

IN-DEPTH TOPIC: BETTER HEALTH FOR THE NEW GENERATION: GETTING IT RIGHT FROM THE START

Introduction

Child health promotion policies are based on the fundamental understanding that prevention of problems and promotion of wellbeing are more effective than treating established problems. Furthermore, early intervention is proven to be more effective and cost-effective than late intervention [85].

In recent years, new evidence has come to light showing that trajectories of child wellbeing may be set long before birth and even before conception, a process known as early life programming [86,87].

Effective promotion of child wellbeing requires the development of interventions that can support healthy child development or modify risk factors at or before the time when these determinants begin to influence child health. The implication of early life programming research is clear: we should not wait until after birth to start promoting child health.

Current research is aimed at providing a more precise understanding of how early life factors may influence child and adult health. Generally speaking, the preconception and pregnancy risk factors that are now being reported in the medical literature are risks that have been known for decades to be harmful to health, such as smoking or mental health difficulties, yet these remain challenging problems in our communities. An understanding that these risk factors can affect future child health adds urgency to the call to address these problems, while the current lack of robust evidence for effective interventions illustrates a need to consider new strategies and approaches that capture the complexity of these pathways.

This chapter outlines what is currently known about several key maternal factors reported to be associated with child health outcomes: pregnancy planning; nutrition and weight management; stress and mental health; and use of tobacco, alcohol and drugs. The next sections summarise current knowledge about the child outcomes that are most strongly affected by these maternal factors. The final section describes the literature around interventions, service provision, and measuring and monitoring, and discusses approaches for developing effective strategies to modify these early pathways.

Why intervene early?

Recent years have seen increasing empirical support for the developmental origins of health and disease (DOHaD) model [88], which proposes that early life exposures may affect future health. One of the earliest observations leading to development of the DOHaD model was the finding that low birthweight is associated with the risk of chronic disease in adult life [87], and more recently birthweight has been linked a range of other outcomes [89].

More recent work has begun to identify specific pathways for these effects, for example maternal cholesterol levels [90]. A concerning finding is that significant exposures may occur before conception and may even have been present in a previous generation: boys born to non-smoking women are larger at birth if their maternal grandmother smoked during pregnancy [91].

The explanation for these effects is based on the concept of developmental plasticity, in which child growth and development changes in response to environmental events [86], by mechanisms such as epigenetic programming, a process by which environments can alter the expression of genes. Pregnancy is known to be a sensitive period for defining epigenetic patterns in an individual; stress and smoking are two examples of pregnancy



exposures that have been observed to alter epigenetic patterns. (See Groom et al. [92] for a review of epigenetics and child health.)

Thus, women's health and wellbeing before pregnancy and before birth may have an impact on their children's health throughout the life course and on into following generations. While intervention and support at any stage of life can be beneficial, intervening in this sensitive time period is a promising strategy with the potential for substantial and long-lasting effects on individual and population health.

Maternal factors that influence child health

Although preconception and pregnancy are considered separately here, in practice there is a continuity between these stages, because (as will be seen in a later section), early pregnancy is a critical period for some risks; yet women may be unaware that they are pregnant at this time. For this reason, pregnancy planning has been identified as an important determinant of child health. Although a similar set of risks operate in both the preconception and pregnancy time periods, tobacco and alcohol intake are discussed in the pregnancy section as the impact on child health is greatest at this time.

Preconception

Preconception health can be defined as "the health of a woman of childbearing age prior to or between pregnancies" [93], and the Centers for Disease Control (CDC) propose that preconception health interventions should address "biomedical, behavioral, and social risks to a woman's health or pregnancy outcome" [94]. An important goal of research in this relatively new area is to identify and quantify these risks. Behavioural risks are of particular interest to health services as they are potentially (although not always easily) modifiable, more so than genetic risks, for example. Also, many biomedical risks, such as a relative deficiency of folic acid, still require behavioural strategies to mitigate them, such as taking periconceptional folic acid supplements.

In 2011, Delissaint et al. [95] published an extensive systematic review of preconception health behaviour research, identifying wide range of preconception factors that potentially could influence maternal or child health. These included pregnancy planning behaviour such as initiating folic acid supplementation; reviewing tobacco and alcohol use and physical activity; optimising glycaemic control; gynaecological care (e.g. screening for sexually transmitted infections); vaccination (e.g. rubella); and, in countries where this was relevant, screening for genetic conditions such as cystic fibrosis. These health issues do not occur in isolation but are influenced by a complex network of environmental circumstances [96].

The following sections will focus on preconception factors that are currently of concern in New Zealand, and that have a significant impact on child health as well as maternal health.

Pregnancy planning

This may take the form of preparing for an intended pregnancy (for example by modifying alcohol intake), or effective contraception use amongst women who do not intend to become pregnant. In a recent study of around 750 women across New Zealand who were questioned shortly after birth, 75% of Māori and Pacific women and 36% of Pākehā reported that their pregnancies had been unplanned [97].

Research into women's attitudes towards pregnancy suggests that concepts of planned and unplanned pregnancies are different from concepts of wanted and unwanted pregnancies, and that circumstances such as the attitude of a partner to pregnancy can be strongly influential in determining how women define their pregnancies [98].

Tsui et al. [99] reviewed the literature on the burden of unintended pregnancy. They commented that evidence relating to child outcomes was sparse, and tended to focus on a few specific outcomes such as prematurity and low birthweight. An additional problem was that many studies were cross-sectional and subject to bias. Nevertheless, there does appear to be evidence of harm. A systematic review [100] of unintended pregnancy



reported that unintended (unwanted or wanted but mistimed) pregnancies were associated with adverse outcomes: unwanted pregnancies had higher odds of low birthweight and premature delivery compared to intended pregnancies. There is also observational evidence of an association between pregnancy intendedness and health behaviours such as smoking before or after the birth and breastfeeding duration [101].

Whether these differences are causal (i.e. ambivalence towards a pregnancy leads to less optimal health behaviours) or associational (the pregnancy is unwelcome because of difficult circumstances which themselves may affect maternal and child health), these findings further reinforce the need for effective approaches to contraception, and suggest that women with an unintended pregnancy may require additional support.

Maternal nutrition

Nutrition is an important aspect of health for women who may become pregnant, but it is also complex: disadvantage may result in a double burden of undernutrition (e.g. lack of essential micronutrients) and overnutrition (e.g. obesity) [102]. In addition, it is difficult to study any single nutritional issue in isolation from other factors. Although macronutrient intake (weight management and healthy eating) and micronutrient intake are discussed under separate headings here, they are of course strongly interlinked. However, there is a lack of robust evidence about the relative impact of different aspects of preconception nutrition on child health, as discussed in a recent systematic review [103]. Some observational findings are discussed but this is still an emerging field.

Macronutrient intake

Preconception obesity has been linked to a number of adverse child outcomes, including child obesity [104], and neural tube and congenital heart defects [102]. A systematic review of the impact of obesity on child neurodevelopmental outcomes noted a number of studies reporting associations, but concluded that it is not yet clear whether there is a causal effect and called for more experimental studies [105]. The review authors noted that there are several alternative explanations for these findings, for example that obesity could be a marker for nutritional problems such as deficiency of folate or vitamin D.

On the other hand, women who are underweight in the preconception time period have a 32% higher risk of preterm birth and small-for-gestational-age babies [102].

There are indications from observational studies that preconception eating patterns may influence child outcomes. For example one study [106] reported that women categorised as having a high protein/fruit intake in the 12-month period prior to conception had a decreased likelihood of preterm birth, whereas women with a high fat and sugar component to their diet had a shorter gestation and higher likelihood of preterm birth and their infants had shorter lengths at birth. Another study, however, reported that a preconception diet high in sweetened beverages and sugars was also associated with smoking and reduced physical activity [107], highlighting the need for caution when drawing inferences from these findings.

Micronutrient intake

The importance of adequate folic acid intake is illustrated by the fact that preconception folic acid supplementation has the strongest evidence of effect of all forms of micronutrient supplementation: it is estimated to prevent 69% of neural tube defects [102]. Women can obtain folic acid from fortified foods and vitamin supplements, as well as from a varied diet [108]. These options are further discussed in the section on interventions.

