

Alcohol metabolism and health hazards associated with alcohol abuse in a South African context: a review

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Abstract

The World Health Organization recently stated that alcohol consumption is the fifth leading cause of death worldwide and that intakes are increasing, especially in developing countries. Alcohol-related effects are major threats to global public health. There is growing recognition of an association between alcohol abuse and a host of health and social problems in many parts of the world. In South Africa, a developing country with a rapidly growing economy, available evidence shows that alcohol is a leading risk factor for mortality and morbidity, and hence a significant contributor to the burden of disease. The observed pattern of binge drinking of about a third of South African drinkers is of concern. In addition to physical dependence on alcohol, other psychological, genetic and social factors may contribute to the development of alcohol-related diseases. To develop a relevant, integrated and coherent strategy to address alcohol use, misuse and abuse in South Africa, we need a much better understanding of the metabolism of alcohol, and how the metabolic products and changes associated with alcohol abuse ultimately lead to biological health hazards. This review offers a broad understanding of the metabolism of alcohol and the biological health hazards associated with its abuse. Levels of foetal alcohol syndrome in South Africa are the highest ever recorded, and hence this review will separately address teratogenic effects associated with abuse.

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Introduction

Alcohol (ethanol) containing beverages are one of the most consumed beverages in Africa.¹ Ethanol, also called ethyl alcohol, has an energy value of 29.2 kilojoules/gram (7.1 kilocalories/gram),² and is made by fermenting and then distilling starch and sugar crops (maize, sorghum, potatoes, wheat, grapes, sugar cane, and even cornstalks, and fruit and vegetable waste).

There are large individual variations in the absorption, distribution and elimination of alcohol.³ Once absorbed, alcohol spreads throughout the body water (alcohol moves easily through cell membranes). The appearance of alcohol in the blood is not related only to the amount of alcohol consumed, but also to various factors affecting alcohol metabolism. These include gender, concentration of alcohol in the beverage, body composition, medication use, genetics, ethnic variations in alcohol metabolism, and the amount and type of food consumed prior to alcohol consumption.³

Most of the ingested alcohol is readily absorbed unchanged from the gastrointestinal tract and is one of the few substances readily absorbed from the stomach. Since alcohol is toxic in high amounts, the body attempts to get rid of it as quickly as possible by excreting the unchanged ethanol, or its metabolites.⁴

Most of the ingested ethanol is metabolised in the liver,⁴ although a small amount is metabolised as it passes through the gut. Two major enzyme systems, namely the oxidative and non-oxidative pathways, mediate the initial phase of ethanol metabolism.^{4,5}

In 2004 the World Health Organization (WHO)¹ estimated that about two billion people worldwide consume alcoholic beverages and 76.3 million have diagnosable alcohol disorders. Thus the global burden of alcohol abuse both in terms of mortality and morbidity is considerable throughout the world.¹ South African drinkers are among the leading consumers of alcohol in the world. What is of greater concern is that the majority of those reported to drink consume huge amounts of alcohol (20 litres of absolute alcohol per drinker per year),⁶ characterising a condition termed 'binge drinking'. The major adverse health effects associated with alcohol abuse are divided into biological health hazards (alcoholic liver disease, alcoholic pancreatitis, cancers, malnutrition, cardiac disorders, gastric complications, neurological disorders) and teratogenic effects.

In this paper we review the metabolism of alcohol and the biological health hazards associated with alcohol abuse in a South African context.

