Chapter

Exploring Cardiovascular Diseases Treatment in Africa

Masebata Ramathebane, Lineo Maja and Molungoa Sello

Abstract

This topic explores current treatments of cardiovascular diseases; what treatment outcomes emanate from current drug treatment. It also covers the reasons why many studies show poor treatment outcomes. It deals with adverse drug reaction and their drug management where necessary. Current cost effective interventions including prevention strategies including drug treatments are discussed. Issues relating to patients' knowledge about medication and benefits of adhering to treatment, method of delivery of patient information, are dealt with in detail. It highlights the issues of barriers to adherence to drug treatment and non-drug life style modifications. It also deals with dispensing models that encourage adherence to medication. It explores reasons for late diagnosis and treatment. This chapter will be informed by current studies published in Africa and elsewhere.

Keywords: treatment, adherence, knowledge, cost – effective analysis, dispensing models, late diagnosis, treatment outcomes

1. Introduction

According to the World Health Organization (WHO), Non-Communicable Diseases (NCDs) refers to the non-infectious and the non-transmissible medical conditions or diseases. These diseases generally progress slowly and are of long duration. The prevalence of NCDs and risk factors varies considerably between countries, urban/rural location and other sub-populations [1]. The four main types of NCDs are cardiovascular diseases, cancers, chronic respiratory diseases and diabetes. Globally, NCDs are the leading causes of deaths; accounting for over 70% of world deaths (56 million in 2015). Some of these deaths are regarded premature as 27% of these deaths occur in people aged between 30 and 70 years. It has been found that 80% of these premature deaths occur in the low-and middle-income countries.

The World Health Organization estimates that mortality due to NCDs will rise by 17% globally in the next decade; while the African region only will experience 27% increase by 2030. Some African countries such as Algeria (76%), Egypt (84%), Libya (72%), Mauritius (89%), Morocco (80%), Sao Tome and Principe (55%), Seychelles (81%), South Africa (51%), Sudan (52%) and Tunisia (86%) have already witnessed over 50% deaths attributed to NCDs since 2018 [2]. Deaths solely attributed to cardiovascular disease (CVD) are the leading almost globally of all other NCDs. The implications to the increasing prevalence of NCDs are that NCDs will soon be the leading causes of illness, disability and death (including premature deaths) in Africa.

There are eight behavioral and physiological risk factors associated with high and continually increasing burden of NCDs, namely, tobacco use, harmful use

of alcohol, consumption of unhealthy diet, physical inactivity, overweight and obesity, high blood pressure, raised blood glucose and raised total cholesterol in blood [3]. Since 2011, NCDs have been elevated onto global, regional and national development agendas through a series of political commitments. These include the 2011 United Nations (UN) Political Declaration on NCD Prevention and Control, 2011 Brazzaville Declaration on NCD Prevention and Control in the WHO African Region, WHO Global NCD Action Plan 2013–2020, 2025 Global NCD targets and 2015 Sustainable Development Goals [4, 5].

With the above global and regional background of NCDs and initiatives, the aim of this chapter is to.

2. Cardiovascular diseases

Cardiovascular diseases (CVDs) refers to a group of disorders affecting the heart and the blood vessels supplying the heart itself (coronary heart disease, rheumatic heart disease, and congenital heart disease), the brain (cerebrovascular disease), the arms and legs (peripheral artery disease, deep vein thrombosis and pulmonary embolism) [6]. Cardiovascular diseases are usually associated with a build-up of fatty deposits inside the arteries (atherosclerosis) and increasing the risk of blood clotting and vessel damage; leading to heart attacks and strokes [7]. Depending on the organ by which blood vessels are damaged, CVDs are also associated with eye, brain, kidney and heart diseases.

More often, CVDs may not have symptoms relating to underlying disease to blood vessels; but heart attack and stroke as usually the first warning of underlying CVD. Heart attack, also known as myocardial infarction, occurs because of failure to supply oxygen-rich blood to a certain part of the heart muscle due to blockade of the blood vessels supplying that part; leading to muscle cell death in that oxygen deprived area (infarct) [8]. Heart attack manifests as sharp chest pain and discomfort at the center of the chest; radiating to the arms, left shoulder, elbows, jaw and back. During the attack episode, the person may also have trouble in breathing. According to Centers for Disease Control, similar to heart attack, stroke occurs because of failure to supply oxygen-rich blood to a certain part of the brain due to blockade of the blood vessels supplying that part; and bursting of the blood vessel in the brain; leading to death of that part of the brain that is deprived of oxygen-rich blood [9]. Strokes are characterized by sudden symmetrical weakness of the limbs, face. The person experiences confusion, difficulty in speaking, vision, walking and there is loss of balance, coordination and unconsciousness may happen.

