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# Environmental and behavioural determinants of cardiovascular health

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## ABSTRACT

Cardiovascular diseases (CVD) are currently the major cause of death in developed countries, and their percentage share in its rate is systematically and significantly increasing. Over twenty years – between 1990 and 2010 – the number of deaths from CVD increased by a third, and now it is estimated to represent about half of all deaths worldwide, with coronary heart disease and stroke being the two most common causes of loss of years of life. That is why CVD are a significant epidemiological problem. Therefore, determining the risk factors and ways of prevention is (and should remain) a task of high priority for the entire health care sector around the world, especially in the developed countries. The aim of this review is to summarize major environmental and behavioural determinants of cardiovascular health. The keywords "health, cardiovascular, determinants, environmental, behavioural" were used. Most of the articles broadened the knowledge about positive and negative impacts of behaviours on cardiovascular health. Physical activity, appropriate diet, cessation of smoking, and a correct body mass index, and thus the correct parameters such as lipid profile, blood pressure and fasting glucose levels, have a significant impact on improving health and life expectancy. In conclusion, CVD are currently among the most important international issues. During the past decades, remarkable progress has been made in understanding of their pathogenesis and risk factors. Therefore, the global efforts should be focused on healthy life-style promotion and particular attention should be paid to modifiable risk factors.

**KEY WORDS:** cardiovascular health, environment, behaviour, cardiovascular risk assessment.

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## HEALTH – DEFINITIONS AND DETERMINANTS

Although it is universally acknowledged that health is the one of the most important subjects for people, defining it was never an easy matter. There have been approximately 300 attempts to state its definition [1], and throughout the ages and centuries, philosophers and poets have tackled the disputed issue. Historically, the word "health" derived from the name of a goddess of wellbeing in ancient Greece. Philosophically, Menander, an ancient Greek poet, wrote that there are "two things in life – the health and the mind" as early as 300 B.C., and Hippocrates stated that *salus aegroti suprema lex* or simply a physician should act in the best interest of the patient, which up to modern days is a major rule for all medical doctors across the whole world [2].

One of the first efforts to define health focused only on the lack of disease though neglected human well-being, and that issue was not considered until 1964 when the constitution of the World Health Organization was signed in New York, where it was stated that "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [3]. Although the definition was widely accepted in many countries, following F. Leonardi, it appears to be unsuitable for modern

challenges in the public health sector, particularly in the aspect of aging society [4].

However, due to the high prevalence of chronic diseases and the fact that an average adult usually presents at least 4 different symptoms during 14 days [5], "complete well-being" is felt to be unattainable and somewhat utopian.

The wide scope of that definition is also being criticised since complete physical, mental and social well-being would mean living in a world free of poverty, discrimination, violence, wars and hunger, which, though being extremely crucial matters, are not by themselves a medical issue (F. Leonardi). Moreover, the combination of treating every social abnormality as a medical concern and progressive medicalisation of many different aspects of life would lead to increasing state expenditure in the medical field as a result of increasing social pressure in this matter [4].

Leonardi proposed the following conditions to establish an accurate definition of health [4]:

- it does not focus only on lack of disease;
- it regards health as a collection of abilities;
- it regards health as a continuous, dynamic process rather than an obtainable state;
- it is potentially attainable by everyone in real life in all circumstances;
- it includes not only good but also bad moods, since difficult, arousing emotions are just a part of human everyday life not influencing health itself. This inclusion is crucial to the idea of not perceiving health as an ideal, almost impossible to achieve. For example, in the elderly chronically ill group, such a definition could be comprehended as an ability to cope with one's limits;
- health must be independent from moral and ethical discourse;
- health must be based on personal priorities, values and needs;
- health must be measured by clearly stated criteria.

Leonardi proposes the definitions as follows: Health is an ability to cope with both good and bad moods, is an ability to react to different environmental events giving rise to desired emotional and cognitive stimuli and at the same time avoiding undesired ones. Despite its simplicity, this definition meets all 9 guidelines, and contrary to the WHO's definition it does not conceive health as unattainable with its all-utopian side effects. Obviously, the definition does not exclude traditional medical criteria, which are curing diseases and alleviation of ailments; they are important elements which influence one's ability to handle good and bad moods. This transformation changes the current idealistic vision of health in a ground-breaking way.

All factors conditioning the state of the organism, both physical and mental, should be considered as health determinants. These aspects together or separately can have either a positive or negative influence on both single persons and whole communities [6]. Different definitions identify different factors, and though they differ in the details, they are generally convergent.