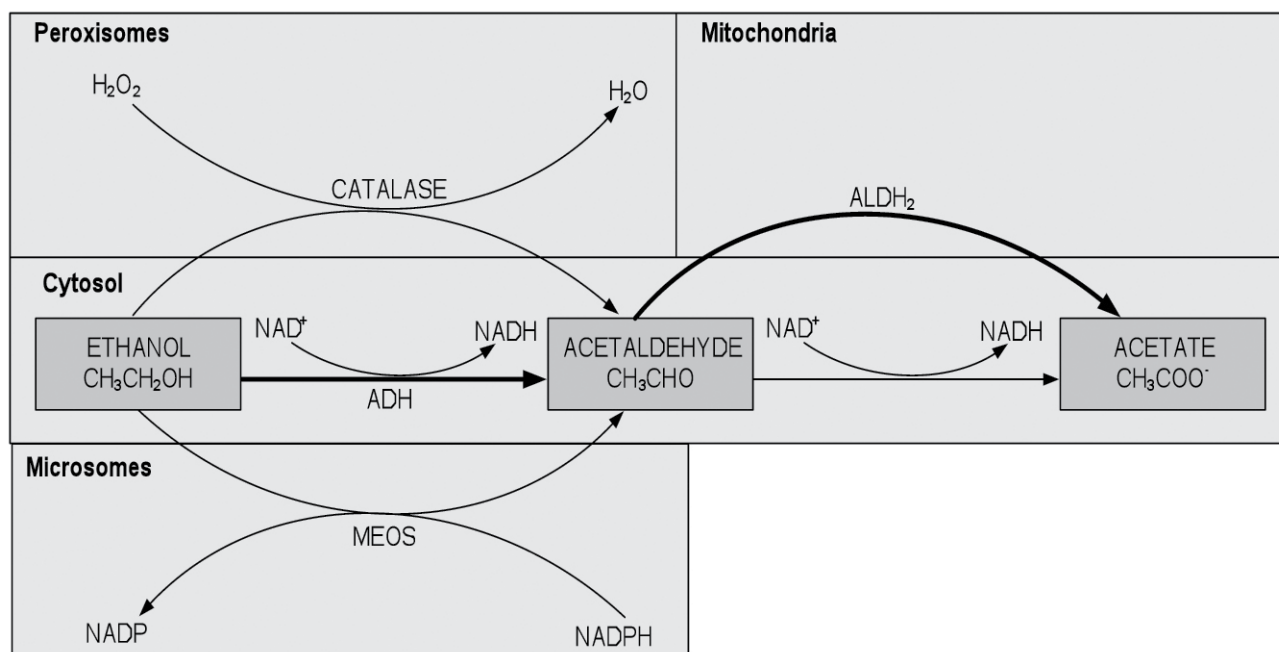


Figure 1: Metabolism of ethanol

ADH: alcohol dehydrogenase; ALDH₂: acetaldehyde dehydrogenase; H₂O: water; H₂O₂: hydrogen peroxide; MEOS: microsomal ethanol oxidising system; NAD⁺: nicotinamide adenine dinucleotide; NADH: reduced nicotinamide adenine dinucleotide; NADP: nicotinamide adenine dinucleotide phosphate

Alcohol metabolism

Alcohol is metabolised via oxidative and non-oxidative processes. The oxidative metabolism of alcohol is a chemical process in which oxygen is used to make energy from ethanol, whilst in non-oxidative metabolism this is accomplished in the absence of oxygen. Oxidative metabolism is accomplished by alcohol dehydrogenase (ADH), the microsomal ethanol oxidising system (MEOS), the catalase enzyme located in the peroxisomes, or first-pass metabolism. First-pass metabolism is defined as the metabolism of orally administered alcohol by gastrointestinal and hepatic enzymes, resulting in a significant reduction of the amount of unmetabolised alcohol reaching the systemic circulation.

Oxidative metabolism of alcohol

In the hepatocyte there are three oxidative pathways responsible for ethanol metabolism (see Figure 1) and these pathways are located in three different compartments: (1) ADH and members of the cytochrome P450 system (predominately CYP2E1 [cytochrome P450 monooxygenases]) located in the cytosol,^{5,7,8} (2) the MEOS situated in the endoplasmic reticulum, and (3) catalase located in the peroxisomes. In each of these systems pathways ethanol is metabolised to the highly reactive metabolite acetaldehyde. Due to the toxicity of acetaldehyde, the body quickly converts it to acetate in a second oxidation step by mitochondrial acetaldehyde dehydrogenase (ALDH). Finally, the acetate produced in the liver is released into the blood and it is oxidised by peripheral tissues via the Krebs cycle to carbon dioxide, fatty acids and water.⁹