Diabetes

Women with diabetes are particularly at risk of adverse pregnancy outcomes such as stillbirth and congenital anomalies. Good glycaemic control and folic acid supplementation prior to becoming pregnant can largely eliminate these risks [109].

Interdependence of preconception factors

These preconception factors do not occur in isolation. Because many factors such as smoking and alcohol use have strong social patterning, individuals who are disadvantaged may experience several factors simultaneously, increasing the cumulative effect on child



health. The issue of women experiencing multiple adversities in pregnancy, and interventions to support them are the subject of a previous in-depth topic [110] and thus will not be discussed in detail here.

In addition, the presence of one risk factor may directly increase the risk of another. One important example is binge drinking, which increases the risk of unplanned or unprotected sexual intercourse and hence, the risk of unintended pregnancy: one study found that 60% of women who reported four or more binge episodes in the three months before conception also reported that their pregnancy had been unintended [111]. There was a clear stepwise increase in the proportion of unintended pregnancies as the frequency of binge drinking episodes increased.

Another example is mental health: unintended pregnancy has been reported to be associated with increased risk of depression and higher parenting stress [112], both of which are risk factors for child health.

Pregnancy

Maternal nutrition

As for preconception nutritional health, while observational evidence strongly indicates that maternal nutrition in pregnancy affects child health, there is a lack of randomised controlled trials examining nutrition factors, and as a result, it is not clear to what extent these associations are causal (and by implication, which aspects of nutrition hold most intervention promise). Selected observational findings are summarised here, but there is a clear need for further research in this area.

Macronutrients

Obesity in pregnancy has been linked to a number of adverse outcomes for the child including cognitive difficulties, attention deficit hyperactivity disorder, eating disorders in adolescence, and psychotic disorders in adulthood [105].

The authors of large prospective cohort study in the UK [113] reported that maternal dietary pattern at 32 weeks' gestation was strongly associated with maternal anxiety levels: in particular, low intake of fish or n-3 polyunsaturated fatty acids (PUFA) was associated with high levels of anxiety. Women reporting diets characterised as 'health-conscious' or 'traditional' were less likely to report high levels of anxiety symptoms. Low levels of seafood consumed during pregnancy have been linked with poorer outcomes across a range of child development measures despite adjustment for confounders in a large prospective cohort study [114], indicating a need to balance the benefit of n3-PUFA against the risks of mercury ingestion [115]. An additional concern with diet is uncertainty about the role of antigen avoidance and food allergy in children [116].

Increased maternal weight gain in pregnancy is associated with increased birthweight and fetal growth [117,118]. Excessive weight gain during pregnancy has been strongly linked to adiposity and cardiovascular risk factors [119] in children. On the other hand, too little weight gain may result in poor growth and low birthweight [118].

In addition, a strong association is seen between poor glycaemic control (in women with diabetes) and child outcomes, particularly macrosomia at birth and increased incidence of cognitive and behavioural problems [120].

Micronutrients

Folic acid, as previously discussed, is the micronutrient with the strongest evidence in favour of supplementation, to reduce the risk of neural tube defects. There is also rising concern about Vitamin D deficiency as evidenced by the re-emergence of rickets in many populations in recent years [121].

Some risks are more subtle, and are emerging as findings in large cohort studies that measure many metabolic pathways. For example, low maternal iodine in pregnancy is reported to have an association with poorer cognitive development in children. This was supported by findings from the Avon Longitudinal Study (ALSPAC), and was somewhat



unexpected as the study is located in England where iodine deficiency is not considered to be a major public health problem [122]. Iodine deficiency has re-emerged in the New Zealand population in recent years [123]. Intervention approaches are discussed in a later section.

Selenium has also been suggested as a micronutrient of importance in pregnancy (see Bergamaschi [124] for a review). Although most of the effects of low selenium proposed in the literature relate to maternal health, Bergamaschi et al. reported there is some evidence of an association of low selenium and preterm delivery. Further work is required to clarify whether selenium supplementation in pregnancy would be beneficial.

Undoubtedly in future years, other micronutrient needs will be described that are currently unknown. However, it is also important to note that overuse of micronutrient supplementation can be harmful: for example, overnutrition with Vitamin A may cause congenital abnormalities and intake above 700 micrograms is not recommended.

Mental health

There is now a substantial body of evidence on adverse child outcomes following maternal mental health problems. Much of this originates in the USA, but Schmied et al. have published a systematic review of maternal mental health in the perinatal period (pregnancy and one year after the birth), based on evidence from longitudinal studies in Australia and New Zealand [125]. This paper is also a good source of locally-based studies on the prevalence of mental health problems during pregnancy and afterwards.

Although any mental health problem may appear or become exacerbated during pregnancy, current research is focused on three common conditions which appear to have a profound effect on child health and wellbeing: depression, anxiety, and stress.

Depression is common, affecting 10–20% of pregnant women [125]. A large meta-analysis found that maternal depressive symptoms in pregnancy were associated with preterm birth and low birthweight [126]; other child health consequences include a higher risk of child mental health problems and cognitive difficulties [88,125]. Depression during pregnancy is also strongly associated with health behaviours that may be harmful to child health such as smoking or alcohol use [127]. In addition, psychotropic medication may have effects on fetal health [88], although the evidence is conflicting. Unsurprisingly, a previous history of depression and having a poor partner relationship (including experiencing violence) are reported to be strong predictors of depression during pregnancy [125].

Austin et al. distinguish between stress and anxiety, stating that “Stress can be defined as a psychophysiological consequence of any event challenging an organism’s capacity to cope, while anxiety is considered the psychological consequence of exposure to real or imagined stress” [128]. This distinction is not always made in the literature, where the terms ‘stress’ and ‘anxiety’ may be used interchangeably. However, as discussed below, when they are defined separately, anxiety and stress seem to have different effects on birth outcomes. Another distinction is that pregnancy-specific stress or anxiety appears to be different from generalised stress, and to have more impact on fetal outcomes [129].

While not all authors report large effects [130], there is now evidence from a number of populations that maternal stress increases the risk of preterm delivery [128,131] and is associated with a range of emotional and cognitive problems in children, including attention deficit/hyperactivity disorders, language delay,[132] and overall infant development during the first year of life [133].

Research on stress in pregnancy has identified several sources of stress for pregnant women in the USA that are also severe enough to show a significant association with birthweight: these include unemployment, overcrowding, and racism [96,134]. Domestic violence is reported to have an association with preterm delivery and low birthweight [135].

Although the mechanisms are not fully understood, it is clear that both maternal and fetal hormonal physiology, particularly cortisol pathways, are affected by maternal stress [132]. Recent research has also highlighted the role of the placenta as the link between maternal



and fetal stress responses. A study of placental blood flow in the third trimester reported reduced flow associated with intrusive thoughts and emotional distress regarding the fetus, potentially explaining how this could affect fetal growth [136].

Although both stress and anxiety are potentially harmful to child health, there are indications that stress has more of an impact on preterm birth, while anxiety affects birthweight to a greater degree [96]. This hypothesis is supported by a study that used sophisticated modelling techniques to disentangle the complex web of cause and effect around stress. Lobel et al. reported that pregnancy-specific stress was a stronger predictor of birth outcome than anxiety or life-event stress [129]. Their results indicated that although pregnancy-specific stress was associated both with earlier delivery and with lower birthweight, only earlier delivery appeared to be a direct effect of stress, while the association with birthweight was explained by the fact that women who felt stressed were more likely to smoke. In this study, pregnancy-specific stress also predicted higher caffeine intake and less healthy eating, and lower vitamin use and exercise.

The link between stress and smoking is consistent with evidence both from New Zealand [137] and from reviews of the USA experience [96] that maternal stress in pregnancy predicts smoking behaviour.

Identifying mental health risks is an active area of research; but there is little corresponding research on mental health strengths and how these may influence women's health and that of their children.

