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Non-communicable diseases – a catastrophe for South Africa

Non-communicable diseases contribute significantly to the disease burden within South Africa. In the most unequal of societies in the world, poverty and socio-economic disparity are amongst the greatest obstacles facing South Africans, impacting heavily on health care. Adverse socio-environmental factors, especially those experienced during early life, can, through neurobiological and epigenetic mechanisms, developmentally programme the outcome of obesity, diabetes, cardiovascular disease and mental health disorders in adulthood. In this narrative review, we describe the social environment experienced by South Africans and discuss the potential contribution of epigenetics to the current and future prevalence of non-communicable diseases. A large part of the population (including 60% of young children) lives in poverty and endures challenging socio-economic environments, due to high unemployment, alcohol and substance abuse, and inter-partner violence. It is imperative that socio-economic factors be considered as risk factors for strategies aimed at reducing or preventing these disorders. If the current situation is left unchecked, the disease incidences could be exacerbated, and be potentially catastrophic for future generations. The consequences can be widespread and can have a direct effect on the future health and economic development of the country. Thus, child and adolescent health requires urgent attention and should be placed at the centre of the healthcare system. Early interventions providing optimum nutrition, a secure environment, together with physical activity and education should be the cornerstones for creating a healthier population for the future.

Significance:

- South Africa already has a high non-communicable diseases burden. Non-communicable diseases – like cardiovascular diseases, cancer, diabetes, respiratory illnesses and mental disorders – are known to be caused by the interaction of socio-environmental factors, physiology, behaviour and genetics. About 60% of South Africa's children currently live in poverty, with adverse socio-environmental factors known to have a negative effect on development, leading to a plethora of health problems in adulthood.
- The implications for the current situation are widespread: a future population with deteriorated physical and mental health, presenting with co-morbidities that render these individuals more susceptible to infectious diseases. It is important to recognise the potential repercussions on the health prognosis of future generations.
- Endeavours should focus on early interventions that can provide optimum nutrition, education, and physical activity within a safe environment. These interventions can have favourable effects on children's brain development and genetics, thereby promoting their well-being and increasing their life prospects.

Introduction

Non-communicable diseases (NCDs) are the leading cause of death worldwide, being responsible for 71% of global mortality, with an estimated 41 million people dying from NCDs each year.¹ South Africa is famously known as the home of the 'Big 5' animal species, but if the current trajectory continues, it will also be the home of the big 5 NCDs. The major NCDs are cardiovascular diseases (CVDs), cancer, type 2 diabetes mellitus, respiratory illnesses (such as chronic obstructive pulmonary disease) and mental health disorders.² NCDs are chronic illnesses that tend to be of prolonged duration and occur as the result of a combination of genetic, physiological, socio-environmental and behavioural factors.³ It is estimated that NCDs will cost the global economy USD47 trillion over the next two decades, driving millions of individuals into or further into poverty and thereby exacerbating inequalities in quality of life and longevity.⁴

An already poor health prognosis for South Africa has been associated with a quadruple burden of communicable diseases, NCDs, maternal and child health, as well as injury-related disorders.^{5,6} The country also experiences a high prevalence of inter-personal violence.⁷ Equally important within the South African context is the growing trend of multi-morbidity, with the combination of human immunodeficiency virus (HIV)/NCDs and tuberculosis mycobacterium (TB)/diabetes, increasing the need for resources in the treatment and management of both chronic infectious diseases and NCDs.⁸

Recently, socio-economic status was recognised as a major contributing factor to the development of NCDs, not only in South Africa but worldwide.⁹ While the role of socio-determinants of health is not new, especially with regard to NCDs, there is increased interest in understanding the influence of epigenetics in this regard.¹⁰ A better understanding of region-specific risk factors could greatly aid the development of initiatives to reduce disease incidences and lighten the burden thereof. In this narrative review, we discuss the potential contribution of the socio-environment experienced by South Africans towards the current NCDs prevalence. We describe the possible interaction of several socio-environmental factors together with epigenetics, and aim to caution against the perpetual effects thereof, which may result in an even higher disease incidence in future generations. Furthermore, several important considerations which could be useful to mitigate the detrimental epigenetic effects are proposed.

