

## Cardiovascular Diseases Due to Stress Arisen from Social Risk Factors: A Synopsis and Prospectiveness

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This paper reviews the causes of cardiovascular diseases (CVD) from a perspective other than traditional clinical pathology. We look at social factors that could arouse stressful feelings, and could further lead to cardiovascular diseases. Major social factors including job stress, daily hassles, life events, social inequity and trauma are covered in our review. This paper also discusses potential interventions which could be taken by environmental professionals to create dynamism within the existing static structures so as to eventually eradicate the causes of mental stress and ameliorate the quality of life for urban dwellers.

**Keywords:** Stress; cardiovascular disease; social factors; environmental interventions; measurements.

### 1. Introduction

It has been broadly contended that an increasing number of people in modern society are suffering from a wider range of health problems due to higher level of stress arisen from urban ambience.<sup>1–3</sup> Stress could further lead to cardiovascular diseases (CVD), a leading cause of death across the world.<sup>4–13</sup> Although the global population has surpassed seven billion with increasing life expectancy over the past 50 years,<sup>14</sup> the number of deaths caused by CVD is nevertheless on the rise despite the medical advances achieved hitherto. Globally, the number of

deaths due to CVD increased by 41% from 1990 to 2013, climbing from 12.3 to 17.3 million.

CVD could then trigger other fatal diseases like heart attack and stroke, and engender premature death.<sup>15</sup> However, the common cure procedures for these illnesses are often prescription of medication with only mitigating effect. The eradication of the diseases is far from reach with the limited traditional medical approach.

The pervasion of CVD has also been an economic crisis for decades. It had been estimated earlier in the 1970s that CVD was responsible for 12% of

working time deprivation and nearly 4 billion USD of economic loss in the US, while the sum in the UK was about 23 million.<sup>16</sup> At present, CVD is still the prime cause of death and is consuming 17% of national health disbursement in the U.S., and the costs are projected to triple by 2030.<sup>17</sup>

It is nevertheless possible to take proactive approaches instead of passively reacting to the outcome of the illness. Either from clinical or economic perspective, it is much more efficient to prevent disease from developing instead of treating the disease after its occurrence. And the key to precaution is being well aware of the generation mechanism of the disease.

This concept drives us to look into external causes that might arouse mental stress and further develop into CVD. Stress could be caused by a variety of extrinsic social factors. Moreover, we pay attention to the relationship between CVD and social stressors based on a systematic review of relevant studies in a purposive and snowball sampling manner.

## 2. Mechanism

We present major pathophysiological and psychophysiology mechanisms to interpret how mental stress could lead to CVD hereinafter.

### 2.1. Pathophysiological mechanisms

Mental stress could trigger psychological distress, and engender a complex of adverse impacts on cardiovascular status, including atherosclerosis, endothelial dysfunction, myocardial ischemia, plaque rupture, thrombosis and lethal arrhythmias.<sup>3,18</sup>

Sympathetic-adrenomedullary (SAM) system and hypothalamic-pituitary-adrenocortical (HPA) axis<sup>19</sup> are both responsible for monitoring body signs, such as an increase in blood pressure, heart rate, sweating and constriction of peripheral blood vessels, as reaction signals to stress. Under stressful conditions, SAM system would be activated with rapid secretion of epinephrine and norepinephrine into the blood stream, which has marked effects on the cardiovascular system.<sup>20</sup> HPA system would also be activated to cope with stressful situations. Once the hypothalamus receives information about stress from the cerebral cortex, it releases corticotrophin-releasing factor, which then leads to the secretion of corticosteroids from the adrenal cortex.<sup>3,19,21</sup> While secretion of epinephrine could be

activated by both positive and negative stimuli, cortisol is more sensitive to adverse conditions.<sup>20</sup> Cortisol plays a vital role in helping the body recover to a normal state after the perception of stress. However, prolonged cortisol secretion could impact the neurons in the hippocampus.<sup>3,19,22,23</sup> HPA activation could also lead to the elevations of hormone, prolactin, opioids beta-endorphins and enkephalin, which have been proven as causes of CVD.<sup>3</sup>

Moreover, coronary atherosclerosis is intimately related to coronary heart disease with a continuous process of arterial wall thickening due to a variety of changes, such as lipid deposition, smooth muscle infiltration and inflammation.<sup>24</sup> Other than episodic plaque disruption, cardiovascular or hemodynamic activation regulated by autonomic nervous system can also lead to acute ischemic events. An acute acceleration of heart rate and blood pressure can cause disordered blood flow across the vessel, which might further induce endothelial shear stress and ventricular tachyarrhythmias.<sup>5</sup> It has been well documented in empirical studies that stress is one of the main contributors to severe cardiac events.<sup>5,12,25,26</sup>