Positive mental health is now recognised to be a construct in its own right, not simply the absence of mental health problems. This is known as the 'dual continuum' model of mental health [138] and it has important implications for how mental health should be promoted, emphasising that this involves more than just preventing problems [139]. This is an early field of research but the author of a World Health Organization (WHO) review notes the evidence that improving positive health can result in improved health behaviours such as reduced alcohol intake and smoking, and that positive mental health is associated with prosocial behaviour and stronger feelings of social connectedness [140]. The author outlines the population health potential of keeping a clear separation between positive mental health and mental health problems, concluding that "a key rationale for promoting positive mental health is the hypothesis that by increasing mental health, we can modify certain outcomes, even if mental illness remains and/or even if other risk factors remain". See the measuring and monitoring section for a corresponding discussion about positive mental health in children.

Smoking

Smoking during pregnancy has been implicated in a number of adverse pathways; however a very large (n=52,919) and carefully designed study [141] did not detect an effect on many proposed outcomes, including cognitive development, conduct disorders and asthma, in children of women who smoked during pregnancy. Smoking has also been suggested as a cause of Attention Deficit Hyperactivity Disorder (ADHD), but this association has been assessed as being likely to be due to confounding factors [142].

Child health outcomes for which there is convincing evidence of a causal effect of smoking during pregnancy include Sudden and Unexpected Death in Infancy (SUDI), low birthweight, obesity, and smoking in offspring. As previously mentioned, smoking during pregnancy is a well-known cause of infants born small for gestational age and is estimated to reduce birthweight by 90–170g [141,143]. There is evidence for an increased risk of obesity in offspring of mothers who smoke during pregnancy [141,144] independently of other confounding factors, with evidence of a dose-response effect and of possible differences in risk by ethnicity [145].

Finally, children of smokers are more likely to smoke themselves. There are obvious social and environmental factors to explain this, but there is now also evidence for a direct effect of smoking during pregnancy on smoking uptake in offspring [146], possibly due to induction of increased nicotine sensitivity in utero.



Alcohol

The child health effects of heavy drinking in pregnancy are well known: maternal intakes of greater than about 1 drink/day on average (or alternatively, binge drinking) have been unequivocally linked to increased risk of congenital malformations and developmental and psychosocial problems [147]. These effects are together known as Fetal Alcohol Spectrum Disorder (FASD) [148,149].

However, it has been much more difficult to establish the effects of low or moderate drinking and results have been contradictory. Because of confounding (low-moderate drinkers tend to be well-educated and otherwise healthy), observational studies have not shown a reliable link between low alcohol intake and child outcomes [150,151]. This has led to controversy in developing guidelines for alcohol use in pregnancy [152], with some bodies supporting low to moderate alcohol intake and others recommending total abstinence. However, newer methodological techniques may provide better evidence in the near future. A major study of alcohol intake on adult health has recently been published, using a technique called Mendelian randomisation to minimise bias from confounding [153]. The findings of this study suggest that lower alcohol consumption is associated with a reduction in coronary artery disease, even among light to moderate drinkers. A recent study of antenatal alcohol exposure using the same technique reported that maternal genetic propensity for alcohol intake predicted school performance in children among affluent women reporting moderate drinking [154]. This is a new area of research but the findings from these studies suggest that there may not be any safe level of alcohol intake in pregnancy.

Drugs

Illegal substance use during pregnancy is a well-established cause of adverse fetal and child outcomes (see Jansson [155] for a review). Amphetamine and opiate intake appears to have less impact on fetal growth than smoking [156], nevertheless, opiate use (heroin) significantly increases the risk of low birthweight, obstetric complications, cognitive and behaviour problems; and it is estimated to cause a 74-fold increase in the risk of sudden death in infancy [157].

Other

There is currently no strong evidence that maternal oral health has a beneficial effect on child health, but several studies have reported associations of oral disease with adverse child outcomes such as preterm birth [158]. This is clearly an area for future research.

Child outcomes affected by maternal risk factors

Lewis et al. have summarised the mechanisms for maternal effects on child health in terms of placental mechanisms, where maternal factors impact on placental function and intrauterine growth retardation is likely to be a final common pathway, and fetal mechanisms, which include responses to blood-borne factors or epigenetic changes [88].

Infant and child mortality

Most of the studies cited in this review did not report on infant mortality as an outcome. However, identified risk factors relevant to children in New Zealand include exposure to alcohol, tobacco smoke and drugs [157,159]; prematurity; and congenital anomalies [2]; suggesting that this represents the worst-case outcome of many of the maternal risk factors discussed in this review. In New Zealand, maternal smoking is known to be a major cause of Sudden Unexpected Death in Infancy (SUDI), particularly in association with bedsharing [160].

Prematurity

Premature birth exacts an enormous cost on children's health, including, but not limited to, increased infant mortality and neurodevelopmental disability, and, in adulthood, hypertension and kidney disease [161]. Furthermore, girls born preterm are more likely themselves to deliver preterm, with complications continuing into the next generation [126].



Low birthweight

Considering low birthweight as an outcome can be misleading because it is generally agreed that low birthweight is not in itself a health problem or a cause of other health problems [89]: instead, its usefulness is as a marker of poor growth in utero that is easy to measure and routinely available for almost all children (see below for a discussion of monitoring birthweight and its relationship to gestational age).

Child development and mental health

The global prevalence of child and adolescent mental health disorders is estimated to be 10–20% [162]. It has been estimated that even optimal treatment at optimal coverage can only mitigate 28% of the burden of mental health disorders [163]. Prevention is thus a key strategy [164], and the evidence now emerging about the impact of preconception and pregnancy factors on child mental health strongly indicates that prevention of child mental health problems should begin before birth [88].

Lewis et al. [88] suggest that prenatal exposures relevant to child mental health can be organised into lifestyle factors (e.g. nutrition); maternal mental health problems; and teratogenic and neurotoxic exposures (such as alcohol).

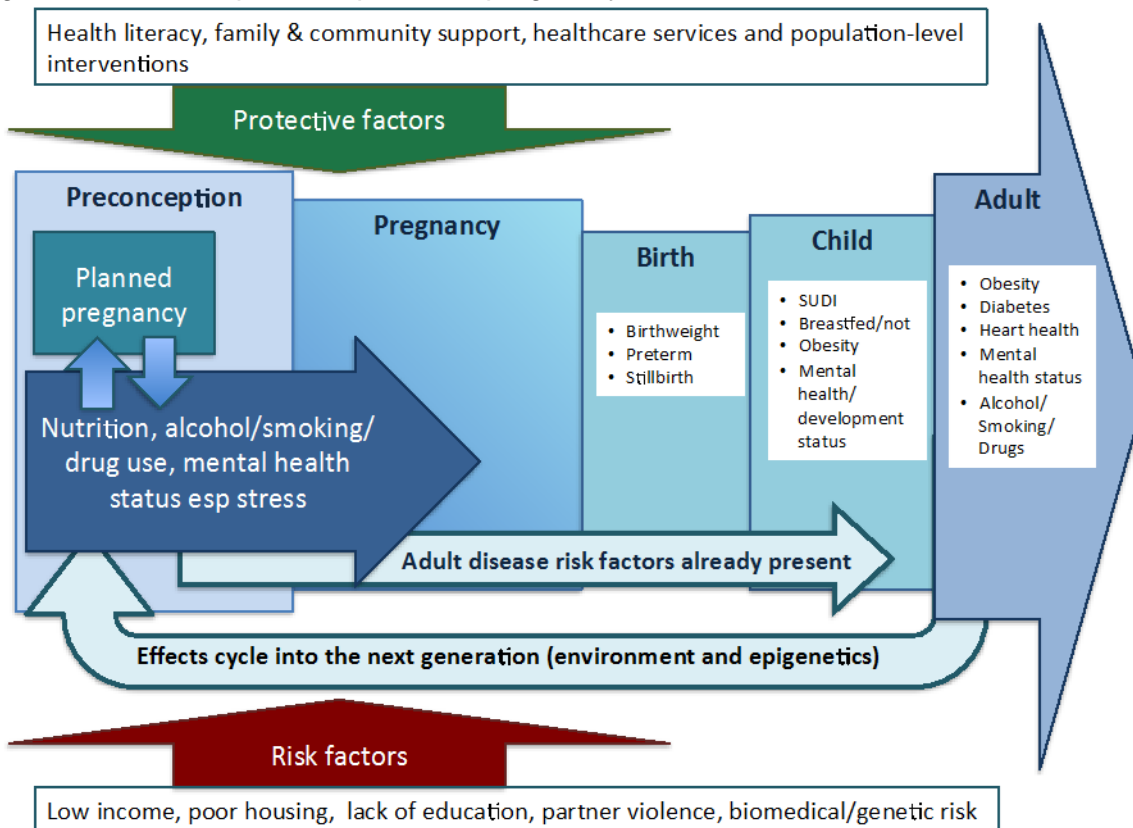
Suboptimal fetal growth is the final common pathway of many of these risks, most notably maternal smoking, alcohol and drug use; poor nutrition; stress; and infection during pregnancy. Poor fetal growth has been linked to a number of mental health disorders in offspring, including impaired cognitive function, inattention/hyperactivity, stress reactivity and possibly personality disorders and schizophrenia [89]. Although there is evidence for all of these pathways, one of the most important single risk factors is likely to be antenatal maternal stress: Talge et al. have estimated that up to 15% of behavioural problems in children may be caused by this single factor [132].