Poverty and socio-economic disparity

South Africa was the most economically unequal society (out of 149 countries) assessed using the Gini index.¹¹ More than half (55%) of the population experiences poverty¹², with childhood poverty affecting 63% of children.¹³ Early-life adversities can have a negative impact on growth and development, with childhood poverty having both short- and long-term consequences.¹⁴ Impoverished children exhibit higher rates of acute and chronic diseases, with worsened physical and mental health in adulthood.¹⁵ Prolonged exposure to early life adversity establishes a developmental 'biology of misfortune', involving neurobiological and epigenetic processes through which one's life course is steered towards diminished health, unrealised potential and reduced longevity.¹⁵ Furthermore, children who do not have access to adequate nutrition (due to malnutrition or over-consumption) are developmentally compromised, exhibit learning disabilities, and are impulsive and prone to erratic and risky behaviour.¹⁶ If poverty and inequality are not adequately addressed, vulnerable children will become adults with a heightened susceptibility to disease. In a country with an already high NCDs burden², harsh socio-environmental conditions may contribute to a vicious cycle of unfavourable health prognosis, as is being witnessed in the current generation¹², which could worsen significantly in future generations.

The failure to optimise nutrition, especially during the critical periods of development for vulnerable young children, should be avoided at all costs. There is a definite requirement for efforts directed at improving the national diet. It should be noted, however, that healthier foods are far more expensive than less healthy, nutritionally poor foods.¹⁷ Products like lean meat, fish, fruit and vegetables generally cost more than oil-heavy processed foods which contain more sugar and fat.¹⁸ This makes the promotion of a quality diet difficult, because it is simply unaffordable for many South Africans. International research has shown that the best strategies for changing the dietary environment in favour of healthier foods are those aimed at population level and are accomplished by mass-media nutrition campaigns and transparent food labelling, and, more drastically, through regulation and taxation of unhealthy foods.¹⁸ To this end, the South African government has implemented policies that ensure stricter food labelling, prohibited advertising to children, introduced mandatory salt reduction legislation in 2016 as well as sugar taxation in 2018 (with South Africa being the first African country to do so).¹⁸ While research into the effect of sugar taxation in South Africa is still underway, data from Mexico and Chile have shown taxation to be partially effective, with a reduction in sugary beverage sales.^{19,20} However, these policies have a greater impact on poorer households²¹, and offer little in reducing socio-economic inequalities in diet-related health.^{19,20}

Cultural dynamics and educational influences

South Africa is famously known as the rainbow nation, with a rich ethnic and cultural diversity comprising a variety of population groups including African, European, Indian and others, each embracing varying beliefs and cultural practices. Yet despite this diversity, dietary diversity is ever decreasing. More nutritious traditional foods have largely been replaced by the 'Western diet', which is characterised by the consumption of energy-rich and nutrient-poor processed food, largely from animal origin²², together with increased consumption of sugar-rich beverages.¹⁸ A concomitant decrease in the consumption of fruit and vegetables, whole grains and fibre has also been observed.²² This type of food environment has been associated with the rise in chronic illnesses including CVDs, cancer and diabetes.²³

More awareness about the effects of an unhealthy diet could be useful, especially to younger children. General nutrition scores for the South African population tend to increase with age and peak at 55–64 years of age.²⁴ Initiatives to improve nutritional knowledge, such as the nutrition education programme, have been implemented, and was shown to improve both the teachers' nutritional knowledge as well as learners' nutrition attitude.²⁵ However, in the same study, no significant improvements in dietary practice of teachers or learners were found.²⁵ It is plausible that, even if most of the public are aware of the health risks associated with the so-called 'Western diet', the consumption of heavily processed foods is unavoidable due to economic constraints

and will therefore remain widespread. Also, amongst certain ethnic groups in South Africa, the type of food consumed is a measure of economic status.²⁶ High adiposity is considered a sign of affluence and comfortable living, while being lean may be associated with being sickly or poor (or both), or having contracted TB, HIV or cancer²⁷, with negative stereotypes and beliefs posing a great impediment to the development and success of healthy eating campaigns.

