis allows the brain and body to achieve stability through periods of change (McEwen & Gianaros, 2010). Exposure to chronic stress, however, places a burden on these pathways known as *allostatic load*, disrupting the ability of the brain and body to respond effectively to stress, causing imbalance to patterns of hormone release, with

subsequent wear and tear to the brain and body (McEwen, 2012; Sokolowski et al., 2013). It is now well established that stress experienced in early life may induce significant biological changes, which in turn modify the maturation and responsiveness of the systems (biological embedding) leading to long-term effects on cognitive functioning and risking physical and mental health (Brunner & Marmot, 2006; McEwen & Gianaros, 2011).

It is also well established that a secure attachment relationship in the first year of life is key to optimal child development (Hertzman, 2012; Maggi, Irwin, Siddiqi, & Hertzman, 2010; National Scientific Council on the Developing Child, 2010). In a review of scientific studies, Hertzman (2012) relates this primarily to the stability of HPA axis function. Nurturing in early childhood, for example, has been found in animal and human studies to support optimal HPA function, and therefore allostasis and positive behavior, even in children genetically at risk of behavioral problems (Mustard, 2006). Similarly, nurturing is key to the development of the immune system (Yirmiya & Goshen, 2011). Mild emotional stimulation or stress which is associated with allostasis, has been found to be beneficial to the development of immune function (McEwen, 2012; Yirmiya & Goshen, 2011). Within a secure attachment relationship the child who finds him or herself in a stressful environment will look for a familiar loved one and feel safe in their care. When the child feels safe hormone release at the SAM pathway and HPA axis subsides and allostasis is maintained. This response supports plasticity providing a stable foundation on which further development will be patterned into brain pathways (Hertzman, 2012).

On the other hand, the brain pathways in children who do not have the protection of secure and nurturing relationships can be impaired by ongoing stress, creating allostatic load. This response, which is patterned into the brain to protect the immediate survival in a harsh environment, develops at the cost of later metabolic functioning, immune response, emotional and social regulation, as well as cognitive functioning and learning (Gunnar &

Quevedo, 2007; Hostinar, et al., 2012; McEwen & Gianaros, 2010; Shonkoff, Garner, et al., 2012; Taylor, Way, & Seeman, 2011). These persistent cognitive and health effects have been referred to as “the biological embedding of social adversity” (Rutter, 2012, p.17149).

The positive effect of an enriched environment.

Despite early exposure to an environment of risk, brain pathways retain their plasticity to some extent so an enriched environment in later years can promote well-being (McEwen & Gianaros, 2010; Repetti, Taylor, & Seeman, 2002; Sokolowski et al., 2013). As previously discussed, this has been demonstrated in multiple studies of children whose earliest months of life were lived in Romanian orphanages during the Soviet era. The literature is consistent in highlighting the poor physical and cognitive development associated with a lack of loving care in the orphanage environment and the improvement in children who were adopted into nurturing homes (Almas et al., 2012; Beckett et al., 2006; Maclean, 2003; Morison & Ellwood, 2000). The age of adoption, however, did have a significant effect on children’s ability to adapt to the new environment with those placed in foster care after 24 months not able to adjust so readily (Beckett et al., 2006; Rutter, 2012). For example, Almas et al. (2012) found that, the earlier children were placed into foster care from the orphanage environment, the higher their social skills were by teacher report at age eight ($r = -0.40$, $p = 0.004$). This study highlighted the roles of both relationships and neurobiology in developmental trajectories, in particular the importance of the attachment relationship to subsequent peer relationships in middle childhood (Almas et al., 2012). Healthy peer relationships in turn support learning (Schonert-Reichl, Stewart Lawlor, Oberle, & Thomson, 2009; Shannon et al., 2010).

