

Adolescence: The age of Proteus

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This article focuses on adolescents as a group, who are exposed to major changes in their near future, with the key transformation being the epidemiological transition from the age of infectious and nutritional problems to that of the non-communicable disorders (NCDs). The major NCDs are: obesity, diabetes, maternal, newborn and child, hypertension and mental health disorders. We also discuss allergies, exposure to pollutants, indoor open stoves, and behavioural factors, such as lack of exercise, unhealthy diet, substance abuse, injuries and violence, and sexually transmitted diseases, which contribute to a risky environment. We particularly emphasise the continuum from birth to old age, during which early events may produce lifelong diseases, and which requires serious attention with regard to preventive measures during the earliest period of susceptibility. Some indicators of disease can serve as diagnostic markers and help healthcare workers to avoid complications and manage a disorder efficiently.

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In Greek mythology, Proteus is god of 'elusive sea change' and will change his shape to avoid certain situations. 'Protean has positive connotations of flexibility, versatility and adaptability.' (Wikipedia)^[1]

Definitions

Adolescence marks a period of transition in both physical and psychological growth, which intervenes between childhood and adulthood. Socially, it serves as a point of evolution into the maturity of acquiring an adult role with the appropriate privileges and related responsibilities. This transition is driven by biological processes, such as the onset of puberty, which subsequently terminates in sexual and physical maturation. The duration of this transition varies owing to geographical, cultural, economic and genetic contexts, although it has been defined by the World Health Organization (WHO)^[2] as being in the 10 - 19-year age group. Furthermore, a youth has been defined as someone in the 15 - 24-year age group. This overlap encompasses all persons between the ages of 10 and 24 years – referred to as young people.

Health: Key issues

The following paragraph on key issues in adolescent health is summarised from articles in *The Lancet*.^[3-5]

There are 1.8 billion adolescents (between 10 and 24 years of age) worldwide, who account for more than a quarter of the global population. Adolescent health has lagged behind improvements in the healthcare of younger children over the past 50 years. It is evident that this generation of adolescents encounters different challenges from those of their predecessors, with dissimilar biosocial and probably neurocognitive responses. Critical temporal factors, such as early childhood events, puberty and, later, social determinants, influence health and development. Social media accelerate sociocultural change. The health and economic burden of non-communicable disorders (NCDs) is significant and increasing. It is propagated by early-life under-nutrition and later-life adiposity, decreasing physical activity, increasing sedentary behaviour, poor dietary diversity, and intergenerational factors. The NCD burden falls heavily on low- and middle-income countries (LMICs). Sub-Saharan Africa is the only region worldwide where the number of adolescents is predicted to grow, despite having the worst adolescent health profile.

A life course

The concept of a life course in the origins and development of disorders, when precursor events during early-age periods predict

later-onset disease, is discussed below, e.g. adolescents along the pathway to NCDs in South Africa (SA).

The NCDs of importance in SA and globally

The NCDs, i.e. obesity, diabetes, hypertension, and mental disorders, are the new epidemic in SA and are especially important for public policy and innovative prevention and treatment programmes. The factors mentioned below are also important because of their biomedical significance and for establishing the injurious environment in which they develop along the causal pathway to NCDs. Furthermore, the prevalence of early sexual debut, unprotected sex, allergies, exposure to pollutants, indoor open stoves, and behavioural factors such as lack of exercise and diet, contribute to a risky environment. Substance abuse, injuries and violence, and sexually transmitted diseases are also likely to be on this trajectory to NCDs.^[6,7]

The basic (non-epidemiological) mechanisms of the transition from infectious diseases to NCDs are poorly understood, but the concept that there are critical periods in early life and during the life course that affect subsequent health and disease, is supported by a growing body of evidence.^[8-10]

The objective of this article is to introduce the emergence of this epidemic to practitioners, and to assist health professionals to recognise, in clinical practice, a constellation of diseases that is a harbinger for the development of NCDs. We discuss a number of common predisposing factors that exist along this pathway and a profile of biomarkers during puberty and adolescence, which are predictive of risk for the most frequently reported NCDs in SA.^[8,9,11,12]

Risk factors for NCDs

The SA National Health and Nutrition Examination Survey (SANHANES)-1 data^[13] and Statistics SA^[14] provide more detail on NCDs. The risk factors are already prevalent in late adolescence and young adulthood. The significance of including a background of HIV and antiretroviral (ARV) treatment is unarguable, as SA is at the epicentre of the global pandemic, with the largest national programme of ARV treatment.