The alcohol dehydrogenase (ADH) system

Human ADH is a zinc-containing enzyme located almost exclusively in the cytosol of cells. The highest ADH concentrations (approximately

80–90% of the total ADH activity in human tissue) are found in the liver. ADH activity has also been detected in other tissues such as the gut, kidneys and lungs. For the ADH reaction, oxidised nicotinamide adenine dinucleotide (NAD⁺) is needed, and NADH (the reduced form of NAD⁺) is produced in the cytosol. This results in an increased NADH/NAD⁺ ratio in the cytosol, with a marked shift in the redox potential.¹⁰ This redox imbalance is responsible for a series of metabolic changes, causing damage to various organs. Acidosis is increased by hyperlactacidaemia and this reduces the capacity of the kidney to excrete uric acid, leading to hyperuricaemia (see Figure 2).

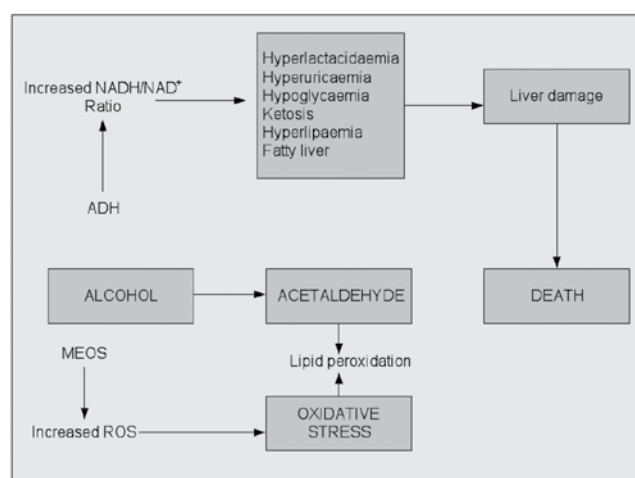


Figure 2: Metabolic changes (hepatic) associated with alcohol metabolism

ADH: alcohol dehydrogenase; MEOS: microsomal ethanol oxidising system; NAD⁺: nicotinamide adenine dinucleotide; NADH: reduced nicotinamide adenine dinucleotide; ROS: reactive oxygen species

The increased NADH/NAD⁺ ratio also leads to an increase in the concentration of α -glycerophosphate, which in turn favours the deposition of triglycerides in the liver. Furthermore, excess NADH also favours fatty acid synthesis and accumulation in the liver in the form of triglycerides. The mechanisms by which this is thought to occur are increased hepatic synthesis, decreased hepatic lipoprotein secretion, a greater mobilisation of fatty acids from adipose tissue favouring their hepatic uptake, and a decrease in fatty acid oxidation.¹¹ In individuals with depleted glycogen deposits or those who have pre-existing abnormalities in carbohydrate metabolism, alcohol intoxication may cause severe hypoglycaemia due to a blockage of gluconeogenesis by the increased NADH/NAD⁺ ratio.¹¹

Microsomal ethanol oxidising system (MEOS)

The MEOS constitutes a second pathway by which alcohol is oxidised. MEOS shares many properties with other microsomal metabolising components, such as cytochrome P-450, reduced nicotinamide adenine dinucleotide phosphate (NADPH) and oxygen. An increase in MEOS activity is usually due to chronic alcohol consumption and this in turn affects CYP2E1, which is the ethanol-inducible form of cytochrome P-450.¹² This phenomenon could be responsible for the metabolic tolerance of alcoholics to ethanol. Although CYP2E1 has a high capacity for metabolising ethanol, it also has the capacity for activating other hepatotoxic agents,¹² consequently contributing to liver damage. Furthermore, the high redox potential of CYP2E1 for nicotinamide adenine dinucleotide phosphate (NADP) as a cofactor leads to the formation of free oxygen radicals, oxidative stress and lipid peroxidation,¹³ as indicated in Figure 2. Apart from the obvious consequences of oxidative stress on cardiovascular disease (CVD), atherosclerosis, diabetes and cancers, it also activates the Kupffer cells. Activation of these by oxidative stress increases the expression of cytokines, such as tumour necrosis factor and interleukins, which in turn lead to the activation of stellate cells with consequent increases in collagen synthesis, favouring alcoholic liver disease.¹⁴