Although children’s early attachment relationships provide a foundation for development, critical or sensitive periods of plasticity exist into adulthood (Beckett et al., 2006; McEwen, 2012; Yirmiya & Goshen, 2011). Another sensitive period in social and

emotional development occurs between two to four years of age. Known as “the terrible twos”, and now recognized as a normal developmental peak in aggression, children learn to regulate their behavior within the secure and consistent limits and nurturing given by adult carers (Shonkoff, Garner, et al., 2012; Tremblay, 2004). Based on review of the most recent evidence in both animal and human research Hertzman (2012) considers that executive function (or cognitive processes) relating to how children respond to social and emotional stimuli develop from approximately three to nine years of age. Children’s capacity to regulate attention and behavior is coordinated by the PFC and plasticity in this region of the brain persists into adulthood (Blair & Diamond, 2008; Shonkoff, 2011). Because the PFC is in constant communication with the structures of the limbic system, social relationships and nurturing continue to underlie children’s goal directed behavior and ongoing development (Blair & Diamond, 2008).

The physical and emotional support received by children is largely determined by the attitudes, beliefs and values of families and communities (culture), and is passed from one generation to the next (Kendall & Li, 2005). Next to family, school is the most important social environment in which children’s development is shaped (Bronfenbrenner, 1979; Commissioner for Children and Young People, 2011; Puskar & Bernardo, 2007). Schonert-Reichl, Stewart Lawlor, Oberle, and Thompson (2009) state that beyond early childhood, middle childhood is critical to development because of the complexity of social relationships in the school environment. The following section will discuss school as an environment that affects behavior, learning, and health through relationships.

Family and school as environment.

How emotions and brain plasticity affect development at school age.

Mustard (2006) refers to allostasis as a “thermostat” (p.17) because it maintains

balance, supporting plasticity and children's adjustment to each new environment. Secure and nurturing relationships in the preschool years support children in their ability to relate to peers and adjust to the learning environment of school. For children raised in families with psychosocial difficulties, such as maternal depression and dysfunctional parental relationships, however, behavior and emotional expression that has protected them (hypervigilance, for example) can become behavior that harms their ability to adapt, relate, and engage in cognitive learning (Blair & Diamond, 2008; Repetti et al., 2011; Shonkoff, 2011; Sokolowski et al., 2013). This places excessive demands on the stress-response system causing allostatic load and reduced plasticity. The outcomes are commonly behavioral and emotional problems in middle childhood, and mental health disorders, substance abuse, risky sexual behavior, truancy, and early school leaving in adolescence (Kerr et al., 2012; Repetti et al., 2011). Because of the ongoing plasticity of brain development, the building of healthy peer and staff relationships at school is key to promoting long-term outcomes of health and well-being (Puskar & Bernardo, 2007). The following sections will discuss how emotions and plasticity affect behavior, learning, and health at school.

Behavior.

Further to his proposal that children's understanding, perception, and motivation are built on their own experience within their environment, Bronfenbrenner (1979) proposed that development is expressed through behavior in the context of a particular environment. Emotions motivate behavior because they give meaning to each situation based on a person's past experience. This occurs through the unconscious appraisal of each situation by the limbic system (Izard, 2007; Kappas, 2002; Organisation for Economic Co-operation and Development [OECD], 2007). Emotional development is ultimately reflected in the way children socialize with others (Repetti et al., 2002). As stated previously, children in an environment of continual impoverished trust are likely to be at heightened alert for harm,

with a negative effect on emotion processing, sense of identity, hope, and capacity to relate to others (Kendall et al., 2009; Meekings & O'Brien, 2004; Repetti et al., 2011; Teicher et al., 2003). At school this can be expressed in behavior that might be regarded by staff as negative, or in poor social interaction with peers (Blair & Diamond, 2008; Gordon, 2005). Poor social and emotional adjustment is associated with the somatic symptoms, school avoidance, and bullying that gives reason for many children to present to the school nurse (Shannon et al., 2010).