According to Plotnikoff and Dusek, hypertension (HTN) is the most important risk factor to getting ill and dying from a CVD [10]. The World Health Organization defined hypertension, also known as high blood pressure (BP), as the condition in which the blood vessels have persistently high pressure. The blood pressure is increased by the sympathetic nervous system and the renin-aldosterone-angiotensin system (RAAS). A drop in blood pressure is detected by pressure-sensitive receptors (baroceptors) which send signals to the cardiovascular centers in the spinal cord. This prompts a reflex response of increased sympathetic nervous system activity on the heart and blood vessels; resulting in increased cardiac output and vasoconstriction. The baroceptors in the kidneys respond to a decrease in blood pressure by releasing the enzyme hormone called renin. Renin converts angiotensinogen component of blood to angiotensin I; that ultimately gets converted to angiotensin II by angiotensin converting enzyme (ACE). Angiotensin II is a potent vasoconstrictor, constricting both arteries and veins. The activity of both sympathetic nervous system and RAAS result in increase in blood pressure [11].

The seventh report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7) define a normal BP as less than 120 mm Hg systolic and less than 80 mm Hg diastolic. If left uncontrolled and untreated, high blood pressure can result in an enlargement of the heart, heart attack, heart failure and eventually to death. Hypertension is also associated with loss of vision, cognitive and erectile dysfunction. The higher the pressure above normal, the greater is the risk of complications [12]. Hypertension is the culprit with end-organ damage in terms of all CVDs (stroke, kidney failure and peripheral vascular disease).

3. Current treatments of CVDs

Despite advances made to the treatment and prevention, CVDs are still the leading causes of death of all NCDs. Nevertheless, majority of CVDs are preventable with just lifestyle changes alone. An integrative approach has been adopted to the prevention and treatment of CVDs; as the approach address the root causes influenced by lifestyle. The approach acknowledges that the great value and potential life-saving benefits of modern pharmacology and procedures cannot use only one approach since each has own limitation [13]. The combinatory approach allows for counteracting limitations of one approach with the other approach. The goal of treating CVDs is to improve cardiovascular health and reduce deaths from heart disease and stroke.

4. Therapeutic lifestyle changes (TLCs)

Therapeutic lifestyle changes are the foundation for non-drug management of HTN and/or CVD. These include smoking cessation, reduced intake of sodium diet, the Dietary Approach to Stop Hypertension (DASH), body weight management, moderation of alcohol consumption and physical activity. The American Diabetes Association (ADA) 2020 standards of medical care recommend that for patients with blood pressure > 120/80 mmHg, lifestyle intervention consists of weight loss if overweight or obese, DASH-style eating pattern including reducing sodium and increasing potassium intake, moderation of alcohol intake, and increased physical activity [14].

4.1 Smoking cessation

Smoking increases the risk of developing serious health problems and death. It is estimated that there are 1.1 billion people who smoke and 80% of them come from the low-to-middle income countries (LMICs). Further estimates reveal that smokers are likely to develop heart disease and stroke 2–4 times higher compared to non-smokers. The **Table 1** below is a summary of the health benefits of quitting smoking from 20 minutes to 15 years adapted from the forefront UChicago Medicine [15].

4.2 Reduced intake of sodium diet

High sodium intake, estimated at >2 grams per day which is equivalent to 5 grams of table salt per day, contributes to high blood pressure and increases risk of heart disease and stroke. If global salt intake could be reduced to recommended levels, an estimated 2.5 million deaths could be prevented [16]. In a systematic review and meta regression done on salt intake in sub-Saharan Africa, the results of the study revealed high sodium intake in many adult population (and some populations of children) above the 2 g intake recommended as the upper limit established by WHO [17].

Time of quitting smoking	Extent of body recovery
20 minutes	Heart rate and blood pressure drops
24 hours	Chance of heart attack decreases
2–12 weeks	Blood circulation improves and lung function improves
1–9 months	Cough, difficulty in breathing and sinus congestion are lowered
1 year	Risk of heart disease drops to half compared to that of a smoker
5 years	Risk of cancers of the mouth, throat, gullet and bladder are cut by half. Stroke risk is reduced to that of a nonsmoker 5 to 15 years after quitting.
10 years	Risk of lung cancer drops to half compared to that of a smoker and risk of cancer of the mouth, throat, esophagus, bladder, cervix, and pancreas decreases.
15 years	Risk of heart disease is equal to that of a non-smoker

Table 1.
Time of quitting smoking and extent of body recovery.

There is a strong content-dependent relationship between raised blood pressure and consumption of high amounts of sodium. Dietary guidelines recommend a daily intake of sodium at less than 2.3 grams in the general population and less than 1.5 grams in people with high blood pressure, diabetes, kidney disease and those aged 50 years old or more. Salt reduction initiates a decline in average blood pressure in a week time. It also improves the body response blood pressure medicines. Lowering blood pressure reduces risk of heart disease, stroke and death due to salt related CVDs.