Catalase oxidative system

The third oxidative pathway in which ethanol is converted to acetaldehyde is by means of the enzyme catalase present in peroxisomes of the liver. Catalase, however, plays a very small role in alcohol metabolism.⁵ *In vitro* catalase is capable of oxidising ethanol in the presence of a system that generates hydrogen peroxide, but physiologically the rate of alcohol metabolism by this system is reduced by the addition of fatty acids. The β -oxidation of fatty acids is inhibited by the NADH generated during alcohol metabolism by ADH, and thus inhibition of hydrogen peroxide production occurs, leading to significantly diminished rates of peroxidation of alcohols via catalase.¹⁵

First-pass metabolism

There is ample evidence that the stomach plays a role in the oxidative metabolism of ethanol. The presence of class I, III and IV ADH isoenzymes for ethanol in the human stomach has been reported.¹⁶⁻¹⁸ Intravenous administration of a low dose of ethanol results in higher

blood ethanol concentrations than an oral intake of the same amount of ethanol. This has been well demonstrated in human and rat studies, and indicates that part of the ingested ethanol will be metabolised before reaching the peripheral blood, as absorption of ethanol from the gastrointestinal tract is virtually unprohibited. This is known as first-pass metabolism and can theoretically occur in the liver, stomach or intestines.^{19,20} Caballeria et al²¹ further describe evidence for first-pass metabolism. They reported ADH isoenzyme activity in the gastric mucosa and also showed that first-pass metabolism disappears in patients undergoing gastrectomy, when gastric emptying is accelerated or when alcohol is administered to the duodenum.²¹ Caballeria et al²² later confirmed this observation in gastrectomised patients. Blood ethanol concentrations were approximately the same after oral intake and after intravenous infusion of ethanol in these patients. They also showed that in healthy men intraduodenal infusion of ethanol results in significantly higher blood ethanol concentrations than an oral intake of ethanol, which also suggested that by bypassing the stomach first-pass metabolism is reduced. Colonic bacteria (human flora) have been shown to contain high ADH activity and produce acetaldehyde after ethanol breakdown.²³ A bacteriocolon pathway for alcohol metabolism has been suggested, with the acetaldehyde produced ultimately being broken down to acetate by bacterial ALDH.²⁴ Due to low activity of the ALDH in the colon, accumulation of acetaldehyde can occur during ethanol oxidation. This is one of the factors that contribute to the pathogenesis of alcohol-related gastrointestinal disease.²⁴

Ethnic variations in gastric ADH levels have been reported and are implicated to contribute to the differences observed in ethnic alcohol tolerance and toxicity. Most Caucasians are reported to have α -ADH while most Asians have very low or undetectable activity, causing the first-pass metabolism to be significantly reduced in the latter population group.²⁰ Frezza et al²⁵ reported that the activity of stomach ADH is lower in women than in men. However, this result is not consistent, as other studies have reported no significant differences between men and women,²⁶ and in individuals below the age of 50.²⁷

Non-oxidative metabolism of alcohol

A non-oxidative pathway for alcohol metabolism in which fatty acid ethyl esters are formed from alcohol has been proposed.²⁸ Evidence for this is seen in intoxicated subjects having significantly elevated concentrations of fatty acid ethyl esters (FAEEs) in various organs, such as the brain, liver and heart, and which are thought to result in the alcohol-induced lesions in these organs.³ FAEEs result from the reaction of alcohol (ethanol) with free fatty acids. These FAEEs can be detected in serum and other body tissue after alcohol ingestion and can persist long after alcohol is eliminated. The effect of FAEEs on alcohol-induced tissue damage remains unclear.²⁸