"Health is a result of factors like genetics, environmental, life-style, and available health-service. A promotion of healthy life-style can positively influence health conditions and reduce the need for health medical services" [7]. These definitions, which also differ from the WHO's one, became a starting point for a discussion published in the "New Perspectives on the Health of Canadians" report in 1974, which was the first conception of Marc Lalonde, who was a Canadian health minister, the health field concept [8].

Lalonde was the first to pay attention to the fact that societies' efforts were focused only on improvement of the health system whereas the remaining fields have the greatest influence on shaping people's condition. However, the report did not include a detailed quantification of the influence of groups of factors on people's health. Those studies were conducted by Badura 21 years later in 1995 [7] with the results as follows: lifestyle 54%, biology 25%, environment 9%, health care system 12% [8, 9]. The fractions vary depending on source but remain consistent in the fact that the smallest fraction is associated with the health-care system. In Poland, regarding the National Health Programme (1996-2005), the proportions are: 50-60% lifestyle, 20% biology, 20% environment, 10% health care system.

"The European health report 2009: Health and health systems", which was published by the WHO 35 years after "New Perspectives on the Health of Canadians", distinguishes the following groups of health factors: environmental, socioeconomic, behavioural, lifestyle [10]. The report highlights that due to different presentation of those factors in European countries they have a different level of influence on health there. A general trend can be observed: lower educated people, with lower income and lower employment status, tend to spend more years in a bad condition and have more health-related problems than the opposite group [10, 11]. Consequently, lifestyle and health related behaviours have a common ground that is socioeconomic conditions and social inequalities have direct relations with health inequalities. Therefore, theoretically they can be modified and then eliminated.

As a result of international efforts to improve public health, the first international conference of health promotion was organised 1986 in Ottawa city by the WHO, Welfare Canada and Canadian Public Health Association [12]. Consequently, the Ottawa Charter for Health Promotion was established and defined health promotion as a "process of enabling people to increase control over, and to improve, their health" [13]. The charter aims to create an effective health promotion strategy and focuses on the following directions [14]:

- build healthy public policy;
- create supportive environments;

- strengthen community action;
- develop personal skills;
- reorient health services;
- moving into the future.

## CARDIOVASCULAR DISEASES AS AN EPIDEMIOLOGICAL ISSUE

Cardiovascular diseases (CVD) are the main cause of deaths in developed countries and their share in deaths is gradually increasing. Particularly between 1990 and 2010 the number of these deaths rose by one third [15] and currently they comprise about a half of all deaths across the whole world from which coronary artery disease (CAD) and stroke are the main causes of loss of years of life (disability-adjusted life years – DALY) [16]. That is a reason why CVD are an important problem and conducting scientific studies in their area and prevention of unhealthy behaviours should have a high priority for the entire health care system especially in developed countries.

In 2011, the WHO passed a new declaration to achieve a 25% reduction in mortality from noncontagious diseases by 2025 through reducing risk factors that may be subject to reduction [16].

Since the 1930s, when major studies on death causes revealed a decrease in contagious diseases, knowledge of the significant role of CVD has been developed [17]. In the 1950s high levels of cholesterol and blood pressure were identified as major CVD risk factors (Framingham). Then in subsequent studies the risk factors were divided into two groups: modifiable and non-modifiable. These groups were composed of age, sex, family history, comorbidities, tobacco, alcohol, lack of physical activity, obesity, hypertension, and dyslipidaemia [18]. The modifiable factors are related to environmental and behavioural determinants of health and therefore can be significantly decreased.

## ENVIRONMENTAL DETERMINANTS OF CARDIOVASCULAR HEALTH

CVD risk factors are measurable and are associated with increased probability of future CVD [19].

1.7 million deaths (18%) are associated with harmful environmental factors annually. They include lack of clean drinking water, poor sanitation conditions, air pollution, organic pollutions, mercury and pesticides, traumas, and occupational exposure [10].

Environmental determinants related to CVD include occupation related: chronic psychological stress due to activation of the hypothalamic-pituitary-adrenal axis (HPA axis) and sympathetic nervous system, which leads to increased blood pressure [20-22]. Acute stress may also trigger acute coronary syndromes in the group of chronic CAD [22] and consequently this stress then may impair rehabilitation and worsen the long-term prognosis [23]. Stress can also contribute to oxidative stress and induce inflammation in walls of blood vessels [24, 25]. It should also be noted that isolation, loneliness, financial difficulties, and problems in private life may contribute to chronic stress and are essential environmental aspects.