4.3 The DASH eating plan

The pioneer trial that examined the role of diet in the management of hypertension was the DASH trial in 1997. The results of the trial revealed that after approximately 3 g sodium intake per day on both control and interventional group; within 2 weeks of the intervention, blood pressures reduced and the results sustained for another 6 weeks. Systolic blood pressure (SBP) reduced by 5.5 mm Hg and diastolic blood pressure (DBP) by 3.0 mm Hg more than the control diet [18].

The DASH eating plan entails a diet rich in fruits and vegetables (8–10 servings/day); and low-fat dairy foods (2–3 servings/day), coupled with reduced saturated and total fat [19]. DASH is a flexible and balanced eating plan that helps create a heart-healthy eating style for life. The DASH eating plan requires no special foods and instead provides daily and weekly nutritional goals. DASH eating plan recommends that the choice of foods should also be based on food that are:

- Rich in potassium, calcium, magnesium, fiber (roughage) and protein
- Low in saturated fat (animal fat) and trans-fats (from snacks)
- Lower in sodium (table salt, flavourants, spices, processed foods including water)

Globally, calories obtained from Proteins, Sugars and Fats have been increasing and those from roughage-rich foods have been declining. Consumption of processed foods continues to rise rapidly in low- and middle-income settings. This nutrition transition affects dietary patterns and nutrient intake, which influence the risk of developing NCDs.

DASH diet is one among such healthy dietary patterns, which emphasizes on;

- Consumption of fruits, vegetables and low-fat dairy foods.
- Whole grains, poultry, fish, and small quantities of red meat, sweets and drinks containing sugar.
- The increased risk of cardiovascular diseases associated with higher sodium intake (>5 g/day) is most prominent in those with high blood pressure.

4.4 Body weight management

Overweight and obesity are major risk factors for a number of chronic diseases, including CVDs such as heart disease and stroke, which are the leading causes of death worldwide. Globally, obesity is one side of the double burden of malnutrition, and today more people are obese than underweight in most regions of the world. A body mass index (BMI) over 25 kg/m^{-2} is considered overweight, and over 30 kg/m^{-2} is obese. The issue has grown to epidemic proportions, with over 4 million people dying each year as a result of being overweight or obese in 2017 according to the global burden of disease [20]. Nevertheless, modest weight losses of 5 to <10% were associated with significant improvements in CVD risk factors at one year, but larger weight losses had greater benefits [21].

4.5 Moderation of alcohol consumption

The Centers for Disease Control and Prevention (CDC) define alcohol moderation as having up to one drink per day for women and up to two drinks per day for men. The definition refers to the amount consumed on any single day and is not intended as an average over several days [22]. However, it is not recommended that that people who do not drink alcohol start drinking for any reason. Excessive alcohol intake includes binge drinking, heavy drinking and any alcohol use during pregnancy. Binge drinking corresponds to five or more drinks in men and four or more drinks in women on a single occasion, generally within two hours; while heavy drinking is defined as consuming 15 drinks or more per week for men and eight drinks or more per week in women. In 2019, top nine African countries with high alcohol consumption in liters per capita were in the order of Nigeria, Eswatini, South Africa, Lesotho, Zimbabwe, Zambia, Malawi, Ghana and Morocco [23]. Excessive alcohol consumption increases the risk of developing heart disease by increasing BP and weakening heart muscles [24].

4.6 Physical activity

Globally, lack of sufficient physical activity is the fourth risk factor to development of NCDs. While physical inactivity is attributed to prevalence of diabetes at 27%, heart diseases caused by heart vessels blockage at 30% and breast and colon cancer at 21–25%; 3.2–5 million deaths globally are associated with physical inactivity [25]. The World Health Organization defines physical activity as a bodily movement produced by muscular and skeletal body systems which require energy expenditure. In other words, physical activity encompasses all activities undertaken while working, playing, carrying out household chores, traveling, recreation; in addition to exercise activities. Physical activity is further classified as moderate- and vigorous-intensity physical activity. Also, physical activities are sub-classified as aerobic (those that engage large muscles of the hands and legs; making the

heartbeat and breathing rate to be faster than normal), muscle-strengthening (those that improve the strength, power, and endurance of your muscles) and bone-strengthening (those that strengthen feet, legs arm to support body weight) [26].

In order to gain health benefits of physical activity; it is recommended that children and adolescents should do at least 60 minutes of moderate to vigorous-intensity physical activity daily; while adults should do at least 150 minutes of moderate-intensity physical activity throughout the week, or at least 75 minutes of vigorous-intensity physical activity throughout the week. Those with poor mobility should perform physical activity to enhance balance and prevent falls, three or more days per week. The general rule is that two minutes of moderate-intensity activity counts the same as one minute of vigorous-intensity activity and the exercise should continue up to sweating [27].