Alcohol elimination (excretion)

Most ethanol (90–98%) is eliminated from the body by oxidation via various enzyme systems to carbon dioxide and water. The remaining ethanol is excreted by the lungs (1–5%) through expiration and 1–3% is excreted via other routes, such as urine (0.5–2.0%) and sweat (up to 0.5%).²⁹

Furthermore, increased tolerance to alcohol is displayed by chronic alcoholics. This is due to an increase in the ethanol elimination rate or metabolic tolerance, and due to the adaptation of the central nervous system to alcohol.³⁰ The causes of increased metabolic tolerance include increased ADH activity, increased mitochondrial reoxidation of NADH, a hypermetabolic state in the liver, increased microsomal oxidation and increased catalase activity.²⁴ Alcohol metabolism is also affected by the nutritional status of an individual, since malnutrition (under-nutrition) diminishes ADH activity, similar to what occurs during high alcohol consumption.³¹

Pathogenic and teratogenic effects associated with alcohol abuse

Pathogenic effects

Metabolic changes associated with alcohol abuse ultimately lead to a number of biological health hazards. These have recently been summarised by Van Heerden and Parry³² and are shown in Table I.

Alcohol affects the central nervous system of the body more so than any other system. Furthermore, ethanol acts as a central nervous system depressant.³³ Normal brain development in humans can be impaired by the consumption of large amounts of alcohol. An unusual complication of acute alcohol ingestion is Wernicke's encephalopathy (WE). It is a syndrome characterised by acute confusion, ataxia and eye movement abnormalities (ophthalmoplegia and nystagmus).^{34,35} It is caused by an inadequate intake or absorption of thiamine, causing lesions in the medial thalamic nuclei, mamillary bodies, periaqueductal and periventricular brainstem nuclei, and superior cerebellar vermis.³⁵ Failure to treat WE leads to an irreversible chronic form of the disease (Korsakoff psychosis), which is characterised by severe short-term memory loss.^{35,36} Twenty-five percent of chronic alcoholics may have peripheral neuropathy, including autonomic disorders,³⁷ and nearly half may have myopathy.³⁸

A common after-effect of ethanol intoxication is the unpleasant sensation known as a hangover, which is partly due to the dehydrating effect of ethanol. Ethanol is known to mitigate the production of the antidiuretic hormone,³⁹ which is a hormone that acts on the kidney, favouring water reabsorption in the kidneys during filtration.

Alcohol affects many organs, most notably the liver, causing both acute and chronic liver disease.^{2,4} In the liver, ethanol can lead to three distinct pathological disorders, namely a fatty liver (alcohol-associated hepatic steatosis), alcoholic hepatitis and cirrhosis. Alcohol-associated hepatic steatosis is the most common form of liver injury but it is reversible with abstinence.^{40,41} Alcoholic hepatitis is characterised by inflammation of the liver, and cirrhosis by progressive hepatic fibrosis. These are the more serious forms of alcoholic liver disease.⁴²