According to Evsevyeva's studies on a group of 68 young males employed in chronic stress exposed sectors, the blood pressure measured continuously resulted in an increase in working days contrary to non-working ones [21]. These results can be compared with the multi-centre INTERHEART study, which analysed exposure to emotional stress and myocardial infarction. In the study 6 independent groups of death risk factors were determined, one of which comprised psychosocial factors – exposure to emotional stress. Other factors were hypertension, dyslipidaemia, tobacco, obesity, and diabetes [26].

It was proved that exposure to stress factors, both occupational and everyday life, increases the risk of myocardial infarction more than two-fold [23].

Due to urbanisation and industrialisation increasing air pollution became a major health problem. According to the WHO, 91% of people live in an environment exceeding norms of air pollution and as a result 4.2 million people die annually of stroke, CVD, lung neoplasms and chronic respiratory diseases [27]. Similarly to emotional stress, air pollution leads to oxidative stress and induces vascular tissue inflammation [24, 25].

Equally, increases in pesticide use and concentrations of organic pollutants contribute to human health and may lead to CVD [28, 29].

## BEHAVIOURAL DETERMINANTS OF CARDIOVASCULAR HEALTH

The WHO's European Health Report [9, 10] distinguishes seven behavioural and life-style risk-factors which are responsible for 60% of diseases in Europe: high blood pressure, tobacco, alcohol abuse, high level of cholesterol, inappropriate diets, not enough physical activity, and obesity. The main factor in Europe is hypertension and its complications. According to the WHO's strategy for the European's region (1989), lifestyle is a 'way of living based on mutual connection between living conditions and individual patterns of behaviour shaped by sociocultural factors and individual predispositions' [30]. On its basis, it can be presumed that health behaviours are in direct and inseparable relations with lifestyle and the contribution of behavioural aspects in prevention of CVD is increasingly emphasised by both American and European guidelines [19, 31-33].

Identification of harmful behaviours is a vital aspect in prophylaxis of CVD and is a basis for developing algorithms used to determine health risk scores. The behaviours significant in sustaining good health condition are cessation of smoking, maintaining appropriate body weight, physical activity and diet, which lead to normalisation of cholesterol level, glycaemia, and blood pressure [34].

In 2005 approximately 31.4% of people above 15 years old smoked tobacco in Europe, including 44.4% of males

**TABLE 1.** Chronology of cardiovascular risk assessment development

| Year | Algorithm |
|---|---|
| 1991 | Framingham Heart Study CHD Prediction: +LVH |
| 1998 | Framingham Coronary Heart Disease Risk Prediction |
| 1999 | British Joint Societies CHD |
| 2002 | PROCAM (Munster) |
| 2003 | SCORE |
| 2004 | British Joint Societies CVD |
| 2004 | WHO/ISH |
| 2007 | ASSIGN |
| 2007 | QRISK 1 |
| 2008 | QRISK 2 |
| 2008 | Framingham General CVD Risk Prediction |

and 23.2% of females [35]. In the group of 13-15-year-olds smoking prevalence was estimated at 22.7% for boys and 16.8% for girls [35], which is particularly worrying due to the strong addictive potential of tobacco. Smoking contributes to CVD due to the influence on vessels, where it induces inflammation and proliferation [36] leading to atherosclerosis.

Obesity caused by inappropriate nutrition and sedentary lifestyle consumes around 6% of total healthcare system costs and leads to nearly as many premature deaths as tobacco [10, 37].

In Europe 20% of people do not undertake sufficient physical activity and follow a diet that contains a high number of calories and excessive quantities of fats, carbohydrates, and alcohol. 30-80% of adults and up to 30% of children have BMI greater than 25 kg/m$^2$ [10]. These factors lead to metabolic abnormalities such as diabetes and dyslipidaemia and lead to increased risk of CVD. About half of diabetics die from CVD [38].

## CLASSIFICATIONS OF CARDIOVASCULAR HEALTH

Evaluation of CV health is based on estimating the probability of occurrence of CVD in future by identifying risk factors leading to atherosclerosis. Global CV risk is defined as the probability of either death or occurrence of CVD in a determined interval of time and is a result of synergic contribution of different atherosclerotic risk factors [34]. Therefore a few scales have been developed to assess CV risk, and from which Framingham Heart Study (FHS) classification and SCORE have external validation, that is they have been supervised and assessed for predictive ability in a different group than the one used in creation of the algorithm. The scales differ in the target populations and number of factors considered:

- age;
- sex;
- blood pressure;
- lipidaemia;
- tobacco;
- diabetes;
- family history;
- obesity;
- metabolic syndromes;
- lack of physical activity;
- left ventricular hypertrophy;
- atrial fibrillation;
- heart rate;
- apolipoprotein B;
- CRP concentration;
- hyperuricemia;
- creatinine level;
- albuminuria;
- socioeconomic status;
- intima-media thickness [33].