Regular and sufficient levels of physical activity are attributed to the following cardiovascular benefits;

- Strengthened heart
- Reduced risk of heart attack
- Reduced risk of hypertension (high blood pressure), heart diseases, stroke, diabetes, various types of cancer (including breast and colon) and depression.
- Maintained healthy body weight control
- Reduced blood cholesterol level

5. Pharmacological treatment of CVDs in Africa

According to Rizos and Elisaf [28] hypertensive patients with African ancestry are a distinctive population of patients that presents with some unique characteristics. These patients commonly have increased incidence and early onset of hypertension and often-poor BP control. They often present at healthcare facilities with additional concomitant CVD risk factors.

The ADA 2020 standards on pharmacological interventions to CVDs recommend the following:

Patients with confirmed office based blood pressure ≥ 140/90 mmHg should, in addition to lifestyle therapy, have prompt initiation and timely titration of pharmacologic therapy to achieve blood pressure goals.

This is strongly emphasized in the African ancestry population that appropriate TLCs and combination of diuretic and/or calcium channel blocker (CCB) should be initiated promptly. In African black populations, patients receive aggressive treatment at lower BPs compared to non-African, non-black counterparts who are recommended initial combination therapy when they fit the requirement below.

Patients with confirmed office based blood pressure ≥ 160/100 mmHg should, in addition to lifestyle therapy, have prompt initiation and timely titration of two drugs or a single-pill combination of drugs demonstrated to reduce cardiovascular events in patients with diabetes.

Treatment for hypertension should include drug classes demonstrated to reduce cardiovascular events in patients with diabetes (ACE inhibitors, angiotensin receptor blockers, thiazide-like diuretics, or dihydropyridine calcium channel blockers).

Whites generally responded better to β-blockers and ACE inhibitors whereas blacks generally responded better to diuretics and calcium channel blockers [29].

Multiple-drug therapy is generally required to achieve blood pressure targets. However, combinations of ACE inhibitors and angiotensin receptor blockers and combinations of ACE inhibitors or angiotensin receptor blockers with direct renin inhibitors should not be used.

Pharmacologically ACE inhibitors, angiotensin receptor blockers and renin inhibitors act on the renin-aldosterone-angiotensin system to lower the cardiac pre- and after-load. So giving one class will be sufficient; although black populations generally respond poorly to ACE inhibitors [29].

An ACE inhibitor or angiotensin receptor blocker, at the maximum tolerated dose indicated for blood pressure treatment, is the recommended first-line treatment for hypertension in-patients with diabetes and urinary albumin-to-creatinine ratio ≥ 300 mg/g creatinine or 30–299 mg/g creatinine. If one class is not tolerated, the other should be substituted.

For patients treated with an ACE inhibitor, angiotensin receptor blocker, or diuretic, serum creatinine/estimated glomerular filtration rate and serum potassium levels should be monitored at least annually [11].

The insufficiencies associated with availability of necessary resources to monitor treatment of CVDs in Low-Middle Income Countries (LMICs) are major barriers to having integrated healthcare system with an effective data flow. These resources include technological infrastructure, financial and human resources [30].

6. Phamacovigilance of antihypertensive medications

According to the World Health Organization definition, an adverse drug reaction (ADR) is 'a response to a drug that is noxious and unintended and occurs at doses normally used in human for the prophylaxis, diagnosis, and treatment of disease, or for modification of physiological function' [26]. Also, pharmacovigilance (PV) defined by WHO as "the science and activities relating to the detection, assessment, understanding and prevention of adverse effects or any other drug-related problem [31].

In Africa, countries differ in terms of a having fully functional PV systems due to differing capacities of national medicines regulatory authorities and performance levels with respect to conducting various pharmacovigilance activities. Therefore, the system for reporting adverse drugs reactions has significant gaps to be strengthened from one country to another [32, 33]. However, in some settings within African countries, the following suspected ADRs were documented as indicated in **Table 2** [34].

Adverse drug reaction	**System organ classifications (Medical Dictionary for Regulatory Activities)**	**Drugs class(es)**
Frequent micturition	Renal and urinary disorders	Diuretics, CCBs,
Dizziness	Nervous system disorders	Diuretics, CCBs, ACEIs, Centrally acting, β-blockers, α- blockers
Headaches	Nervous system disorders	Diuretics, CCBs, Centrally acting,
Diarrhea	Gastrointestinal disorders	ACEIs
Weakness	Musculoskeletal and connective tissue disorders	Diuretics, CCBs, Centrally acting
Dry cough	Respiratory, thoracic and mediastinal disorders	ACEIs

Table 2.
ADRS, system organ classifications and suspected causal drug classes.