Table I: Summary of health hazards associated with alcohol abuse*

Nervous system	Acute intoxication: 'hangovers' and blackouts Persistent brain damage: Wernicke's encephalopathy, Korsakoff's syndrome, cerebellar degeneration
Cerebrovascular disease	Strokes, particularly in young people Subarachnoid haemorrhage Subdural haematoma following cranial injury Withdrawal symptoms: tremor, hallucinations, fits Nerve and muscle damage: weakness, paralysis, 'burning sensation in extremities'
Liver	Fatty infiltration Alcoholic hepatitis Cirrhosis leading to liver failure Liver cancer
Gastrointestinal system	Acid reflux Tearing/rupture of oesophagus Cancer of the oesophagus Gastritis Aggravation and impaired absorption of food Chronic inflammation of the pancreas which may lead to diabetes and malabsorption of food
Nutrition	Malnutrition due to reduced food intake, toxic effects of alcohol on the gastrointestinal tract, impaired metabolism leading to weight loss, obesity – particularly in the early stages of heavy drinking
Heart and circulation	Arrhythmias Hypertension Chronic damage to cardiac muscle leading to heart failure
Respiratory system	Pneumonia from inhalation of vomit
Endocrine system	Increased production of cortisol leading to obesity, acne, hirsutism, hypertension Condition mimicking hyperthyroidism, with weight loss, anxiety, palpitations, sweating, tremor Severe hypoglycaemia resulting in coma Intense facial flushing in diabetes when using chlorpropamide
Reproductive system	Men: loss of libido, impotence, testicular and penile shrinkage, loss of sexual hair Women: menstrual irregularities, shrinkage of breasts and external genitalia
Foetal development and teratogenic effects	Foetal alcohol effects: alcohol-related birth defects, alcohol-related neurodevelopmental disorders, and foetal alcohol spectrum defects

*Adapted from Van Heerden and Parry³²

The fibrogenic effects of ethanol and its metabolites on hepatic stellate cells (HSC)^{42,43} include changes in cellular activation such as increased collagen and deoxyribonucleic acid (DNA) synthesis,⁴⁴ increased expression of α -smooth muscle actin and depletion of retinyl palmitate.⁴⁵ These manifestations ultimately increase fibrosis. Ethanol and acetaldehyde additionally increase fibrosis by increasing autocrine transforming growth factor beta-1 (TGF β -1) expression in HSCs. In turn, TGF β -1 is able to upregulate type 1 collagen gene expression.^{46–48}

Oxidative stress tends to increase in both chronic and acute ethanol administration.⁴⁹ Within the hepatocyte, ethanol-induced oxidative stress occurs acutely through ethanol metabolism or chronically following the induction of CYP2E1.^{2,50} CYP2E1 has been shown to

generate ROS, including the superoxide anion, hydrogen peroxide and hydroxyethyl free radicals.^{2,51} Oxidative stress further activates HSC in alcoholic liver fibrogenesis, as human HSC collagen synthesis is induced by 4-hydroxynonenal, one of the common lipid peroxidation by-products.⁵² The accumulation of NADH through ethanol metabolism promotes steatosis by stimulating the synthesis of fatty acids and opposing their oxidation. Through the reduction of pyruvate, elevated NADH levels also increase the levels of lactate, which stimulate collagen synthesis in myofibroblasts.² The fatty liver is largely a result of the accumulation of acetyl CoA, which in turn favours fatty acid synthesis and inhibits the Krebs cycle.

The energy per gram that ethanol provides exceeds that of carbohydrates and proteins, and could account, on average, for half an alcoholic's (heavy drinker's) kilojoule intake.² Alcohol displaces nutrients like folate, thiamine and other vitamins, causing malnutrition.² Inadequate intake and malabsorption due to gastrointestinal complications such as pancreatic insufficiency and impaired hepatic metabolism of nutrients causes secondary malnutrition.²

Alcohol is also known to have a carcinogenic effect and is classified as a Group 1 carcinogen by the WHO.⁵³ Although some studies have failed to establish a direct relationship between alcohol and cancer there is a strong indication that it may act as a carcinogen by enhancing the carcinogenic effects of other chemicals like tobacco. Garro and Lieber⁵⁴ report that alcohol enhances the ability of tobacco to stimulate tumour formation in rats. In humans, the risk for mouth, tracheal and oesophageal cancer is 35 times greater for individuals who both smoke and drink than for people who neither smoke nor drink.⁵⁵