School is the central place in which children encounter bullying (Barker et al., 2008; Cross, Erceg, & Hearn, 2007; Runions, 2008). Bullying occurs within a social context, and the intent is to cause harm to another (Cook, Williams, Kim, & Sadek, 2010). Bullying may be in the form of physical aggression, or relational aggression using words, gestures, or social exclusion (Cross et al., 2007; Vlachou, Andreou, Botsoglou, & Didaskalou, 2011). The method of bullying changes as children develop cognitive awareness, for example, they may develop subtle forms of relational aggression often purposely hidden from adults (Runions, 2008; Schonert-Reichl, Smith, Zaidman-Zait, & Hertzman, 2012). The intent of relational aggression is to obtain a goal such as social status or power (Runions, 2008; Vlachou et al., 2011). Children who are bullied are at risk of poor developmental outcomes including depression and loneliness, and they are at increased risk of suicide and early school leaving (Cook et al., 2010; Troop-Gordon & Gerardy, 2012; van der Wal, de Wit, & Hirasing, 2003). Bullying harms the person who is bullying others, as well as the recipient. Children who bully others have been found to be at increased risk of delinquency, depression, and suicidal ideation (Cross et al., 2009; van der Wal et al., 2003).

Adults are more accepting of relational aggression than physical aggression, and attribute less responsibility to children for perpetuating relational aggression (Runions, 2008; Troop-Gordon & Gerardy, 2012; Werner & Grant, 2009). Acceptance of bullying by adults,

or the belief by a child that the teacher advises avoidance of the bully, such as to walk away, have been found to place children at risk for poor self-esteem and other negative outcomes (Troop-Gordon & Gerardy, 2012). This is because the emotional load on the limbic system is heightened when children believe they do not have the support of adults (McEwen & Gianaros, 2010). For example, children of parents who considered that relation victimization was a normal part of childhood showed higher levels of depression ($p = 0.002$) than when parents held average ($p = 0.42$) or low (ns.) normative beliefs regarding relational victimization (Troop-Gordon & Gerardy, 2012). On the other hand, victims of bullying show less emotional distress and cope more effectively with stress when adults are emotionally responsive, helping children learn to effectively regulate painful emotions (Troop-Gordon & Gerardy, 2012). Troop-Gordon and Gerardy (2012) found heightened social withdrawal in children whose parents held high ($p < 0.001$), or average ($p < 0.001$) levels of belief that avoidance was the best way to deal with relational aggression, but no significant association with social withdrawal for children whose parents who had low levels of belief that avoidance was the best strategy for dealing with relational aggression (ns).

Research has shown that children who have bullied others often lacked empathy for the bullied child (Cross et al., 2009; Putallaz et al., 2007). Empathy is considered a principle factor that motivates prosocial behavior - behavior intended to improve the situation for another (Bierhoff, 2002), and empathy has been related to the capacity for self-regulation (Gordon, 2003; Schonert-Reichl et al., 2012). In very young children, empathy is the ability to feel with another; as children age, a cognitive form of empathy develops in which children begin to understand the perspective of others (Catherine & Schonert-Reichl, 2011; Davis, 1983; Hunter, 2003). It is believed that cognitive aspects of empathy develop after five years of age (Hunter, 2003). Overall, however, empathy concerns responsiveness to others (Davis, 1983). This responsiveness results in the development of prosocial behavior, including

children's tendency to be considerate to others and to form positive relationships (Mustard, 2006; Schonert-Reichl et al., 2012; Wake et al., 2008).

Recent research examining the development of aggression and empathy of children at school entry has shown that teacher-reported aggression decreases between five and six years of age, while empathy increases in children between six and seven years of age (Nelson, Kendall, & Shields, 2013). These results suggest that this is a sensitive period for modifying aggressive behavior. Maggi et al. (2010) describe this time of schooling as a "critical transition" (p. 6) because children experience a fundamental change in social environment and social dynamics that shapes their lives in either a positive or negative way. Just as two year olds learn to regulate their behavior within the supportive nurturing of adult caregivers, children at school require the support of nurturing adult relationships. School nurses and teachers have an important role in building an environment of trust and nurturing for children at school.

Learning.