7. Cost effectiveness of cardiovascular disease prevention and treatment

The highest age standardized death rate from non-communicable diseases (NCDs) (779 per 100, 000) occur mostly in the African Region [35]. In sub Saharan Africa, the probability of dying from NCDs between 30 and 70 years is very high. It is also indicated that behavioral risk factors are estimated to be responsible for about 80% of coronary heart disease and cerebrovascular disease and these include tobacco use, physical inactivity, unhealthy diet and harmful use of alcohol. The cost of implementing reduction measures for tobacco control (smoke-free policies, raise tobacco taxes, package warnings, advertising bans), harmful alcohol consumption, and physical activity and diet modification is found to be low [36]. Usually these costs include media campaigns and overall program management. It is feasible to deliver cardiovascular risk reduction interventions in primary care, even in low-resource settings with non-physician health workers [37]. Currently, there are major gaps in access to these essential primary care interventions in developing countries including in those in sub-Saharan Africa [38].

There are other strategies that can be employed to prevent cardiovascular diseases. This becomes attractive to providers and can lead to policy change. According to recent surveys there is high prevalence of salt consumption [39] in South Africa. The burden of cardiovascular disease (CVD) in the same country is rising, and to address this, the government recently developed policies to reduce salt consumption in the population [39]. Population-based salt reduction strategies have been found to be a cost-effective approach to lowering the prevalence of hypertension and preventing cardiovascular disease (CVD). The cost saving for both household and providers was significantly different. The extended cost-effectiveness analysis (ECEA), which models the health gains, financial risk protection and distributional effects of public policies.

Mathers [40] states that cardiovascular diseases are responsible for about 30% of all deaths worldwide, and total deaths occurring in developing countries amount to about 80% [41]. Several authors have suggested that the combination of several preventive treatments could cut more than half the occurrence of cardiovascular disease [41–43]. The analyses have shown that two multidrug regimens of four highly effective drugs could lead to cost-effective prevention and treatment for patients with cardiovascular disease in all developing regions [44]. Wald and Law [41] specifically proposed a polypill, consisting of a statin, aspirin, a β blocker, an angiotensin-converting-enzyme inhibitor (ACEI), a thiazide, and folic acid. Suggested primary preventive therapy consists of aspirin, ACEI, calcium-channel blocker, and statin. While secondary preventive therapy consists of aspirin, ACEI, β blocker, and statin [41]. If two polypills, consisting of the same drug combinations as the primary and secondary prevention strategies, would also improve adherence, the results would be even more favorable.

In conclusion, these lifestyle modification strategies such as tobacco use control, reduction in harmful effects of alcohol, diet and physical activity and salt intake reduction are perceived to be cost-effective. Primary and secondary preventive treatments are also found to be cost-effective in preventing cardiovascular disease. This can improve on patients quality of life with cost savings.

8. Patients knowledge about cardiovascular diseases and medicines

An individual must know at least 75% of the items used in the summary variables to qualify as having acquired adequate knowledge [45]. For those patients who can achieve adequate knowledge, this should be the target for having

comprehensive knowledge. However, in cardiovascular diseases, this may be affected by age, agility, and cognitive skills particularly in elderly patients.

According to Mugomeri and colleagues, nearly 36% had inadequate knowledge about hypertension while 44% had inadequate knowledge about their medicines [46]. In this study, in total, 52.4% of the patients did not turn up for appointment dates while 64.6% failed to take their medications according to the prescription at least once. It was also stated that inadequate knowledge of antihypertensive medicines was significantly associated (P = .028) with having uncontrolled hypertension [46]. Inadequate knowledge of antihypertensive medicines is an important determinant of uncontrolled hypertension [46].

The study carried out on village health workers (VHW) in Lesotho, as health workers, determining adequate knowledge and translation of knowledge to offered services indicated that among household members aged 15 years and above, only a third was advised by the VHW to go for HIV testing [47]. Communities served by VHWs with adequate knowledge did not only demonstrate better knowledge compared to their counterparts served by VHWs with inadequate knowledge, in utilization VHWs' services were high [47]. The finding confirmed what was suggested by the literature of Hirsch-Moverman [48]. Community health workers (CHWs) form part of the primary health care system [47]. The community health workers who have adequate knowledge can play a very important role in their communities in terms of education, monitoring adherence and referrals [47]. It is therefore, recommended that training of CHW on cardiovascular diseases, treatment and prevention of complication be taken as a priority in the African continent.

Information is crucial to promote patients' knowledge which increases the sense of control, decrease emotional distress, support effective self-management, and eliminate disruptions of daily activities [49, 50]. Patients want to have control over their symptoms therefore, they need as much information as possible about their symptoms and strategies to manage these symptoms. The patient knowledge about cardiovascular diseases leads to good management of the diseases. Bandura [51] reiterates that a contributing factor to the difference in symptom self-management is a person's perceived self-efficacy. Perceived self-efficacy forms the basis of any decision to act on and is defined as the perception of one's own ability to implement behavior(s) to achieve designated types of outcomes such as symptom management. Bandura [52] further explains that perceived self-efficacy beliefs are considered to be central and influential factors in determining the course of action to be chosen, the degree of effort applied, and the perseverance to continue in the face of problems and obstacles.