Alcohol also has adverse effects on the human reproductive system. In males, alcohol causes atrophy of the seminiferous tubules, loss of sperm cells and increased production of abnormal sperm.⁵⁶ Alcohol also has an adverse effect on testosterone synthesis and secretion,^{57,58} and is regarded as a testicular toxin.⁵⁹ Alcohol also reduces the sperm quality (deterioration of sperm concentration, output and motility).^{60,61} In women, alcohol abuse is also associated with early menopause.⁶² The mechanisms underlying alcohol's disruption of the female menstrual cycle and anovulation are the temporary elevation of oestradiol⁶² and testosterone,⁶³ decreased levels of insulin-like growth factor 1 and reduced or absent pituitary luteinising hormone, respectively.⁶⁴ Additionally, alcohol abuse causes a variety of reproductive disorders, ranging from irregular menstrual cycle⁶⁴ to the absence of ovulation and infertility.⁶²

Teratogenic effects

Alcohol is the most well-known teratogen, worldwide.⁶⁵ Of the many substances of abuse (e.g., cocaine, heroin, marijuana), alcoholic beverages produce the most serious neurobehavioural effects in an unborn foetus.⁶⁵ This ultimately burdens the economy and the health sector as a whole. It is already well known that alcohol consumption by pregnant women increases their chances of miscarriage or premature delivery,³² and the chances of the baby having low birth weight, congenital malformations^{32,66,67} and foetal alcohol syndrome (FAS).^{66,68}

Expression of FAS and the related disorders appears to be dependent on other component causes.⁶⁹ Burd et al⁶⁸ describe FAS as a multi-element causal chain of interacting factors commonly including smoking, poor diet, poverty, low maternal education, heavy drinking, binge alcohol use, being unmarried, physical abuse and increased parity. The pattern and amount of alcohol consumed, timing of intake, developmental stage of the foetus at the time of exposure and socio-behavioural risk factors are pivotal determinants of birth outcome.⁶⁹ The full FAS phenotype manifests in children whose mothers had a history of chronic, daily, heavy alcohol use or frequent, heavy, intermittent alcohol use (binge drinking).⁶⁹

FAS can develop at any stage of the pregnancy, however, it is during the first trimester that the foetus is most vulnerable to alcohol damage.⁶⁹ In some cases, alcohol exposure during pregnancy does not always lead to a full manifestation of the syndrome. The related disorders that develop are described as foetal alcohol effects, alcohol-related birth defects, alcohol-related neurodevelopmental disorders or foetal alcohol spectrum defects.^{66,70–72} These manifestations of the syndrome are widely variable and are six to eight times more prevalent than full-blown FAS.⁷⁰

The mechanisms by which excess ethanol consumption results in a toxic effect on the developing foetus are becoming increasingly clear.⁷³ Ethanol and acetaldehyde both cross readily through the placenta, depriving the developing foetal brain of both nutrients and oxygen. When ethanol crosses the placenta, foetal blood ethanol rises until it reaches equilibrium with maternal blood ethanol concentrations.⁷⁰ The harmful effects of alcohol in the foetus are, however, more pronounced than in the alcohol-consuming mother, as the foetus is smaller in comparison to the blood alcohol levels and its detoxification system is not yet developed. Hence the ethanol remains longer in the foetal blood, prolonging the damage to its system.⁷³ Ethanol has also been shown to reduce neural cell progenation in the central nervous system of the developing foetus and cause cell death by apoptosis.⁷⁰ Acetaldehyde is also highly toxic to the developing foetus. Acetaldehyde is implicated in impairing DNA methylation, resulting in intra-uterine growth retardation, and hence lower birth weight and height, facial feature abnormalities (underdeveloped maxillary region, small fissures between the lids of the eyes); neurodevelopmental abnormalities, such as microcephaly; congenital abnormalities of the joints and heart; and persistent mental retardation.³²

Discussion and conclusion

Metabolic changes associated with alcohol abuse ultimately lead to a number of biological health hazards as mentioned. Ingestion of alcohol during pregnancy can have severe effects on the developing foetus. Over time, alcohol abuse has become a major public health concern, and there is an increasing awareness that alcohol-related problems constitute serious problems for not only individuals, but also families, communities and economies. This pattern of irresponsible drinking in South Africa has increased public health and social problems, making the reduction of alcohol intake a priority for policy

makers. There is, therefore, an urgent need to make a paradigm shift with regards to policies on alcohol use. Major problems that current policy makers face are (a) how to accurately quantify whether drinking patterns in a particular community are comparatively heavy, thus exacerbating health and psycho-socioeconomic problems, and (b) how to curb or overcome dangerous drinking patterns when they arise.