Identifying the antenatal causes of mental health problems is an active area of research, but little attention has been given to positive mental health, and to positive preconception and pregnancy factors that may promote this. This issue is further discussed in the 'Measuring and monitoring' section (see page 180).



Overview: Current understanding of preconception and pregnancy effects on child health

Figure 1. Links with preconception and pregnancy health across the life course



As **Figure 1** indicates, child health risks can begin in the previous generation(s) and the cycle of harm can extend across generations if not interrupted. The diagram reflects the current literature in being predominantly about risk; but when pathways to positive outcomes are better understood, effective interventions may arise from promoting these. The diagram also shows that there are multiple potential time points and populations for intervention. These are considered in more detail in a later section.

In linking specific risk or protective factors to specific outcomes, some caution is required because most of the studies reviewed in the previous sections were observational rather than randomised controlled trials (RCTs). RCTs are the 'gold standard' method for determining the effect of risk or protective factors on outcomes, but for many of the health risks discussed here, RCTs would not be ethical. This means that studies are vulnerable to bias: when many risk factors coexist (such as smoking, alcohol use and poor nutrition) but are incompletely measured or (as commonly happens) when these multiply occurring risk factors are studied in isolation rather than together, it can be hard for health planners to establish which of many potential intervention strategies have the most potential to influence outcomes.



Interventions

Implementing interventions to improve preconception and pregnancy health requires having sustainable efficacious and effective interventions and the means to measure change. These are challenging requirements at present. Many of the same difficulties encountered in identifying preconception and pregnancy risks are also apparent in evaluating interventions or comparing one to another. Testing interventions rigorously using an RCT design is often not feasible. In addition, studies show wide variation in populations, intervention approaches, and measurement of risks, outcomes, or confounders: as a result, it is rare for intervention studies to be similar enough to be combined into a meta-analysis. Thus, systematic reviews of interventions aimed at improving maternal health in pregnancy and in the preconception period are often inconclusive.

The following subsections will review the current evidence on intervention, considered in terms of timing and populations to target; whether focused on preconception or pregnancy life stages; issues-focused interventions or service strategies; and whether these are delivered at the individual or population-level. Most of the evidence reviewed is from observational studies; where evidence from RCTs are available this is indicated. At the end of this section, current evidence on measuring and monitoring health is reviewed as an introduction to the next section which discusses challenges in translating the evidence.

In this review, the focus is on strategies that can be implemented within the health services framework. It is recognised, however, that interventions that are not primarily about health may have a profound influence on pregnancy and on child wellbeing.

A final note is that, as this review demonstrates, the health of mothers and children is closely interlinked. This close alignment of health goals is a compelling argument in favour of better continuity of care between life stages (for example preconception to pregnancy to postnatal care; pregnancy to childhood) and between services [165]; the separation presented here is to aid clarity but in practice, these aspects are overlapping and are continuous with one another.

Timing of interventions

In considering the best time to intervene, two aspects to consider are sensitive periods during which a risk factor may have a greater effect than at other times (indicating critical intervention points), and cumulative effects over time which give an indication of the value of earlier versus later intervention.

Early pregnancy represents a critical period for many risks as it is an active time of growth and development, and is a time of high fetal sensitivity to environmental influences. This hypothesis is supported by observational studies, particularly with regard to alcohol intake and FASD [149]. A recent prospective study from the UK examined the effect of timing of alcohol consumption on birthweight and prematurity risk [166], reporting that the strongest association between alcohol consumption and birthweight or prematurity was seen in the first trimester.

A new body of research is also suggesting an important role for nutrition in early pregnancy, in particular that poor nutrition may adversely affect brain development [167]. The effect of maternal weight on child outcomes appears to vary according to the timing of the risk: one study [168] reported that maternal pre-pregnancy weight had a stronger association with childhood BMI and cardiovascular risk than weight gain during pregnancy; during pregnancy, higher weight gain in early (but not mid- or late-) pregnancy was associated with increased risk of childhood overweight and cardiovascular risk factors.

A US study [169] of 4600 pregnant women reported that the prevalence of past month serious psychological distress was 6.4% for women in the first trimester of their pregnancy and 3.9% in the third trimester, suggesting that early pregnancy might be a particularly vulnerable time. However, the sensitive period for an effect of stress on pregnancy outcomes may be later than that: a large study from Sweden [131] reported that maternal stress during months 5–6 of pregnancy had the strongest association with birth outcomes



such as preterm delivery, shorter gestational age, low birthweight and small-for-gestational-age, while a different large cohort study found that stress on behavioural and emotional problems was greater at 32 weeks than at 18 weeks [170].

There may be a cumulative risk for smoking during pregnancy: in one study, the effect of smoking on fetal growth at 34 weeks was milder for mothers who stopped smoking before 12 weeks compared to those who continued [171], while in another, infants of women who stopped smoking before or during early pregnancy had no increased risk of being small for gestational age or preterm compared to infants of non-smokers [172].

Populations to target

Pregnancy offers many opportunities for health promotion because most women engage with health services at this time [88]. However, many pregnancies are unplanned and as this review shows, there is substantial evidence for the need to support preconception health. This has important implications for service delivery. Pregnant women are a well-defined population who are likely to make contact with health services by a number of routes. Women of childbearing age who are not pregnant, by contrast, are a much larger group with little routine contact with health services; yet this is the population of interest for preconception health interventions.

One more efficient way to define the target population for preconception health interventions is to focus on women who may be at an interconceptional stage, i.e. women who have had at least one previous pregnancy [173] and can therefore be identified using routine healthcare datasets. In some settings, a negative pregnancy test result can present an opportunity for intervention [174]. Another option may be to focus on women attending fertility- or preconception healthcare clinics: these women, however, are likely to be already highly motivated and well-informed about preconception health [173].

An alternative strategy for preconception health promotion is to identify and target women who are most at risk of adverse outcomes. These might include women who have previously delivered a very low birthweight infant [173], teenagers and young women, women from historically disadvantaged ethnic groups, and women known to be at risk from violence, alcohol or drug use.

However, interventions which focus solely on pregnant women or women who may become pregnant are likely to be limited because they do not take context into account, for example, addressing smoking habits of pregnant women without considering the other people in the household who are smoking [137]. Similarly, as noted, stress is likely to be a driver of high-risk behaviours; addressing the behaviours without addressing the stress is unlikely to be helpful.

Pryor et al. have reported some interesting findings from the Growing Up in New Zealand study [175] in a paper which provides a snapshot of the children's fathers during pregnancy. Approximately 18% (728/4156) were current smokers, and 806 men reported that they had cut down on smoking (by smoking outside only, cutting down or quitting), 43% had reduced their alcohol intake, and half of the men interviewed were eating more fruit and vegetables. This suggests a potential for including partners in interventions supporting women to make healthier choices during pregnancy.