The emotions children experience at school affect their capacity to learn (OECD, 2007; Shonkoff, 2011). While knowledge of the mechanisms involved is not fully developed, researchers already have many clues. One mechanism, for example, is the effect of emotions on glucose availability to the brain through the allostatic response (Repetti et al., 2011; Sokolowski et al., 2013). The primary role of cortisol is to provide the brain and the body with glucose in order to cope with environmental demands. The short-term elevations in cortisol associated with minor stress regulate the metabolism of glucose (Repetti et al., 2011). The feedback loop of this process supports plasticity involving memory and learning (Chugani, 1998; Yirmiya & Goshen, 2011). On the other hand, the constant emotional load that accompanies chronic stress is related to consistently elevated base cortisol levels and a blunted response in times of acute stress (Repetti et al., 2011). If the metabolism of glucose

by the brain is disrupted a negative feedback loop develops that places the child at risk of poor learning at school (Shonkoff, Garner, et al., 2012; Yirmiya & Goshen, 2011).

Children's capacity to learn is either supported or diminished by the joy or stress associated with the experience of learning and the relational environment of school (Blair & Diamond, 2008; OECD, 2007). Involvement, motivation, self-esteem, hope, play, and the positive emotions experienced with the grasp of new concepts, all facilitate plasticity and learning supported by positive emotions (Kolb et al., 2012; OECD, 2007; Yirmiya & Goshen, 2011). The emotion associated with anticipation, for example, can prepare people to meet challenges and support cognition and learning through HPA axis and SNS stimulation (Yirmiya & Goshen, 2011). Fear and high levels of stress, however, reduce analytical capacity through a build up of stress, referred to as allostatic load (Blair & Diamond, 2008; OECD, 2007; Shonkoff, 2012).

High levels of stress are often associated with family psychosocial factors, such as maternal depression and a lack of social support, and features of the school environment, such as uncontrolled bullying (Kerr et al., 2012; Pavletic, 2011; Shannon et al., 2010). The school nurse is in a unique position to support these children and families by identifying patterns of presentation that may indicate unmet needs (Humensky et al., 2010; Pavletic, 2011; Shannon et al., 2010). Moreover, the school nurse is a responsive adult with whom children develop a relationship of trust, fostering a sense of connectedness to the school environment (Pavletic, 2011). The evidence presented in this section suggests that the relationship between nurse and child is very likely to support learning. Learning in turn will support health, with the potential to support the health and development of future generations because social gradients tend to be as strong according to achieved levels of education as to income (Hertzman, 2012).

The role of the school nurse in supporting relational development.

School nursing is a specialised practice, and school nurses work actively with teachers, families and children to build children's capacity to adapt and learn (Council on School Health Services, 2008; Shonkoff, 2011). In this role, the school nurse works with parents and teachers toward assisting positive responses to normal development in children; and to early identification of, and intervention for, children's health concerns (Council on School Health Services, 2008; Humensky et al., 2010). These concerns are not only related to illness and injury, but also to somatic symptoms (without objective sign of illness or injury), school avoidance, and bullying (Ladwig & Khan, 2007; Shannon et al., 2010; Vernberg, Nelson, Fonagy, & Twemlow, 2011). Children with such issues are likely to present as frequent visitors to the school health service and may be dismissed as malingerers while the underlying cause of the behavior remains neglected (Shannon et al., 2010). In a review of available literature on somatization Shannon, Bergren, and Matthews (2010) found that stress was the one comprehensive predisposing factor of somatization at school, including: stress associated with low socioeconomic status; maternal depression and anxiety; and stress associated with adult and peer relationships. Likewise, Gini and Pozzoli (2009) reported an increased risk of somatic symptoms for children who bullied others (OR: 1.65, $p < 0.001$), and who were bullied by others (OR: 2.00, $p < 0.001$). Peer social support, on the other hand, is associated with fewer health complaints (Shannon et al., 2010).