Intervention is required in order to improve the knowledge of patients regarding cardiovascular diseases, hypertension, and associated medications [53, 54]. This intervention comprises of the patient essential educational topics and method of delivery of patient education. Patient education topics should include pathophysiology and etiology, symptoms and signs, pharmacological treatment, risk factor modification, diet and exercise, sexual activity, immunization, sleep and breathing disorders, adherence, psychosocial aspects and prognosis associated with certain skills or self-management behaviors [54–56]. However, patient education alone is not enough, the delivery of patient education content should consider level literacy, age, and other cognitive measures. Medium of delivery of patient education must be individualized according to the needs of the patient. Some patients benefit from one-on-one sessions, while others benefit from group sessions, some still can benefit from both sessions.

The guidelines recommend patient education and counseling targeting patient skills and behavior [57]. For patient education to be effective Meng and colleagues [53] recommend outcome and measurement strategies to enlighten on primary and secondary outcomes. The primary outcome entails self-management competencies which are measured through self-monitoring and insight, skill and technique acquisition,

and self-efficacy. While secondary outcomes are measured through self-management health behavior (symptom control, physical activity, medication adherence), health-related quality of life, and treatment satisfaction. Meng and colleagues [53] concluded that a patient-centered self-management might be more effective regarding certain self-management outcomes than a lecture-based usual care education.

Hinderlang [58] suggests that the material for patient education should be developed bearing in mind patients' cultural and language barriers. Patients' preferences should also be considered before embarking on patient education that may not be effective [59]. The content of patient education material should be broken down into concise, manageable sessions that do not overwhelm with vast amounts of facts and details and be free of medical jargon. The learning environment should be free of stress, environmental distractions, cultural conflicts, and value judgments all should be eliminated if possible. Timing should be based on the available time, attention span, and readiness for learning without rushing or taking too much time. The patients have to be actively involved in the process of learning and understand the value of the information and procedures being taught for improving the quality of his or her life [58]. Patients increasingly demand access to medical information, this has improved the patient-physician relationship and consequently improved patient care.

The disease management education plan should also include practical skills for patients and caregivers to participate in their own care. These may include:

a. Gargets to use and how to use them and what readings mean (BP machine etc.)

b. Assess patients understanding and their educational needs

c. Identify patients' barrier to receive information

d. Need to involve a caregiver

e. How to take one's own pulse;

f. How to take weight accurately (at the same time each day, with the same clothing on);

g. How to measure one's blood pressure correctly (if appropriate);

h. How to manage one's medications (which includes the name of drug; purpose it is used for when to take it, what to avoid and how it is stored)

i. Return with the remaining medicines in each clinic visit

j. How to lift one's feet to reduce swelling

k. How to manage food and fluids;

l. How to manage with stress and

m. How to keep a record of weight, blood pressure and any other information on the diary or calendar and share with healthcare workers

n. Self-referral and preferred method of communication

In summary self-efficacy and self-management of cardiovascular diseases will encourage patients to be in control of their diseases, and their treatment. This will

improve their treatment outcome. The community health workers can provide education, support and referral roles particularly in rural settings.

9. Adherence to medications

Non-communicable diseases (NCDs) are chronic diseases where adherence to medication is essential to controlling these diseases. Patients with NCDs such as cardiovascular diseases, diabetes mellitus and hypertension are put on long-term therapy to manage their conditions. The health outcomes of these patients depend mainly on how they adhere to medication as well as on lifestyle modification. The World Health Organization (WHO) defined adherence as the extent to which the behavior of a person, such as taking medication, following a diet or lifestyle modification, corresponds with the agreed recommendations from a health care provider [60].

Although adherence is important to patients with NCDs who are on medication, non-adherence to medications is a concern in Africa. In a study conducted among patients with NCDs in Puducherry, South India, the prevalence of low adherence to medication was 32.7% [61]. In contrast, prevalence of poor adherence to diabetes mellitus medication in rural Kerala, South India was 74% [62]. A study conducted in a health facility in a peri-urban district in the Ashanti region of Ghana found that the overall prevalence of medication noncompliance among patients with chronic diseases was 55.5% [63]. Inadequate medication possession ratios and thereby treatment adherence was observed in hypertensive patients at two private outpatient health clinics in Sierra Leone, with more than 80% of patients assessed not having medication for more than 40% of the time period studied [64]. In a specialist clinic and general outpatient clinic in Nigeria, the overall self-reported high medication adherence was low among Nigerian hypertensive subjects [65]. Adherence level of hypertensive patients at Jimma University specialized hospital, Ethiopia, to antihypertensive medications was found to be sub-optimal due to daily alcohol intake, comorbidity, number of antihypertensive medications and availability of medications without fee [66]. A study conducted in Kampala (Uganda) among hypertensive stroke patients found that 17% of the patients were adherent to antihypertensive medications, and the main cause of non-adherence was lack of knowledge [67].