Also of note is that although the prospective fathers expected their partners would have a greater involvement and responsibility with caregiving than themselves, 78% intended to be involved with the day-to-day care of the child. This is encouraging in the light of emerging evidence for the value of social support, including partner support, on maternal wellbeing [96]. Support needs might include for example emotional support to reduce stress or tangible support such as help with transport to access antenatal care, or help with food shopping to support healthy eating [96].

Thus, identifying different target populations suggests that there are multiple potential levels of intervention and service delivery, including individually based care delivered by a Lead Maternity Carer; family/Whānau e.g. Whānau Ora approach [176]; women considered to be at risk; all women of childbearing age e.g. "Show Your Love" campaign in



the US (see box below); and whole population approaches such as smoking legislation [177] or mandatory micronutrient fortification of foods [97,178].

Intervening at the preconception stage

Interventions in the preconception period can be aimed at stopping or reducing high-risk behaviours such as binge drinking or smoking, or alternatively initiating and maintaining positive behaviours, for example, folic acid supplementation or healthy eating [95].

In 2006, the Centers for Disease Control (CDC) published a set of recommendations for improving preconception health, based on literature review and expert consensus [94]. The recommendations are based on the US health system and are not always applicable to the NZ context, for example in calling for more complete health insurance coverage for women with low incomes. Also, the recommendations begin by calling for 'individual responsibility across the lifespan', an emphasis on individual effort that is not shared by other authors [96].

Overall, the evidence for specific preconception health interventions is somewhat inconsistent. The authors of a recent systematic review of preconception interventions [179] concluded that there was substantial evidence of effectiveness for interventions targeted at dietary change and birthweight, smoking, and folic acid use. In the successful smoking intervention identified in this review, women were given a video, a guide and counselling [180]. This contrasts with the findings of a Cochrane review of nicotine replacement therapy which reported no benefit [181].

Evidence for the effectiveness of preconception alcohol reduction interventions is likewise mixed [179,182] with no clearly effective widely-available intervention. One interesting development is a report on a web-based self-guided change intervention to reduce alcohol exposure in pregnancy in the USA [183]. At baseline, all women receiving the intervention had some alcohol exposure and were not using effective contraceptive methods. At 4 months, 58% of the enrolled women were no longer at risk of alcohol exposure in pregnancy. Child outcomes were not measured in this study. Participant characteristics were similar to those of typical internet users in the USA, suggesting that the intervention may be particularly suitable for this group. However, lack of access to the internet by more disadvantaged women would prevent this from being more widely used in high-risk populations.

The role of health services in preconception care

In seeking to improve preconception health at the individual level, there is some evidence for the effectiveness of programmatic approaches, targeting multiple interventions [179]. For example, a case-control study of women attending a preconception care service in Brisbane between 2010–2013 [184] found that women who had received preconception care were more likely to report adequate periconceptional folate, being vaccinated against influenza and hepatitis B, specialist consultation regarding a pre-existing health condition, less weight gain up until booking, and a lower incidence of hypertensive disorders in pregnancy, compared to women who had planned their pregnancy but had not used the service.

In New Zealand, best practice guidelines for general practitioners [149] recommend asking all women of reproductive age about pregnancy risk or intent. In a general practice consultation, advice can then be tailored to the needs of the individual.

However, multiple contacts may be necessary: a Cochrane review of the effectiveness of routine pre-pregnancy health promotion [185] found that brief advice about folic acid supplementation had no detectable effect, while an intervention that delivered several sessions of group education was associated with increased consumption of folic acid supplements.

The role of population-level strategies in preconception care

Interventions targeted at women who intend to become pregnant are limited by the fact that such measures cannot address the consequences of unplanned pregnancy. Alternative strategies include aiming to improve health in all the population (see Box below



Case Study: Show Your Love). Effective interventions to reduce harm from risks such as substance use in the general population are likely to benefit pregnant women whether or not the pregnancy was intended. For the New Zealand context, a more detailed summary of population tobacco cessation interventions can be found at Error! Reference source not found. (on page **Error! Bookmark not defined.**), and of alcohol interventions at Error! Reference source not found. (on page **Error! Bookmark not defined.**).

Young people are particularly at risk of unplanned pregnancy in the setting of high-risk behaviours and there is an urgent need for interventions for this vulnerable population. Bearinger et al. have reviewed the challenges and approaches to sexual and reproductive health in adolescents, taking a global perspective [186].

Interested readers are also referred to an excellent review of interventions for young people by Jackson et al. [187]. The focus of this paper is on addressing multiple risk behaviours, in particular tobacco, alcohol and illicit drug use and sexual risk behaviour. The authors considered interventions delivered through a number of platforms including mass media campaigns, alcohol and tobacco pricing, school-based programmes and family-based interventions. They identified few interventions with clear evidence of effectiveness, but noted that multi-component interventions appeared to have the most effect. Another interesting finding from the review was that one of the more successful interventions was aimed at pre-adolescent children, not (as is more usually the case) children in early- to mid-adolescence. Finally, the authors noted that effective interventions aimed to increase young people's resilience and to support positive development, instead of simply focusing on reducing risk behaviours.

Case Study: Show Your Love

Show Your Love (<http://www.cdc.gov/preconception/showyourlove/>) is a national campaign in the USA, designed to improve the health of women and babies by promoting preconception health and healthcare. Information and resources are provided for members of the public, health professionals, policy makers and the media.

A key feature of this campaign is its broad target population: it is aimed at both women and men, and is not restricted to people planning to have children, noting that "preconception health is important for all women and men, whether or not they plan to have a baby one day". In this way, it aims to improve outcomes both for planned and unplanned pregnancies. In addition, the campaign explicitly recognises that there are health benefits for people who never have children: the campaign button for women who want to become pregnant is "Show Your Love. Your baby will thank you for it", while the button for women who do not want to become pregnant is "Show Your Love. Your body will thank you for it."

In recognition of the high proportion of unplanned pregnancies in the USA, a central strategy of the campaign is to reduce the number of unplanned pregnancies by encouraging individuals to develop a "Reproductive Life Plan".

The campaign was launched in 2013 and it will therefore be some time before it can be formally evaluated, but it is robustly evidence-based. The design of the campaign was informed not only by evidence on risk factors and pathways but, importantly, also by evidence on issues for implementation such as audience research, reaching vulnerable populations, and how to bundle several health topics into an intervention package. A good source for further detail on these approaches can be found in the commentary by Mitchell and Verbiest [93] in a special supplement issue of *the American Journal of Health Promotion*.

Further development of preconception care in New Zealand

Because understanding of the importance of preconception health is relatively new, in New Zealand, health service support is not as well-established as for antenatal services. The recent "Inquiry into improving child health outcomes and preventing child abuse with a focus from preconception until three years of age" (and government response) [188,189] has highlighted this as an area that requires development.

The World Health Organization has published a policy brief entitled "Preconception care: Maximizing the gains for maternal and child health" [190]. The authors define the scope of preconception care as "the provision of biomedical, behavioural and social health interventions to women and couples before conception occurs", with the aim of "improving



their health status, and reducing behaviours and individual and environmental factors that contribute to poor maternal and child health outcomes”.

This is a consensus document based on expert opinion. The recommendation in the policy brief is for preconception healthcare to be delivered as a ‘preconception care package’, addressing diverse topics such as psychoactive substance abuse and interpersonal violence that are ultimately seen to be connected. **Figure 2**, reproduced from this document, summarises the steps that could be taken at a national level to implement these recommendations.

Figure 2. A strategy for country action



Figure reproduced from WHO policy brief for preconception care [190]

Intervening during pregnancy

In this section, interventions are first considered in terms of specific health topics, then as service provision approaches, and finally as applied to the whole population.

Intervening on specific health topics

The literature on topic-specific interventions is extensive; for this review the focus is on pregnancy health topics that are likely to have the most influence on child health and is intended to be illustrative rather than exhaustive.

