A consequence of the high prevalence of obesity in developed countries is that an increasing number of women of reproductive age are obese. Despite the reduced fertility and increased risk of miscarriage associated with obesity, rates of maternal obesity are high in developed countries and rising, particularly in low socioeconomic groups. Recent analyses of prepregnancy obesity rates in the United States found that 20% of women who delivered a live infant were obese, with rates higher in women from low socioeconomic status (28%), and as high as 36% for some racial-ethnic groups. Similar prevalence data have been reported in Australia; however, Cunningham and Teale suggest that the rates in regional/rural areas may be twice that of metropolitan centers with this study demonstrating that 33% of pregnant women in a rural cohort were overweight, and 32% of women were obese. Thus, in developed countries, we are fast reaching a state where the number of pregnancies initiated on a background of obesity and overweight outnumber pregnancies initiated on a background of normal bodyweight/ body mass index.

Maternal obesity is associated with high rates of maternal and neonatal morbidity and mortality. Maternal obesity is also associated with large and small for gestational age babies, premature birth, cesarean birth, postpartum hemorrhage, and congenital defects. As such, obesity is now considered in the United States as the most common preventable risk factor for complicated pregnancy. Because of these significant complications, obese pregnancies are associated with longer stays in hospital and increased admittance to intensive care units for both mother and neonate. Thus, in addition to the significant personal costs, the economic costs are dramatically higher for the management of obese pregnancies and births. However, although the high personal and economic costs of maternal obesity are not restricted to this period, indeed recent data suggest these higher costs may be faced by offspring during the course of their lifetime.

The seminal work by Barker and others, originating 20 years ago, highlighted how sensitive the developing human is to adverse intrauterine events and led to the establishment of the Developmental Origins of Adult Health and Disease hypothesis. Original studies in this field focused on undernutrition in humans (Hertfordshire records; The Dutch Famine), and global food restriction or restriction of dietary protein or placental flow in animal models. Broadly, these studies showed that cardiovascular, renal, and metabolic disorders could all be programmed by undernutrition. Although these malnutrition models still have significance in today’s society, the high rates of obesity in the Western world, and urbanized regions of the developing world, have led to a shift in the field of programming from one of maternal undernutrition to one of maternal overnutrition. As the prevalence of maternal obesity rises, so too has the number of children at risk of fetal programming.

Given the rise in maternal obesity is relatively recent, few studies have examined children of obese women, and fewer still as these children reach adulthood. However, as highlighted by Gademan et al in the current issue of Hypertension, maternal obesity in humans is associated with increased risk of being overweight during infancy through to adulthood, and the presence of cardiometabolic disorders such as hypertension. These human data are supported by extensive experimental data in animal models of obesity. Although the programming effects of maternal obesity for offspring are generally well characterized, particularly in these animal models, what remains unclear are the mechanisms by which maternal obesity drives higher blood pressures in offspring. Such mechanistic programming studies are even rarer in the clinical setting. Driven by evidence in the human fetus and studies in rats showing maternal obesity program activation of the sympathetic nervous system, Gademan et al investigated whether autonomic function mediated the association between maternal obesity and blood pressure of 5- to 6-year-old children.

This important work used a large and well-defined cohort of 3074 mothers from the ABCD (Amsterdam Born Children and their Development) study who had singletons, and whose children did not have congenital malformations. This study confirmed the findings of previous studies that maternal obesity is associated with higher blood pressure in children, and that child body mass index mediated this association. A key feature identified in studies in animal models of programming is that blood pressure and the autonomic nervous system are hyper-reactive. Using pre-ejection period, a derivate of sympathetic nervous system activity, and respiratory sinus arrhythmia, a derivate of parasympathetic activity, Gademan et al were unable to detect an association between resting autonomic function and child blood pressure. However, as discussed by the authors, it is difficult to detect, particularly in
children, differences in autonomic function using noninvasive methodologies. Therefore, the authors highlight that studies challenging the autonomic nervous system are necessary to clarify the role of the sympathetic nervous system in the programming of blood pressure by maternal obesity.

This study is significant on many fronts. It has been performed on a large and well-defined cohort and has used methodology that is appropriate for measuring cardiovascular function in children, albeit with limitations. Most importantly, despite the negative findings, it denotes a shift in the clinical literature from characterization of the offspring phenotype to investigation of the mechanisms underlying these phenotypes. Maternal overweight and obesity are endemic, and there is strong evidence that the next generations are going to bear the brunt in the form of future risk of not only hypertension, but also many other disease conditions. To limit the impact of this epidemic, we need to make inroads into understanding the consequences for the child, particularly the mechanisms driving the increased risk, and provide evidence-based strategies for future interventions; the study of Gademan et al9 has started down that path.

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None.

References
Maternal Obesity: Bad for Baby's Future
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