Non-adherence is when patients do not take their medications at all, are taking reduced amounts, or are taking doses at the prescribed frequencies but not taking into consideration medication to food requirements [68]. Non-adherence can either be intentional or unintentional. Intentional non-adherence is when a patient makes a rational decision not to use treatment or follow treatment recommendations [69–72]. Intentional adherence includes patient-related, therapy-related, and condition-related factors [69–72]. Unintentional non-adherence is unplanned patient behavior and is less strongly associated with beliefs and the level of cognition as compared to intentional non-adherence [69–72]. Unintentional non-adherence may be caused by forgetfulness and not knowing when and how to take medicines [69–72]. Factors affecting adherence of patients to their medicines such as therapy-related and condition-related factors are associated with unintentional non-adherence [69–72].

Barriers of adherence to medication are discussed in the subsequent subsection and mainly include categories of factors affecting patients' adherence to their medicines.

10. Barriers of adherence to medication

There are barriers of adherence to medication that affect patients with cardiovascular diseases, diabetes mellitus and hypertension thus, leading to

non-adherence. These barriers are classified into different categories of factors affecting adherence of patients to their medication. Categories of factors affecting patients' adherence to medication in Africa include sociodemographic, economic, environmental, condition-related factors, therapy-related, health care team and system-related factors, and patient-related factors [73–79]. Sociodemographic, economic and environmental factors are composed of low-income, poverty, minority race-ethnicity, social support, copayments, and health literacy [73, 77]. Health care team and system-related factors include patient-clinician relationship, communication style, lack of team-based care, clinician burn out, lack of knowledge, lack of policies, lack of ad hoc screening and proper referral systems, and poor universal health insurance coverage [73, 74, 76, 77, 80, 81]. Complex regimen, treatment changes, failure and duration, adverse effects, and refill frequency and consolidation are therapy-related factors [73, 78]. Condition-related factors include multiple chronic conditions, depression, psychoses, drug or alcohol abuse, dementia, major disability, severity of symptoms, and quality of life [73]. Patient-related factors include perception of illness and treatment efficacy, denial of diagnosis, fear of dependence or adverse effects, lack of knowledge, forgetfulness, and low self-efficacy [73, 80, 81].

Several interventions can be put in place to curb factors affecting patients' adherence to medication. Therapy-related and condition-related factors could be minimized by prescribing few medications which can be implemented using once daily single-pill combinations [71]. Use of once daily single-pill combinations is associated with better adherence and hypertension control [71, 82]. Also, clinicians can prescribe a larger number of medications with each prescription to reduce refill frequency [69, 71]. Patients with NCDs frequently have co-morbidities requiring additional medication to their medicines for NCDs thus, refill consolidation so that multiple medications are obtained at the same time can improve adherence [69, 71].

To curb some of the health care team and system-related factors, patients should trust and be confident that the clinician is competent and has their best interest when making management decisions [73]. Patients, especially racial-ethnic minorities, should actively participate in decisions about the management of their NCDs and what medication to take [69, 73]. Policies addressing procurement process of medication and control of NCDs should be developed and implemented in health systems [74]. Also, the use of generic medicines for NCDs and improvement of health insurance coverage will reduce the cost of care for patients with NCDs therefore, solving some of the barriers to adherence [74].

Dispensing models can be implemented to assist with monitoring adherence to medicines and the treatment outcome.

11. Dispensing models to assist with adherence and treatment outcome

Poor adherence to medication is a major contributor to uncontrolled cardiovascular diseases, diabetes mellitus and hypertension. Monitoring and detection of adherence of patients to their medication using different dispensing models assist with assessing the treatment outcome. Medication adherence can be measured directly or indirectly using several measurements either separately or together [83, 84]. Indirect measurements include pill count, patient interviews, prescription refills data, electronic monitoring system, directly observed technique, and questionnaire [83, 84]. Direct measurements include measurement of drug levels and digital medicine [83, 84]. Prescription refills data, pill count, directly observed technique, and electronic monitoring system are objective

measurement whereas, questionnaires and patient interviews are subjective measurements [83, 84]. Biomedical measurements consist of measurement of drug levels and digital medicine [83, 84].

12. Different dispensing models used to measure adherence

Dispensing models include interviewing patients, questionnaires, pill count, prescription refills data, electronic monitoring system, measurement of drug levels, digital medicine, and directly observed technique [73].

Patient's interview is when a physician questions the patient about adherence to medicines. The physician asks the patient questions related to medicine-taking behavior thus, communication skills of the physician and the ability to conduct nonjudgmental discussion is important [73]. The health care professional asks the patient to estimate their own medication-taking behavior, such as which percentage of dose that they may miss within a designated period or the frequency that they are unable to follow the medication regime [83]. On the other hand, questions asked to the patient by the health care professional can be based on the patient's knowledge on the prescribed regime, including drugs' name, schedule, and indications [83]. Health care professionals then evaluate their response to determine the level of adherence [83].