Despite the high number of factors, most algorithms are based on evaluation of 6 main ones: age, sex, cholesterol level, diabetes, hypertension, tobacco [39].

Estimating CV risk is a basis for preventive cardiology, which plays an important role in the response to the increasing CVD mortality rate. Table 1 presents a chronology of CV risk assessment development.

### FRAMINGHAM HEART STUDY CLASSIFICATION

FHS is a scale used to estimation of occurrence of a cardiovascular event that is either followed or not by death (such as coronal artery diseases, ischaemic and haemorrhagic stroke, TIA, peripheral arterial diseases, heart failure, acute coronary syndromes, stable angina) in following Americans 30-74 years old for 10 years. It is one of the oldest (1948) studies of its type, and probably a cornerstone of preventive cardiology. Its history is related to the death of Franklin D. Roosevelt, the 32$^{nd}$ president of the United States, caused by a haemorrhagic stroke caused by hypertension up to 300/190 mmHg [15]. His successor, President Harry Truman, signed the National Heart Act and founded the National Heart Institute. Its headquarters was located in Boston [40].

The Framingham Heart Study (FHS) is the longest American cohort study in the field of CVD [40] and up to 2018 had three generations of participants (15 000 people), with continuous monitoring of the number of cases and mortality from CVD.

In 1961 major risk factors for CAD were identified and became the basis for development of CVD estimating algorithms. The risk factors were high blood pressure, high cholesterol level, and left ventricular hypertrophy in ECG examination. In its present shape FHS is used to evaluate patients aged 30-79, without a history of CVD events and based on the following parameters (2018) (Prevention Guidelines Tool CV Risk Calculator) [40-42]:

- age;
- sex;

- tobacco;
- total and HDL cholesterol;
- diabetes;
- systolic pressure and hypotensive prescriptions.

FHS can be used only as primary prevention due to the fact it is used only to asses' patients without history of CVD events.

There is abundant scientific evidence that the most important risk factor for CVD is blood pressure [41]. Furthermore, during FHS studies it was revealed that blood pressure alone could identify patients with high risk of stroke and approximately 57% of it occurred in the population where systolic pressure was greater than 160 mmHg (19% of total participants and 36.2% of all CVD events) [43]. In hypertensive heart disease statistics were similar as well. However, in CAD and in peripheral arterial diseases the correlation is slightly smaller and high blood pressure precedes a lower rate of CAD and even fewer cases of intermittent claudication [41]. That is why algorithms that include superposition of some of the factors appears to be particularly useful.

### SCORE

Systemic COronary Risk Evaluation (SCORE) is a scale developed by the European Society of Cardiology (ESC) and published in 2003. It is used to estimate individual risk of death in European countries due to CVD in the following 10 years in the patient group without a history of CV events and similarly to the previously discussed scale it is also a part of primary prevention [44]. The algorithm was based on a cohort study conducted during 1970-1988 and included 205 178 patients (with 7934 deaths from CVD) in 12 European countries [33]. Two tables have been designed used to estimate global CV risk and countries were divided into either low or high risk. Low risk countries were Andorra, Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, the Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, and the UK. High risk countries were Albania, Algeria, Armenia, Azerbaijan, Belarus, Bulgaria, Egypt, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Macedonia, Moldova, the Russian Federation, the Syrian Arab Republic, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan [45]. In Poland since 2007 Pol-SCORE is used and the current version was published in 2015.

Pol-SCORE takes into consideration the following factors:

- age;
- sex;
- tobacco;
- systolic blood pressure;
- cholesterol level concentration.

The relative risk score is expressed as a percentage and puts the patient in one of three categories:

- low CV risk (less than 1%);
- medium CV risk (1-4%);
- high CV risk (5% and above).

Based on this qualification, a decision is made on the implementation and type of preventive treatment which may regard life-style modification, hypotensive and statin prescription. A different approach is for patients with high CV risk – that is called a strategy for high-risk patients [33].

Different circumstances may also influence the final risk, such as:

- sedentary lifestyle;
- family history;
- socioeconomic status;
- diabetes (most diabetic patients are regarded as high or very high CV risk);
- low level of HDL;
- chronic kidney disease (GFR < 60 ml/min/1.73 $m^2$).

Patients with a history of diabetes 2, diabetes 1 with complications, or CVD events are regarded as a very high-risk group [33].