Shannon et al. (2010) found that children who frequently visit the school nurse are more likely to have mental health problems, including depression and anxiety. The two studies most cited by Shannon et al. (2010) were Campo et al. (2002) and Lieb et al. (2002); both defined mental health problems as "mental disorders" and Lieb et al. (2002) categorized such disorders according to Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM IV) (American Psychiatric Association, 1994) criteria. However, mental health

problems in early childhood are often not diagnosed psychiatric disorders, rather, are problems with emotional and social regulation including aggression, fears and anxiety (Royal Children's Hospital Melbourne, 2012; Sawyer et al., 2000). Children who have difficulty with social and emotional adjustment to school account for a disproportionate number of visits and referrals to school health services and are at increased risk of poor health, somatic symptoms, loneliness, fear, and anxiety (Kerr et al., 2012; Shannon et al., 2010). Such children can be supported through identification and referral, however with the increasing burden on children in relation to problems of mental health (Blair & Diamond, 2008; Council on School Health Services, 2008), nurses are also in a position to support school success through advocating for research and prevention strategies.

McEwen (2012) proposes that because “brain circuits are plastic and remodelled by stress” (p. 17180) preventative and intervention efforts that target the prefrontal cortex, hippocampus, and amygdala have the potential to reduce mental and physical illnesses, because of their role in allostasis. The plasticity of these areas of the brain occurs largely through the neurobiological response to the emotions children experience. Interventions that target social integration are therefore of key importance to mental health, physical health, and learning (McEwen & Gianaros, 2011). In addition, extensive animal studies have shown the hippocampus to have a highly adaptive plasticity throughout life that is increased by physical exercise (McEwen & Gianaros, 2010). Interventions that support plasticity therefore include positive behavioral therapy, physical exercise, play, and the integration of programs that support healthy peer relationships and meaning and purpose in life (Kolb et al., 2012; McEwen, 2012).

The success of many strategies aimed at preventing bullying have been limited (Cook et al., 2010; Runions, 2008), and those promoting social and emotional development have been mixed (Blair & Diamond, 2008). In addition, there is a lack of empirically demonstrated

long-term effectiveness of interventions promoting social and emotional development (Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011). On the other hand, an evidence-based program promoting prosocial behavior that has involved the partnership of nurses and teachers in the first eight years of schooling is “Roots of Empathy” (Cain & Carnellor, 2008; Gordon, 2005; Schonert-Reichl et al., 2012). There is potential for school nurses to promote the long-term empirical evaluation of interventions aimed at supporting social and emotional development and preventing bullying (Forbes, White, Ullman, & Murgatroyd, 2007; Kendall et al., 2006; Nelson et al., 2013).

In defining the environment Bronfenbrenner (1979) included policy as an overarching contributor to environments that support optimal outcomes of health and development. Siddiqi, Kawachi, Berkman, Hertzman, and Subramanian (2012) found that rather than direct spending on education, it is the distribution of resources at a policy level that is the significant indicator of outcomes of health and education in developed nations; and named social policy in particular. Such policy must be mindful of the significant effect that an enriched social environment in school years can have on development through plasticity and biological embedding (McEwen & Gianaros, 2010; Repetti et al., 2002). Policy based on understanding the importance of nurturing and relationship to life-long outcomes of behavior, learning, and health, will provide for a multidisciplinary team of social, educational and health professionals to work together to support social and emotional development in children and families at school (Shonkoff, Richter, et al., 2012).

Conclusion

Outcomes of learning and health result from developmental processes that combine social, biological and neurological pathways. As children adapt to each new environment, the way they relate socially and respond emotionally to others is based on the prior

understanding they have developed, beginning within their family, and extending as children enter new relationships (Bronfenbrenner, 1979). Understanding these influences is important because children's behavior, capacity to learn, and attitude to health are not purely a matter of choice; rather are shaped in a social surround of regulation by others, and the social surround is shaped by not only the history of the family, but also by society.

Healthy peer relationships and nurturing adult care promote school success and well-being. Conversely, schools are also the place where aggression occurs in the form of bullying. Social rejection by peers has the capacity to enforce neurological feedback mechanisms that hinder effective emotion regulation and positive social interaction at a crucial time in children's lives, effecting outcomes of health and well-being. There is a close tie in pathways of health, behavior and learning, and all members of the education team must work together to support success in the social and learning environment of school. The school nurse has a role not only in recognising patterns of presentation that may indicate children are unhappy at school, but in promoting well-being from the time of school entry. When school staff work together to build a relationally safe and nurturing environment for children they promote developmental pathways of protection for learning and health.

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