Nutrition

The NICE guidelines for antenatal care [191] recommend that folic acid supplementation should continue throughout the first 12 weeks of pregnancy, at 400 micrograms per day. (Fortification of food using folic acid and iodine is discussed in the section on population-level interventions below.) Under the NICE guidelines, women are also advised to consider Vitamin D supplementation (10 micrograms per day). There is, however, conflicting evidence about the effectiveness of maternal Vitamin D supplementation on offspring bone mineral density [192,193].

Weight gain in pregnancy

The Institute of Medicine (IOM) has recently updated its advice on optimal weight gain during pregnancy, based on new evidence that suggests that women should gain less weight than was previously thought. The guidelines are reproduced in the Ministry of Health 'Guidance for healthy weight gain in pregnancy' [194]: for example, a woman of with a BMI in the healthy range (18.5–24.9) should aim to gain 11.5–16kg during pregnancy. The guidelines also stress the importance of weighing and measuring women rather than relying on self-report and provide examples of advice that can be given for healthy nutrition and exercise during pregnancy.

The IMPROVE (Improving Maternal and Progeny Risks of Obesity Via Exercise) study is a promising Auckland-based RCT investigating the effect of an antenatal exercise programme on maternal and fetal outcomes, and is currently ongoing [195].

Smoking

Interventions to ameliorate the health effects of smoking may take place at population or individual level. A recent systematic review and meta-analysis reported that smoke-free legislation was associated with reductions in preterm birth and hospital attendances for asthma. A slight decrease was seen in the incidence of low birthweight although this was not significant at the 95% confidence level [177].

The New Zealand Ministry of Health has guidelines on smoking cessation in pregnancy [196], based on a review of the literature. The guidelines stress the importance of offering multi-session behavioural smoking cessation interventions to all pregnant and breastfeeding women and recommend conservative use of nicotine replacement therapy (NRT).

A more recent Cochrane review has concluded that psychosocial interventions to support women to stop smoking during pregnancy can be effective in decreasing the prevalence of smoking during pregnancy and can reduce the incidence of low birthweight and prematurity [197]. Types of interventions assessed in this review included incentive-based interventions, feedback interventions, counselling, health education, and social support. Incentive-based interventions had the largest effect sizes when compared with less intensive interventions. Counselling interventions appeared to have significant effects only where counselling was provided along with other types of intervention, while evidence was mixed for health education.

Also, the review of NRT to which the NZ guidelines refer [198] has since been superseded by a more recent Cochrane review of pharmacological interventions (e.g. NRT) for smoking cessation in pregnancy [181] which did not identify a difference in smoking cessation in later pregnancy between pregnant women offered NRT and controls. There appeared to be no differences, either positive or negative, in pregnancy outcomes (reported as stillbirth, premature birth, birthweight, neonatal intensive care admissions and neonatal deaths). The authors recommended that the next step should be placebo-controlled RCTs investigating higher doses of NRT.

Alcohol

Links to evidence on overall population alcohol interventions were provided in an earlier section. One major barrier to effective alcohol intervention during pregnancy is likely to be the timing of risk, given that the most sensitive period occurs before women may be aware they are pregnant [166] and before they are likely to have made contact with antenatal providers [199].

Mental health

Routine screening for mental health problems in pregnancy is recommended, but to date the evidence of effect is limited. A systematic review identified two trials [200]. In one, use of an antenatal diagnostic tool did appear to increase physician awareness of risk, but in the other, an intervention consisting of communication of test scores and a patient information booklet was not associated with reduction in Edinburgh Depression Scores at 16 weeks after delivery, compared to controls who received standard care. A systematic review of mind-body interventions for anxiety during pregnancy reported "some but no



strong evidence” that this type of intervention could reduce anxiety [201]. These results seem to suggest that identifying women with mental health problems in pregnancy is not difficult; rather, the challenge is to follow diagnosis with an effective intervention.

For current recommendations about perinatal and infant mental health services in New Zealand, see the “Healthy Beginnings” guidelines [176], and for a detailed review of child and adolescent mental health services, see the previous in-depth review of this topic, in the 2012 report, “The Determinants of Health for Children and Young People in New Zealand” [110].

Dunkel Schetter reviewed the current state of knowledge on coping in pregnancy and how this could be supported [96]. She concluded that this is an area requiring more research, amongst other reasons because previous research has been too nonspecific to generate robust theories or evidence. As a first step, she recommended that studies of coping behaviours in pregnant women should gather information on the specific stresses experienced by women in a population and the strategies they currently use to manage stress. This understanding could then be used to select the most appropriate coping and stress management interventions from an array of existing options.

Service provision during pregnancy

Services available to pregnant women include universal services, targeted services, and services outside the maternity framework, including antenatal education.

Universal services

Publicly funded maternity and child health services in New Zealand cover the period from preconception to 6 years [202].

Early access to antenatal care is highlighted as an important population health goal. NICE recommends that first contact should occur in the 1st trimester and ideally before 10 weeks [191]. This has been recommended as a target for New Zealand and is under consideration by the Ministry of Health [189]. However, a recent study of young (<20 years) Māori women reported that, although the participants promptly initiated contact with health services upon realising they were pregnant, many encountered systematic barriers to accessing care, for example, being unable to register immediately with a Lead Maternity Carer [199].

In addition to barriers in accessing services, a further concern is that there is limited evidence for the effectiveness of antenatal care in improving child outcomes. Recently, the Lancet published a quality framework review of the scope of midwifery and potential to improve outcomes [203]. The authors identified over 50 outcomes that could be influenced by midwife care, and called for a shift in focus from identifying and treating pathology to providing skilled care for all. They specifically recommended working to strengthen women’s capabilities and to promote normal reproductive processes.

Another opportunity afforded by antenatal healthcare is discussing breastfeeding, but currently, although antenatal promotion of breastfeeding is agreed to be an important discussion [204], there is a lack of consistent evidence regarding the effect of antenatal breastfeeding education on outcomes such as initiation and duration [205] of breastfeeding. See the National Strategic Plan [206] for more detail.

This feeling that current models of care are not optimal has prompted health practitioners to consider novel ways of delivering antenatal care. A systematic review of group antenatal care concluded that this was well received by mothers and that infant outcomes were no worse amongst women attending group antenatal care compared with one-to-one care [207].

Home visits have also been suggested as a method of improving outcomes for women who are drug or alcohol users. However, a Cochrane review [208] of home visit trials was not able to draw firm conclusions due to the poor methodological quality of the trials reviewed and the small number of studies reporting antenatal interventions.



Targeted services

Mental health is an important area where evidence of effectiveness is limited. A systematic review of interventions that could be delivered by midwives to improve maternal mental health and wellbeing [209] did not identify any interventions with clear evidence of benefit. The authors of the review called for further research into midwife-led mental health interventions, pointing out that midwives have multiple contacts with women during pregnancy and would be well-placed to deliver such interventions. However, access to services may be an additional barrier: a study from the USA [169] reported that fewer than half of pregnant women with severe psychological distress were accessing mental health services, and that access was predicted by social advantage.

Likewise, a systematic review of programmes providing additional social support to pregnant women who were at risk of having low birthweight babies did not identify a protective effect on birthweight, but there was a slightly decreased risk of antenatal hospital admission and Caesarean section [210]. However, there are some indications of effectiveness. A PRAMS-based study of the impact of antenatal counselling on maternal risk behaviour analysed data from just under 200,000 women. The authors reported positive behaviour changes following risk-appropriate counselling for women who used alcohol or tobacco, and that women with unintended pregnancies were more likely to use postnatal contraception [211].

Antenatal education

In New Zealand parenting and pregnancy antenatal education for pregnant women and their partners is offered by a range of providers, and is funded for approximately a third of women in a DHB population [189]. Internationally, reviews of antenatal education have not identified clear evidence that attending antenatal education improves outcomes [212]. One explanation may be that these and other services tend to be accessed less frequently by women who are disadvantaged. Another identified concern [213] is that because of time constraints, antenatal education can have a limited focus, with much of the content devoted to issues around management of labour such as pain relief.