Questionnaires are forms which can be completed by patients, trained nurses or healthcare professionals as a tool to monitor adherence [73]. Types of questionnaires used to measure adherence are the Brief Medication Questionnaire, Hill-Bone Compliance Scale (Hill-Bone), Eight-Item Morisky Medication Adherence Scale (MMAS-8), Medication Adherence Questionnaire (MAQ), Self-Efficacy for Appropriate Medication Use Scale (SEAMS), and the Medication Adherence Report Scale (MARS) [85, 86]. A well-known and mainly used questionnaire to measure adherence is the Morisky questionnaire [69, 83].

Pill count is a frequently used dispensing model to monitor adherence where counting returned pills by a patient gives an overview of what has been taken by the patient [73]. The health care provider counts the number of dosage units that have been taken by the patient between two scheduled appointments or clinic visits [83]. This number would then be compared with the total number of units received by the patient to calculate the adherence ratio [83]. The equation for calculating pill count is as follows: (Number of dosage units dispensed − Number of dosage units remained) / (prescribed number of dosage unit per day × number of days between 2 visits) [83].

Prescription refill data requires availability of electronic monitoring of drug prescriptions in pharmacies [73]. Prescription refill data assists with obtaining a rough estimate of medicines adherence and persistence by calculating the percentage of days covered by the prescriptions [73]. When measuring adherence using prescription refills, it is assumed that prescription-refilling patterns correspond to the patient medication-taking behavior and that the medication is taken exactly as prescribed [83].

Electronic monitoring system consists of a device in which a microcircuit is incorporated into medication packages and any removal of a dose of the medicine is detected in real time, time stamped, analyzed, stored, and communicated [73, 83]. Commonalities of different electronic monitoring devices include (i) recorded dosing events and stored records of adherence, (ii) audiovisual reminders to signal time for the next dose, (iii) digital displays, (iv) real-time monitoring, and (v) feed-back on adherence performance [83]. The commonly used electronic monitoring device is the Medication Event Monitoring System (MEMS) [73, 83].

Measurement of drug levels involves the measurement of the medicine or its metabolite concentration in body fluids, such as blood or urine, and evaluation of the presence of a biological marker given with the medicine and direct observation of patient's medication-taking behavior [73, 83]. Complete absence of medicine in a sample indicates that the medicine has not been taken by the patient for a duration equivalent to half-lives of the medicine [73].

Directly observed technique is an approach when medicine is given and taken by the patient under supervision of a member of the clinical staff every day for a certain period of time [73].

Digital medicine consists of ingestible sensors incorporates in the pill during manufacturing process, which will be ingested by the patient [73]. After ingestion, an electrochemical reaction is triggered in the stomach leading to an activation of the sensor and generating a unique message coded for the medication name and dose to a wearable patch worn by the patient on the torso and recorded the date and time of the sensor ingestion [73]. The information collected by the patch is encrypted and transmitted wireless to a designated device using Bluetooth. The sensors are then eliminated as solid waste within 72 hours [73].

There are other dispensing models used to monitor patient medication adherence thus, treatment outcome. Modern technology can be used to monitor adherence and includes the use of internet, real time medication monitoring (such as electronic pill boxes), and mobile phones [69]. The use of electronic pill boxes combined with Short Message Service (SMS) reminders are specifically designed to improve unintentional adherence [69]. These interventions have resulted in an increase in refill adherence in diabetic patients with suboptimal adherence [68]. Mobile phones can be used to send alerts to take medication to patients, track doses, and provide appropriate medication instructions [86]. Automatic home medication dispenser (AHMD) integrated with a smartphone application can be used to address adherence issues especially for elderly patients [86]. The AHMD holds up to 90 day's supply of several medications, and addresses cognitive impairment and age-related changes using components such as counter, clock dispensing mechanism, power source, input/output interface, locking system, transceiver and antenna, and physical indicators for alarms [86]. The AHMD also notifies the patient of due dosage per set dosage time or due refills through audio/visual reminders, and notifies the caregiver of missing dosages through calls or text messages [86–88].

In conclusion, it is important to monitor adherence of patients with chronic diseases to their medicines using appropriate dispensing models (either alone or in combination) as uninterrupted life-long consumption of medicines will prove patients' health outcome. In instances where non-adherence has been identified, it is essential to note factors affecting adherence of patients to their medicines and address those factors.

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Author details

Masebata Ramathebane*, Lineo Maja and Molungoa Sello
National University of Lesotho, Maseru, Lesotho

*Address all correspondence to: mv.ramathebane@nul.ls; mvramathebane@gmail.com

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