Indeed, several studies have shown the prevention or partial reversion of NCDs through implementation of lifestyle modification therapies, such as increased levels of physical exercise together with a balanced quality diet.^{28,29} Such preventative approaches are heavily under-represented, are certainly not available to most South Africans, and much awareness can be created around them.²⁸ A school environment represents a controlled system, which could be targeted with efforts aimed at promotion of such interventions. This endeavour could be aided through the implementation of the teaching of crop cultivation within the school curriculum that culminates in a food garden project. The national school nutrition programme has aimed to establish food gardens, and even though the benefits are well known, this pillar of the framework has been described as under-funded and neglected.³⁰ Such efforts could help feed the children nutrient-rich foods, to support surrounding communities as well as to educate about the health benefits of foods in preventing disease, whilst also being therapeutic. Furthermore, it would enable knowledge transfer to the general public, with regard to health risks associated with unhealthy diets, whilst simultaneously, efforts can be aimed at breaking the negative stereotypes related to obesity/leanness, beginning with young children as the key intervention group.

Socio-environmental factors and epigenetics

Socio-environmental conditions, even before we are born, are extremely important and can fundamentally affect our biological physiology³¹, and thereby activate or deactivate specific genes, with experiences of parental hardship in early childhood leading to alterations in chromatin structure, which are detectable a decade and a half later.³² Epigenetic modifications – which include DNA methylation, micro-RNA circulation, histone modification and chromatin remodelling – have been implicated in the pathophysiology of obesity and several NCDs³³, including diabetes, CVDs, cancers, and neurodegenerative and mental health disorders. Epigenetic markers constitute a biological 'memory' of early life experience, even more so in experiences of misfortune, poverty and stress.³² Epigenetic alterations can have long-lasting effects, spanning across generations, as observed in the Dutch famine cohort³⁴ and the seasonal famines of Gambia.³⁵ The same holds true for children suffering maltreatment, who exhibit long-lasting mental health perturbations and behavioural problems, which persist into adulthood.³⁶

It is conceivable that the interaction between epigenetic changes arising from challenging socio-economic conditions are partially responsible for the high prevalence of NCDs in South Africa. The interplay between socio-environmental factors and epigenetics (Figure 1) must be considered and taken seriously when developing strategies to attenuate disease progression. The high genetic diversity together with varying socio-economic factors, although complex, offers a unique milieu of conditions for clinical investigations, and due to the paucity of research, calls for programmes to be initiated for this purpose, not only in South Africa but within Africa too.³⁷

Obesity

Obesity has been described as a normal response to an abnormal environment³⁸; however, the social and environmental factors contributing to disease aetiology are often underappreciated.³⁹ While South Africa is the most food secure nation on the African continent, more than half of the population are at risk of hunger.^{12,24} Despite high levels of food insecurity and elevated risk of starvation, the country remains one of the top 20 overweight and obese nations in the world.¹²

An estimated 27% of the population is obese, with South African women being amongst those with the highest rates of obesity worldwide, with a prevalence of 42%.⁴⁰ This can partially be explained by high levels of physical inactivity amongst women, which is estimated to be 48%.²