The WHO has recently stated that alcohol consumption is one of the leading causes of death worldwide and that intakes are increasing alarmingly in developing countries.⁶ According to the database of the WHO, fewer South Africans drink compared to people in 44 other countries. What is disturbing, however, is the pattern of drinking in South Africa; those reported to drink consume huge amounts of alcohol (20 litres of absolute alcohol per drinker per year). The observed pattern of binge drinking in about a third of South African drinkers is of serious concern.^{74,75} Alcohol misuse and abuse in South Africa is responsible for at least half of the 14 000 annual reported road deaths. It is also known that this misuse is associated with crime,⁷⁶ violence, high sexual risk behaviour, family disruption, and a host of individual and societal problems.⁷⁵ Binge drinking also results in a loss of the cardio-protective effects associated with alcohol, and an increase in micronutrient deficiencies,⁷⁷ both of which are highly prevalent in the South African population.⁷⁸ The observed pattern of drinking among South Africans can also lead to alcohol dependency and addiction, further exacerbating this problem. South Africans are somewhat prone to developing alcohol-related problems, largely due to the increasing economic hardships that usually accompany alcohol abuse.

The causal relationship between poverty and alcohol abuse can be compared to that of the egg and the chicken: which one comes first? The following results were obtained in a study that investigated the short- and long-term effects of poverty and unemployment on alcohol abuse using structural equation modelling to better understand the observed conflicting relationships among them: (a) increased poverty causes increased alcohol use and alcohol problems, and (b) recent unemployment decreases alcohol use while longer unemployment increases it. It was concluded that the effect of unemployment on alcohol abuse changes direction with time, and thus both cross-sectional and longitudinal data are required to assess any meaningful relationship between them.⁷⁹ Thus unemployment and poverty could be the leading causes of alcohol abuse in South Africa, since these two variables investigated are high in this sub-Saharan country.

The “French paradox” is a phenomenon that describes the low incidence of CVD in France, despite a general dietary pattern high in saturated fats.⁸⁰ Several factors have been proposed to explain possible mechanisms by which alcohol could reduce CVD and atherosclerosis.^{81–84} These include the effects of low/moderate alcohol consumption on lipid and lipoprotein profiles, haemostatic function, the cardiovascular system, insulin sensitivity, homocysteine and oestrogen levels.⁸⁵ Although the beneficial effects of moderate alcohol consumption remain stimulating, the levels of alcohol abuse among South African drinkers are of serious concern. Conclusively,

more research is needed, particularly for this African population, to determine whether the French paradox is also applicable to this population before promoting the health benefits of moderate alcohol intake. The health hazards pertaining to this population also need to be weighed by policy makers, to assist them in their efforts to try to devise a comprehensive strategy to overcome abuse and dependency, while still retaining the attributed health benefits from alcohol consumption.

The final guideline proposed by the Food-Based Dietary Guidelines Work Group in 2001 is “If you drink alcohol, drink sensibly”, and this addresses the use of alcohol in South Africa.³² However, considering the current abuse of alcohol in South Africa, this guideline might need to be re-examined. Currently, total abstinence from alcohol may be the only solution for this country in crisis, but the applicability of such a goal could be far-fetched and probably impossible to attain. Banning alcohol will surely lead users to turning to ingenious, exploitative and criminal methods of obtaining alcohol-containing beverages,³² and will increase the number of people brewing homemade alcohol concoctions. Therefore, the solution seems to be in educating the public to drink moderately or sensibly.

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