An alternative approach would be to reframe the aim of antenatal education as health literacy rather than as a simple transfer of information [213]. A health literacy approach would aim to increase women's skills and confidence when making healthcare-related decisions for themselves and their children. Health literacy can be defined as "the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand, and use information in ways which promote and maintain good health." (see Nutbeam [214] for a review of concepts of health literacy relevant to health promotion). Health literacy is critical to empowerment. It can influence health outcomes at three points: access to healthcare, the interactions between individuals and healthcare providers, and self-care, all of which are important for preconception and pregnancy health. Health literacy can enable parents to make better health decisions for their children [215], and there are indications that supporting mental health literacy, in particular, has the potential to improve outcomes for pregnant women [216].

Interventions at the population level

Health interventions implemented at the national level include alcohol and tobacco initiatives as mentioned above; micronutrient fortification is a promising population-level approach for nutrition.

Mandatory folic acid fortification has been advocated for New Zealand but to date has not been implemented. The authors of a New Zealand study in which postpartum women were asked about their folic acid supplementation history and bread intake estimated that 33% of women had received optimal amounts of folate, but that fortification of bread would have increased this to 59% [97]. Furthermore, modelling of projected folic acid intake suggested that mandatory fortification would decrease the inequalities in folic acid intake observed between women from different ethnic groups in this study.

Iodine fortification of salt used in bread has been implemented in New Zealand, but a recent survey of women of childbearing age in Palmerston North reported that iodine levels



were suboptimal despite apparently adequate intake in the presence of fortification [123]. Results from an earlier modelling study had suggested that pregnant women would need to take iodine supplements in addition to iodine fortification of bread [178].

Measuring and monitoring to inform intervention

An essential aspect of policy and intervention planning is to measure and monitor the prevalence of determinants and outcomes in the population of interest. This section outlines approaches to measuring and monitoring key aspects of women's and children's health relevant to this topic.

US screening tools and interventions for preconception and/or inter-conception care have recently been summarised in a report for CDC [173]. The authors identified a number of screening tools but noted the lack of rigorous evaluation of these interventions and instruments.

In the US, the Pregnancy Risk Assessment Monitoring System (PRAMS) collects data each year on maternal health and attitudes to health before, during, and shortly after pregnancy. A detailed description of the system can be found on <http://www.cdc.gov/PRAMS/>. PRAMS data can be used to answer specific research questions [111] or to produce surveillance reports [217].

Factors that could be measured at the preconception stage or during pregnancy include dietary patterns [106,114], smoking (measured using self-report or urinary cotinine levels), and alcohol intake, particularly binge drinking [111,147,183]. Kesmodel [147] has reported robust measures of binge drinking in a Danish population using two questions: 1) "Try to think of your entire pregnancy, including the first weeks before you knew you were pregnant. How many times have you been drinking five or more drinks on a single occasion?" and 2) "How many weeks pregnant were you on this/these occasion(s)? These questions require clarification of the timing (which is spelt out in the study design), to avoid previously observed variations in surveys of early pregnancy binge drinking.

For individual women, it is important to identify their pre-pregnancy weight category: underweight (<18.5 kg/m²), normal (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), or obese (30.0 kg/m²) [102], because this determines their recommended weight gain during pregnancy [194].

Birth outcomes that are strongly influenced by preconception and pregnancy factors include fetal or neonatal death, prematurity, and birthweight. Perinatal deaths are collated at national level. Prematurity can be reported as delivery at <37 weeks or as a continuous measure, i.e. gestational age at birth [106]. Birthweight is an important measure that is discussed in detail in the following section.

Birthweight

Like prematurity, birthweight can be reported as a categorical measure, for example labelling infants with a birthweight <2500g as 'low birthweight', or as a continuous measure, e.g. weight in grams.

Lewis notes that "placental transmission or compromised placental function may comprise a small number of mechanisms that interrupt fetal development and therefore result in a similar set of child outcomes... Fetal growth, therefore, could continue to be considered a useful index of fetal adversity but also as an outcome for prenatal and preconception intervention to target, particularly for population-level interventions" [88].

Birthweight is influenced by numerous characteristics aside from the risk factors presented in this chapter. These include maternal factors (age, height, parity, and previous history of low birthweight) and infant factors (sex, gestational age at delivery, and ethnicity) [218,219] as well as a range of health conditions. It is particularly difficult to separate effects on birthweight and effects on gestational age, and new evidence suggests that adjusting for gestational age in analyses can introduce bias [220]. This complexity can make it difficult to use birthweight to assess the effect of an intervention at the individual level, even for risk factors where there is very strong evidence of an effect on birthweight at the population level.



Smoking is a good example of this problem. Maternal smoking is estimated to reduce birthweight by about 90–170g [141,143], but because of normal variations in birthweight due to the above-mentioned factors and systematic differences between women who continue to smoke in pregnancy and those who do not, it is difficult in practice to demonstrate significantly improved birthweights following changes in smoking, especially among women who reduce consumption without stopping completely [221,222]. Thus, a failure to demonstrate significantly increased birthweights following an intervention does not necessarily mean that the intervention was ineffective. Secker-Walker et al. have published a helpful discussion about how to assess the effect of smoking reduction interventions on birthweight [218].

This problem further emphasises the need for a co-ordinated, programmatic approach rather than a single-issue intervention to improve outcomes for children: even if all smoking were prevented, other risk factors would continue to impact on birth outcomes.

Mental health

Mental health is a complex concept, and unlike birthweight, it is not routinely measured in adults or infants. It has been suggested that routine, universal psychosocial assessment of women during pregnancy may be effective in identifying women at risk and hence, intervening to improve perinatal outcomes. However, a systematic review [200] which identified two such trials was inconclusive; the studies were underpowered and confidence intervals were wide and included the null.

Measurements of child mental health need to take child age into account. Infants and young children can be assessed using the Diagnostic Classification of Mental Health and Developmental Disorders of Infancy and Early Childhood: revised edition (DC:0-3R); an overview can be found in the ‘Healthy Beginnings’ report [176].

In New Zealand, as the twelfth core contact in the Well Child Tamariki Ora schedule, children undergo the B4 School Check, which includes the Strengths and Difficulties Questionnaire (SDQ) [223]. This instrument is designed to identify children with mental health or development problems who may require additional supports as they start school; it could potentially also be used as an outcome measure of preconception or pregnancy policy at the population level, because the B4 School Check had approximately 90% of the eligible child population checked in 2013/14.

However this measure is limited to identifying problems: despite its name, the SDQ is not designed to measure child strengths. This focus on problems gives an incomplete picture of children’s functioning, and does not take into account more positive factors such as resilience in adversity. Given that preconception and pregnancy risk factors are strongly linked to disadvantage, it may be especially important to understand pathways to positive mental health and factors that can protect children born into families experiencing adversity. An alternative measure has been developed in the Australian Early Development Index and is described in the box below.

Case study: Measuring positive child mental health at the population level using the Australian Early Development Index

This study was instigated as a response to the observation that population-level reporting of child mental health focuses almost exclusively on mental health problems. The first step was to develop a definition of positive child mental health, drawing on the public health, psychology and social science literature. The major finding of this investigation was that population mental health researchers should adopt the dual continuum model, in which positive mental health and mental health disorders are seen as separate though correlated states [138]. The conclusions of this study were that concepts and measures of positive child mental health for public health purposes should be based on child strengths (not the absence of difficulties), should be developmentally contextualised, and should have a multilevel perspective, taking into account the complex relationships between children and the societies in which they live [139].

Based on these requirements, a novel indicator, mental health competence, was derived from positive constructs: overall social competence; responsibility and respect; approaches to learning; readiness to explore new things; and prosocial and helping behaviour.



The data source for this indicator is the Australian Early Development Index (AEDI), a three-yearly national census of child development at school entry [224]. It is an adaptation of the Early Development Instrument (EDI), which was originally developed in Canada and has since been rolled out in a number of countries [225].

The mental health competence indicator performed well in validation tests against the Strength and Difficulties Questionnaire. In logistic regression models, maternal education and mental health emerged as strong predictors of child mental health competence that may also protect against the adverse effect of family hardship [226]. Further work is ongoing to report on mental health competence in a full national cohort of Australian children as they started school.