The main differences of SCORE in comparison to other algorithms is:

- it estimates death risk from not only CAD, but all CV diseases caused by atherosclerosis. It estimates the risk of death itself rather than CV events not necessarily followed by death.

### AHA LIFE'S SIMPLE 7

AHA Life's Simple 7 (AHALS7) includes 7 modifiable risk factors defined by the American Heart Association [46] and was designed to improve Americans' CV health by about 20% with a simultaneous decrease in CV event induced mortality by 20% by the year 2020 [47]. It is a part of prevention and these factors, sometimes described as "prescription for health", are control of hypertension, control of cholesterol level and glycaemia, regular physical activity, diet, body weight control, and cessation of tobacco. Altogether there are three biometric and four behavioural factors. These recommendations do not require great financial outlays, are not complicated, and implementation of them may significantly improve public health [48].

Each of these factors may take one of three values: ideal, intermediate, and unfavourable, as presented in Table 2 [47].

Despite the efforts made, the number of people with ideal CV health is still very low. Common problems are poor diet and lack of physical activity, which together lead to overweight and obesity [49].

Both the AHA and the WHO pay attention to socioeconomically inequalities contributing to health status due to unfavourable health behaviours, poor education, and limited access to health care [49].

It is estimated that approximately 20-30% of US annual healthcare costs are spent on diseases associated with

**TABLE 2.** AHA Life's Simple 7 scoring

| Factor | Level of health for each metric | | |
|---|---|---|---|
| | Poor | Intermediate | Ideal |
| Tobacco | Continuous | Ceased in previous 12 months | Never or ceased earlier than 12 months ago |
| BMI [kg/m$^2$] | ≥ 30 | 25-29.9 | 18.5-25 |
| Physical activity minutes per week | None | 1-149 of moderate<br>1-74 of intensive<br>< 60 min daily | ≥ 150 of moderate<br>≥ 75 of intensive<br>≥ 60 min daily |
| Number of components included from the healthy diet pattern* | 0-1 | 2-3 | 4-5 |
| Level of total cholesterol | ≥ 240 mg/dl | 200-239 mg/dl | < 200 mg/dl |
| Blood pressure [mmHg] | SBP ≥ 140<br>DBP ≥ 90 | SBP 120-139<br>DBP 80-89 | SBP < 120<br>DBP < 80 |
| Fasting glycaemia [mg/dl] | ≥ 126 | 100-125 | < 100 |

**Healthy diet pattern is the Dietary Approaches to Stop Hypertension (DASH): ≥ 5 fruit and vegetable servings daily, ≥ 2 fish servings weekly, ≥ 3 grain product servings daily. No more than 1000 g of sugar-sweetened beverages weekly, no more than 1500 mg of salt daily*

modifiable CVD risk factors, most of which are included in AHALS7 [48]. Further studies on an ethnically diverse population proved that people with at least 5 ideal factor values have 78% lower probability of death from CVD than people with no parameters at an ideal value [50].

Similarly, Milstein *et al.* [51] tested three strategies which could decrease mortality and healthcare costs: 1) extended health insurance, 2) increase in preventive and chronic care, 3) promotion of healthier lifestyle and environmental conditions. In the results, when all these three strategies are employed, approximately 90% of patients can be saved and the costs of health care can be reduced by about 30% in 10 years, and in 25 years by 140 and 62%. Furthermore, patients at high risk will benefit from both intensive behavioural and medical interventions which although initially increasing costs, will prevent progression of chronic diseases to a stage at which costs will be much greater. Conversely, in low-risk patients the preventive measures themselves will benefit in the long term and will decrease the needs for sophisticated high-end and highly priced care.

The presented model illustrates the assumption of "guidelines of healthy life" – the elimination of CVD risk factors is easy to implement and an effective way of achieving real benefits for both the individual and society.

## CONCLUSIONS

CVD are currently one of the most important international problem. During the past decades, remarkable progress has been made in understanding their pathogenesis and risk factors. Therefore, global efforts should be focused on healthy lifestyle promotion and particular attention should be paid to modifiable risk factors. Introducing such measures will significantly contribute to increases in both life expectancy and quality and will directly support the health care budget. CV related costs, though not expensive in the preventive modifiable stage, rise swiftly when left to progress to chronic and severe disease.

## DISCLOSURE

The authors report no conflicts of interest.

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**AUTHORS' CONTRIBUTIONS**

PG nad RP prepared the concept of the paper. AŻ collected data. AŻ and PG interpreted data. AŻ wrote the article. All authors have given their final approval to the final version of the paper.