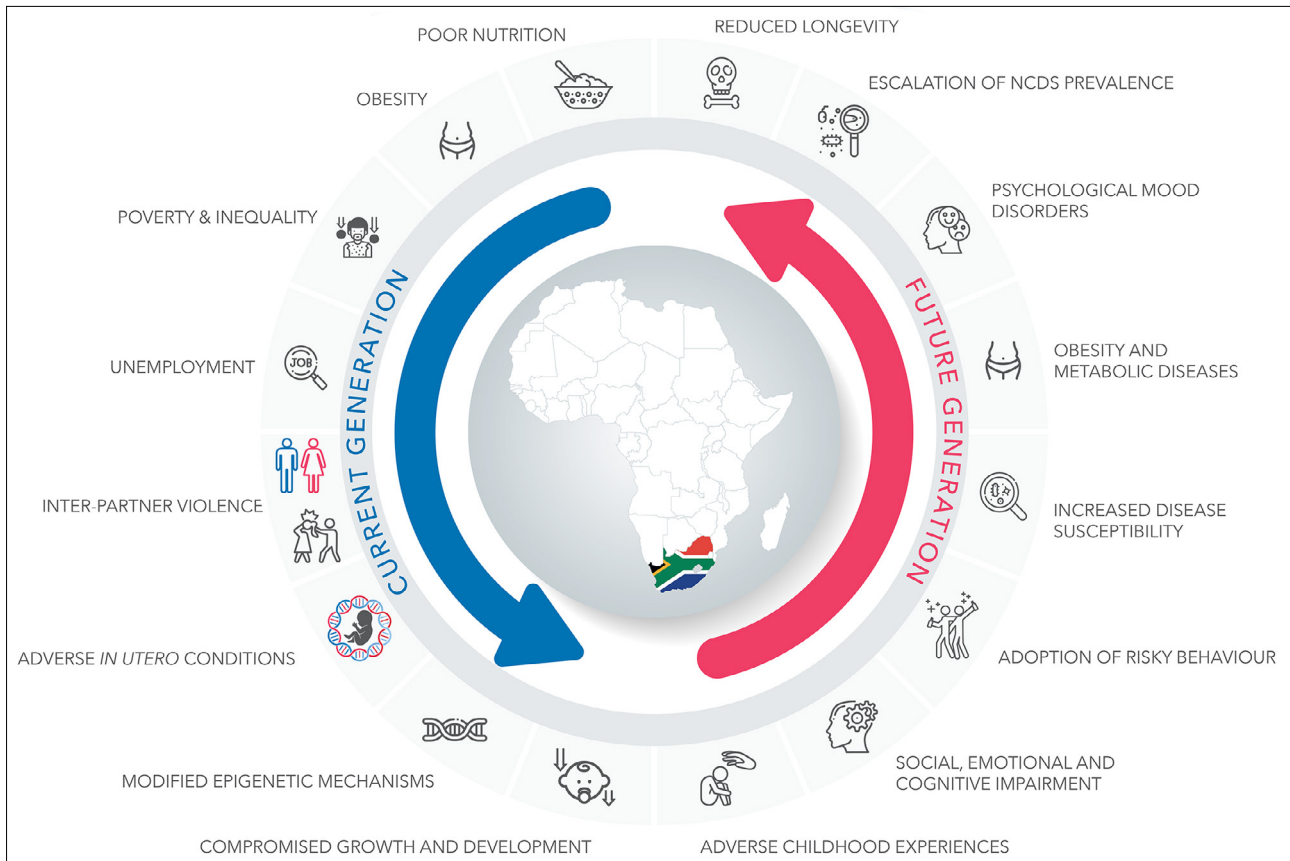


Figure 1: A cycle of non-communicable diseases in South Africa, in which adverse socio-environmental factors affecting a large number of children exponentially increase their susceptibility to diseases and promote the development of chronic illnesses in adulthood – the effects of which can potentially be perpetuated across generations.