Translating the evidence into action

As this review shows, the effect of preconception and pregnancy health on child health is an area of active research and it is understood that these are extremely important life stages in determining child health. However, this extensive literature does not currently provide a clear mandate for action in the form of a proposed programme of interventions with robust evidence of efficacy and effectiveness.

Nevertheless, although evidence on specific interventions is often inconclusive, some patterns can be discerned. One is the observation that successful interventions tend to be co-ordinated and programmatic rather than addressing a single issue [95,179,187]. Another is that successful trials tend to have a higher level of engagement with their participants than unsuccessful ones: interventions that seek to support behaviour change using counselling and multiple contacts seem to have more effect than interventions simply providing information [180,185,187,197]. Taken together with evidence that risk factors tend to co-associate and influence each other, these patterns suggest that maternal and child health is best regarded as a complex system where the effect of a single intervention is not linear and may be influenced by multiple factors external to the intended focus of the intervention.

This in turn indicates a need to build an explicit recognition of complexity into service and intervention design. FSG (www.fsg.org), a US-based consulting firm, has produced a thoughtful practice brief, 'Evaluating Complexity: Propositions for Improving Practice' [227] based on their experience of working with agencies across all sectors to bring about social change in complex circumstances.

This policy brief outlines nine propositions for evaluating complexity, based on nine characteristics of complex systems identified by the authors. These characteristics include observations that events in one part of the system affect all other parts; that "relationships between entities may be more important than the entities themselves"; that "context matters; it can often make or break an initiative"; and that "each situation is unique; best principles are more likely to be seen than best practices". The authors also emphasise the importance of gathering information about all of these aspects, and in particular, they stress the need to elicit information and then rapidly feed it back into the system so that initiatives are constantly learning and adapting.

This outline of the information demands of a complex system suggests that these demands are not well served by the traditional medical literature model of evaluating single interventions at a single time point (usually after the conclusion of the trial), and of focusing on interventions and outcomes without contextualising this and taking relationships into account. The authors of the practice brief discuss an array of methods and tools that they use for obtaining information and it is notable that these are outside the traditional RCT or quantitative study structure, for example using systems mapping to understand relationships within a complex system, or causal diagrams to understand multiple pathways of effect.

Recently, a similar need for additional and complementary sources of information was identified by health planners in the US as they considered public health strategies for another very complex problem, obesity. The box below describes the L.E.A.D. framework that was developed in response to this identified need.



Developing an evidence base for a complex system

Even very large and authoritative systematic reviews such as those produced in the Cochrane system are generally commenting on just one aspect of the evidence, the internal validity of the studies, in other words how likely studies are to have measured the true effect of an exposure or intervention on an outcome. What is additionally required and essential to health planning, however, is evidence on external validity: how well study findings can translate into other settings [228]. This is harder to measure and fits less easily into an RCT paradigm [229], but is more suited to the information needs of health planners considering a complex problem.

Case Study: L.E.A.D.

The L.E.A.D. framework was developed in the US by the Institute of Medicine and is described in a recent paper by Chatterji et al. [228]. This is a systems-oriented framework which was originally developed to address obesity and is applicable to many other complex population health problems. The L.E.A.D. acronym stands for 'Locate the evidence, Evaluate the evidence, Assemble the evidence, and inform Decisions' and the framework locates these cyclical steps within a systems perspective, with panels showing that decision-makers may identify a need and opportunity to generate evidence at any step.

The authors describe three types of questions that can be used to guide evidence gathering:

- 1) 'Why' questions e.g. 'Why should we be concerned about preconception health?'
- 2) 'What' questions e.g. 'What actions could be taken to ensure adequate folic acid intake before and during pregnancy?'
- 3) 'How' questions e.g. 'How can this be implemented in the most disadvantaged populations?'

All types of questions are important, but the biggest evidence gaps in this topic are in the 'how' questions.

As an example of how a study that was not RCT-based can provide critical information to guide interventions, a recent paper in the New Zealand Medical Journal "Why Māori women continue to smoke while pregnant" reported on the results of a survey of 60 pregnant Māori women who were smokers [137]. These in-depth interviews provided detailed and specific information about women's beliefs about smoking and their circumstances, and in doing so identified a number of barriers to smoking cessation, including, for example, the observations that women were smoking to self-medicate for stress, and that for all the women interviewed there was at least one other smoker in the household (with a third of the participants agreeing that they might as well continue smoking as they were exposed to so much second-hand smoke). This suggests that a smoking cessation intervention for these women that did not address the stress they are experiencing or that did not encompass all members of a household would have limited success.

This need for practical, local knowledge is summed up by Green and Glasgow who note that "if we want more evidence-based practice, we need more practice-based evidence" [229].

Conclusions

As this review demonstrates, there is a growing understanding that risk factors and behaviours that are present before conception and during pregnancy can influence child health [86].

Major influences on child health that have their effects both in the preconception period and during pregnancy include nutrition at the macro- and micronutrient level, mental health status, and exposure to alcohol, smoking and drugs. Moreover, risk factors commonly co-associate and the presence of one may lead to another. The relationships are complex: unintended pregnancy may both cause and be caused by other health behaviours. An additional problem of unintended pregnancy is that early pregnancy is an especially sensitive period for a number of harmful influences and women may be unaware of pregnancy at this time: this adds weight to recommendations for greater support of preconception health.



Maternal stress during pregnancy is now understood to pose a major risk to child physical and mental wellbeing and the evidence is strong enough to indicate that this should be an intervention priority; there is also evidence that as well as being harmful in itself, maternal stress can be a driver of other harmful behaviours [96].

Consequences of these risks for children include adverse birth outcomes such as stillbirth and prematurity; outcomes that emerge during childhood such as obesity and mental health difficulties [88]; and, it is now increasingly recognised, adult health problems such as diabetes and cardiovascular disease [87]. Low birthweight or small size for gestational age is a finding common to many of these problems although not an outcome in itself [88].

The urgency of addressing these health issues is underlined by emerging evidence from longitudinal cohorts and epigenetics research showing that adverse effects originating in the preconception period can carry through into adulthood and potentially into the next generation [126]. This increasingly detailed evidence of the importance of preconception health signals a need for a new, broader approach to promoting child health. As Mitchell and Verbiest put it: “Ultimately, a key task of the preconception health movement is to change social norms about the importance of the health of women and men and the impact it can have on their future reproductive goals” [93]. As a population health goal, this will be neither easy nor simple to achieve, but the influence on child wellbeing is likely to be profound [196].

Taking action requires a sound evidence base. This is challenging: when evaluating preconception or pregnancy interventions that impact on child health, randomised controlled trials are not always feasible; nor do they always provide the information that is most needed [169], such as specific, local understandings of barriers to intervention uptake and success.

The issue of external validity (how well interventions translate into new settings) is critical for this topic. Most of the risk factors discussed here are already well known to be harmful to human health, and further clarification of risk, even when this has high precision, will add little to our recognition of these as important problems that require action. The challenge is not so much to measure the risks but to address them effectively in the real-life settings in which women live.

The intractability of these problems indicates a need to consider new approaches and solutions. For example, it is clear that knowledge of risk alone is not enough to support health-promoting behaviours or behaviour change in the preconception period [95] or during pregnancy [200]. Similarly, current interventions tend to require intensive investment of resources to be effective [180,185,187,197]. These and other considerations highlight the importance of approaches that can address the complexity of these issues.

Finally, a striking feature of the research literature on preconception and pregnancy health is that it has a very strong focus on risk, with little attention given to strengths and resilience in individuals and communities. This may limit the strategies currently available to healthcare services and professionals.

Dunkel Schetter warns against blaming women for poor health choices, pointing out that “mothers are embedded in multiple layers of influence, including social and cultural contexts containing many complex causal determinants that are often uncontrollable.... Societies that nourish resilience in mothers and their families are surely likely to see maternal optimality” [96]. This resilience might take the form of health literacy [214], positive mental health in mothers [140] and children [139], or the knowledge and support of family and whānau. Indeed, this positive, supportive approach to maternal health is closely aligned with the principles of Whānau Ora [230] suggesting that our communities may already hold the key to supporting a healthy start for the generations to come.