Health practitioners must pay particular attention to the clinical features of puberty in the assessment of health and disease. Puberty-associated changes, a critical segment of the life course, probably create conditions for the subsequent development of NCDs. The fundamental changes during puberty, and the multiple vulnerabilities to ill-health

throughout adolescence, may constitute critical periods in the genesis of NCDs. The combination of these two contiguous and probably continuous sets of factors could influence the subsequent progression to NCDs in adulthood. The mechanisms of this process are not clearly understood, but possibly include the hormonal, psychological and socioeconomic disturbances during puberty and adolescence, which, when added to the formative elements in childhood, cumulatively impact on the development of NCDs in later life. Ninety-five percent of SA children between 12 and 15 years of age attend school.^[15] Therefore, secondary schools and youth centres are the most likely public sites where adolescents gather and socialise, and thus become susceptible to disorders leading to NCDs and targets for interventions.

Clinical risk factors: The example of pregnancy

Clinical factors such as lack of exercise, diet, obesity and substance abuse are already of relevance to public health. While the extreme dangers of teenage pregnancies, such as deaths, are well known, the moderate to severe effects of this period may be less well recognised, despite being protean and clinically identifiable. A recent large study,^[9] which is of considerable relevance to developing countries, including SA, has shown that pregnancy in young mothers identifies a critical period for NCDs, during which interventions could successfully be applied. The key findings, derived from outcomes from ~17 000 birth samples, ~13 000 children samples and ~10 000 adult samples, indicate that there are differences in risk to these offspring according to extremes of maternal age (<19 years; >35 years) compared with mothers 20 - 24 years of age. The COHORTS Collaboration,^[9] which includes 19 403 participants located in five birth cohorts in Brazil, Guatemala, India, the Philippines, and SA, was established to investigate risk factors for NCDs in pregnant women and outcomes in their infants. The findings revealed an increased risk of low birth weight, preterm birth, stunting at 2 years, failure to complete secondary schooling, and lower adult height in children of young mothers (≤19 years) compared with mothers aged 20 - 24 years. Although mothers aged ≥35 years had an increased risk of preterm birth, their children had less stunting, better school progression and adult height attainment, the latter two being novel findings in LMICs. Adult fasting glucose concentrations were increased in offspring of young and old mothers,^[9] but adult blood pressure was unrelated to maternal age. Children of women <19 years and >35 years may benefit from focused public health endeavours to offset their risks of abnormal glucose metabolism, with its attendant disorders.

These findings suggest that in addition to the well-recognised temporal thresholds of greatest risk for morbidity and mortality in children in LMICs, which rightly concentrate on young age groups (perinatal, infancy, first 1 000 days, and under-5s), there is a strong case to be made for continued vigilance throughout the adolescent years. Policymakers and clinicians need this evidence.

Interventions to reduce NCDs

A recent systematic review, specifically examining LMICs, identified various interventions aimed at reducing adolescent fertility, including improved communication, peer education and school-based programmes.^[16] Young women in LMICs should be exposed to programmes that discourage early marriage. Allowing for cultural constraints, marriageable age legislation may be introduced for this purpose. It is well recognised that early marriage transgresses human rights conventions and inhibits social integration and educational progress; interventions to promote delayed child-bearing are important. Health-related and social support for teenage pregnancies to minimise adverse effects of young age, is essential. It is of major importance to improve child nutrition and invest in early childhood education. We suggest standardisation of definitions for rapid growth, overweight and obesity in children.

As indicated above, nutrition, obesity, diabetes, hypertension, mental disorders, early sexual debut, unprotected sex, allergies, exposure to pollutants, indoor open stoves, and behavioural factors such as lack of exercise and diet, substance abuse, injuries and violence, and sexually transmitted diseases, are especially important for public policy and innovative prevention and treatment programmes. The interventions to minimise these risk factors are available from a number of articles,^[2,3] and others are mentioned below.