Physical inactivity is also prevalent amongst children and youth, with levels deemed insufficient to promote health and prevent NCDs.⁴¹ Obesity in young children in South Africa is also rapidly increasing, which is intriguing as a large proportion of children are at risk of starvation.^{12,24} The prevalence of overweight and obesity in 2013 was reported to be 19% and 7%, respectively, for boys, and 26% and 10%, respectively, for girls within urban areas.⁴⁰ In 2008, these figures were reported at 11% and 3% for boys, and 29% and 8% for girls within a nationally representative cohort.⁴² The country experiences what has been described as the double burden of malnutrition. A large number of children have been found to be developmentally stunted and thereby are at an increased risk of becoming overweight and obese, with a higher likelihood of developing NCDs in adulthood.⁴³ Not only do obese individuals have an elevated risk of developing metabolic diseases, but offspring born to obese women are increasingly vulnerable to chronic disease development later in life.⁴⁴ It has been estimated that more than 90% of type 2 diabetes mellitus, 68% of hypertensive, 45% of ischaemic stroke and 38% of ischaemic heart disease cases in South Africa occur as a result of excess body weight.⁴⁵ The sub-Saharan African region is undergoing rapid demographic and epidemiological transition, which is believed to be the driving factor behind the increased risk, prevalence and burden of CVDs, diabetes and neurodegenerative diseases.⁴⁶

It is worthy of mention that obesity is an underlying and re-occurring theme within the development of several major NCDs and thus represents a pivotal preventative and/or therapeutic target. Therefore, strategies aimed at addressing obesity could go a long way in reducing the prevalence of NCDs. In this regard, strategies should target young children, particularly through providing adequate nutrition together with education that facilitates their growth and development. Additionally, specific policies that address physical inactivity amongst children and

young adults in both rural and urban settings across diverse socio-economic status are also required.⁴⁷ It is notable to mention that the prescription of exercise is a specialist therapy and the importance of having biokineticists in the public sector in the fight to reduce NCDs should be recognised.⁴⁸

Stress, anxiety and depression

The *in utero* environment is increasingly being recognised as important in determining our future health prognosis.³² An adverse *in utero* environment can contribute to altered epigenetic and gene expression profiles as well as compromised growth and development. Individuals enduring such challenging environments may suffer emotional and cognitive impairment, with an increased likelihood of adopting risky behaviours (Figure 1). Additionally, such circumstances can also contribute to an increased susceptibility for developing metabolic diseases as well as psychological mood disorders.

Childcare often subjects parents to anxiety, stress and depression. Both antenatal and postnatal depression affects an estimated one-third of all mothers. This is indeed worsened by a lower socio-economic status with such conditions affecting 39% and 47% of pregnant mothers in informal settlements and rural areas, respectively.^{49,50} Maternal depression during infancy has been associated with dysregulation of the child's biological stress response.⁵¹ Furthermore, alcohol and substance abuse during pregnancy is also rife, with South Africa having one of the highest occurrences of foetal alcohol syndrome in the world.⁵² Another alarming matter is the high prevalence of intimate partner violence, with approximately 20% of pregnant women being affected.⁵³ Half of female homicides in South Africa are perpetrated by intimate partners^{54,55}, with violence against women being a significant problem that profoundly affects the physical and mental well-being of the individuals involved.⁵⁵

Early-life adversity and struggles are linked to pro-inflammatory shifts in cytokine expression and increased CVDs risk⁶⁶, whilst also increasing an individual's vulnerability to developing depressive disorder in adulthood.⁵⁷

In South Africa, we are witnessing an ever-increasing rate of depression, and perhaps due to the stigma associated with mental health disorders, many incidences are unreported.⁵⁸ Depression induced by HIV-stressors is also prevalent.⁵⁹ It is estimated that one in three South Africans will experience a depressive episode at least once in their lifetime.⁶⁰ Interestingly, substance and alcohol abuse are also significant public health problems in South Africa, which are inadvertently linked with increased violence and injury.^{61,62} Furthermore, there is a considerable loss of life due to self-harm, with 70% of individuals who had attempted suicide shown to be suffering from a mental health disorder.⁶³ A high lifetime prevalence of substance abuse is also rife within the country, and with these disorders known to have an early age of onset, it provides an important indication in regard to which demographic to target when planning mental health initiatives and services.⁶⁴