To provide the wider context for these necessarily focused biomedical indicators, a number of relevant biosocial factors detected during puberty and adolescence must be assessed to determine the strength of their association along the pathway to development of NCDs later in life. There remains a gap in the scientific evidence linking clinical entities to the subsequent development of specific NCDs. The NCDs in SA and other high-prevalence countries should be placed in the context of the prevailing HIV epidemic. It is possible that ARV treatment also has a bearing on NCDs. A range of problems, including prevalence of anaemia, early sexual debut and unprotected sex, allergies, exposure to pollutants and indoor open stoves, should be included in the assessment.

Useful investigations to diagnose the common risk factors for NCDs

Clinicians should routinely screen adolescents for NCD risk factors and should ask questions relating to substance use, sexual behaviour, diet, level of physical activity and mental health status. Healthcare providers should be alert to mental health problems and behaviours. Counselling and information should be provided on reducing the risk of developing NCDs in adulthood. This should include information on healthy lifestyles, i.e. increasing physical activity, a nutritious diet, and reducing intake of salt, sugar, *trans* fats and junk food. Effective communication with adolescents requires confidentiality, consulting the patient alone, tailoring the discussion to the individual, and understanding the role of parents/caregivers.

Clinical assessments and blood samples will be needed, such as weight and height, waist circumference and blood pressure measurements. Abdominal ultrasound for subcutaneous and visceral fat determination is useful for establishing overweight and obesity (set out below). Samples should be assayed for the following biomarkers: fasting insulin, fasting blood glucose, highly sensitive C-reactive protein, and a lipogram. If these pathways are identified, and it is assumed they indicate an individual on the pathway to the NCDs of interest, prevention and therapy can be addressed.

The list of biomarkers is given below. The choice of NCDs possibly prevalent in SA can be gauged from the burden of disease in this country. There is emerging evidence that exposure to various challenges, especially environmental and nutritional ones, but possibly also infection and other factors during fetal life, are associated with health outcomes later in life.^[10] However, less is known about the evolution of exact biomarkers and specific NCDs. Pre- and postnatal growth patterns should be ascertained, as these are associated with the timing of the menarche.^[11] As there are well-established interactions between nutrition and immune responses, these interactions should form part of the investigations. These factors have implications for interventions and behavioural change, and may even extend to healthy ageing.

Established criteria may be used to select specific biomarkers to define risk, and describe clinical and biochemical characteristics to diagnose individual NCDs.

Puberty is determined by a validated self-assessment protocol (from birth-to-10 study, using Tanner's stages to assess pubertal development).^[17] Predetermined, established clinical and biochemical criteria are used to diagnose the individual NCDs. Methods used for the different aspects of adolescence are the following: mood disorders; household socioeconomic status; education/employment/household relationships; and the Snyder's trait hope scale, which can

be adapted from the Life Course, Developmental Pathways for Health Research Unit, University of the Witwatersrand, Johannesburg, SA.^[18]

Blood samples to establish the presence and trends of biomarkers over this critical segment of the life course should be taken after permission has been obtained, around the onset of puberty and again 2 - 3 years later, and during early and late adolescence (at about 14 and 19 years of age). Mobile technology can be employed to ensure reliable collection and retrieval of blood samples, and analysis of the results.

Biomarkers of NCDs

- **Diabetes mellitus:** fasting blood sugar; urine Dipstix for glycosuria
- **Hypertension:** urine Dipstix for albuminuria
- **Mental health** (psychological) disorders: history, including substance abuse, depression and suicidal tendencies; clinical examination; and psychological tests, if indicated
- **Obesity:** height, weight, body mass index and waist circumference; questionnaire on physical activity; fasting insulin; lipogram; highly sensitive C-reactive protein
- **Chronic lung disease:** history; chest radiograph, if indicated
- **Cancer:** full blood count; erythrocyte sedimentation rate; exclusion of haematological cancers and chronic anaemias.

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