Food for thought

Unhealthy diets high in fat and sugar negatively affect the brain⁶⁵ and contribute to 1 in 5 deaths worldwide.²³ Diet-induced hypothalamic inflammation is one of the first symptoms to occur in the development of obesity and metabolic diseases.⁶⁵ Increased neuronal inflammation is also a commonality for several neurodegenerative diseases like Parkinson's and Alzheimer's, as well as in psychological mood disorders such as depression.⁶⁶ With diet being intertwined with emotions, cognition and behaviour⁶⁷, close attention should be paid to nutrition in order to prevent the induction of metabolic and inflammatory perturbations.

There are dietary regimens, particularly those high in polyphenols, which confer beneficial health effects. Dietary polyphenols are plant compounds found in tea, chocolates, herbs and spices, fruit, vegetables and nuts. Several polyphenols have been shown to be able to attenuate metabolic disease pathologies partially through preventing oxidative stress and inflammation in the brain.⁶⁸ These plant compounds are regarded as exercise mimetics and have shown synergistic effects in combination therapies.⁶⁹ Interestingly, like exercise, polyphenols hold the potential to positively modulate the epigenetic machinery and thereby restore normal gene expression.^{70,71} Furthermore, South Africa sits on a botanical 'goldmine' of indigenous medicinal plants that exhibit anti-obesity, anti-cancer, anti-diabetic as well as anti-ageing properties amongst others⁷², and more efforts are required in order to develop such natural therapeutics.

Finally, while the benefits of breastfeeding for both mother and child have long been known,⁷³ South Africa, like most countries, is still not doing enough to support mothers to breastfeed, despite the immense economic implications.⁷⁴ For mothers, breastfeeding decreases stress and promotes positive affect, while improving maternal compassion and care.⁷⁵ According to the World Health Organization, all babies should ideally be breastfed exclusively from birth up to 6 months of age. Breastfeeding has positive effects on epigenetics⁷⁶ and is critical for the establishment of optimal reference intake values for specific nutrients during lactation. This in turn creates a personalised pattern of nutrition, programming a healthy phenotype in early childhood that will continue into adulthood.⁷⁷ Interestingly, there are reports that extended breastfeeding has been positively associated with increased childhood consumption of vegetables, even amongst obesity-prone young children.^{78,79} Just as the consumption of vegetables and exercise is important for boosting physical and mental wellness, breastfeeding has been associated with enhanced cognitive performance and socio-affective responses in children, promoting positive affect and social behaviour, while relieving stress and anti-social behaviour.⁷⁵ An early investment into a child's health, education, development, security and well-being, provides benefits that compound during their lifetime, and increases prospects for their future and for that of their children and, thus, society as a whole.⁸⁰

Conclusion

South Africa has a high prevalence of NCDs namely, obesity, diabetes, CVDs, cancer and mental health disorders. A large part of the population (including many young children) lives in poverty and under challenging socio-economic environments due to high unemployment, alcohol and substance abuse, and inter-partner violence, amongst others. It is plausible that adverse socio-environmental conditions together with modified epigenetic mechanisms are responsible for amplified disease susceptibility and diminished health outcomes, as is witnessed in the current generation, and if left unchecked can persist to worsen the situation in future generations. The plight of young poverty-stricken children requires urgent attention and should be prioritised and placed at the centre of the country's sustainable developmental goals. It is imperative in South Africa, as well as in countries experiencing similar socio-economic challenges, that children's health and well-being is improved in order to circumvent an impending catastrophe.

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Competing interests

We declare that there are no competing interests.

Authors' contributions

E.S. conceptualised and produced the original draft. All authors contributed to the paper, with N.C., C.M. and J.L. providing overall guidance. E.S. and Y.A. finalised the manuscript based on comments and feedback from other authors.

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