### 2.2. Other relevant psychophysiological theories

Two other psychophysiological theories can help us understand why stress can lead to CVD. The first one is the theory of “sense of coherence” proposed by Aaron Antonovsky in the terminology of medical sociology. The concept interprets the relationship between stress and health by illustrating the role of stressors in human’s psychophysiological functioning.<sup>27</sup> The sense of coherence is about a counter-balanced yet dynamic sensation of confidence that (a) the encountered stimuli in the course of living is explicable and predictable, namely comprehensibility; (b) the demanded resources for coping with the stimuli are accessible, namely manageability; and (c) the corresponding demands are worthy of investment and engagement, namely meaningfulness.<sup>28</sup> Once the sense of coherence is violated by certain sort of stressors, detrimental impacts will be engendered towards the normal psychophysiological status neglecting any form of perception or response to the original causers.<sup>27</sup>

Another emerging theory that interprets relationship between chronic stressors and their CVD-related health consequences is “allostatic load”

proposed by McEwen and Stellar.<sup>22,23,29</sup> The framework is mainly about the predictive regulation of human brain's cognitive function, which largely depends on the hippocampus and the adrenal steroids resided in it,<sup>22,30</sup> and which indicates its ability to predict future needs and be prepared in advance as part of its responsibility is to anticipate and cope with encountered uncertainties.<sup>31</sup> From this perspective, the concept of "sense of coherence" and "allostasis" actually overlap with each other to some extent.

Being exposed to chronic stress could violate the allostatic regulation's ability of mitigating uncertainty and lead to the experience of "allostatic load", which involves the persistent activation of neuroendocrine, cardiovascular and emotional responses and further lead to the fluctuation of blood flow, the turbulence of coronary and cerebral arteries, high blood pressure and atherogenesis.<sup>3,31</sup> Such being the case, the psychophysiological mode of allostasis could then cement to the pathological mechanism of chronic stress stimuli. The mode of allostasis could become adverse with excessive activation and further lead to hypertension, heightened blood pressure and heart disease.<sup>23,32</sup> The indices of allostatic load could be measured by biomarkers related to various physiological systems including cardiovascular system.<sup>33</sup>

### 3. Social Dimension of Stress Stimuli

We investigate stress stimuli arisen from social factors, respectively based on the perspective of its pathological and psychophysiological mechanism. There are different but often interactive stimuli of mental stress and causes of CVD. These impacts on the risk of CVD are independent from traditional risk factors, such as tobacco use, hypertension, diabetes mellitus, dyslipidemia, family history of premature coronary disease and sedentary lifestyle.<sup>18</sup>

#### 3.1. The social dimension of stress stimuli

The association between certain social factors and the aroused mental stress coupled with risk of CVD has been well established with an enormous body of research.<sup>1,9,12,34,35</sup> Various social stressors have been identified, including stressful working environment, daily hassles, psychosocial inequality and exposure to violence or trauma. Meanwhile,

CVD could also reversely cause detrimental damage to the society regarding socioeconomic level<sup>16</sup> and status of holistic public health.

Social stressors could be classified into the following types.

##### 3.1.1. Stress arisen from workplace

Nowadays, people are more likely to engage in tight-scheduled and challenging jobs due to the high cost of living and strong sense of job insecurity. These situations often expose people to overwhelmed working load,<sup>22,23</sup> acute and chronic strain, and mental stress.<sup>9</sup> Researchers have reported that experience of job stress was associated with elevated level of left ventricular mass, which was considered consistent with the impacts of sustained increase in blood pressure.<sup>3</sup> Individuals working with higher level of job stress were also reported to have larger odds of elevated ambulatory blood pressure, either during or after working, which make workers more vulnerable to CVD.<sup>26</sup>

Job stress can stimulate over-secretion of salivary cortisol, which confirms the argument that stress can lead to the dysfunction of HPA axis.<sup>36</sup> It has been well documented that people with high-risk occupations are more vulnerable to acute and chronic traumatic stress exposure.<sup>37</sup> Studies have proved that greater prevalence ratio is associated with adverse psychosocial work environment regarding traits of high demands, poor self-control and insufficient social support.<sup>34</sup> Meanwhile, acute and individual stressful events in workplaces are correlated with myocardial infarction. A case-control study has proved that several daily factors of accumulated stress events during the past 12 months were associated with a higher risk of myocardial infarction for males.<sup>35</sup>

##### 3.1.2. Stress arisen from stressful daily hassles and events

The rapid pace of life in modern society has fundamentally transformed urban dwellers' trait of life in recent decades. The information revolution in the last decade has shifted people's lifestyles even more dramatically. These marked changes have kept urban dwellers from making prompt and appropriate responses to health-threatening stimuli.<sup>38</sup> Meanwhile, the global culture driven by industrialization and urbanization is also producing

uniformity and consistency, and brings numerous hassles into urban dwellers' daily routine. This "prolonged or repeated stress" has been proved to be associated with the prevalence of CVD.<sup>3</sup> The chronic imbalance of the autonomic nervous system caused by acute yet mild daily hassles would trigger adverse cardiovascular events.<sup>39</sup> According to the theory of allostatic load, accumulation of this type of stress can ultimately result in the inability to reset oneself back to regular status. And on prolonged basis, this would lead to CVD.<sup>9,22,23</sup>

Taylor has stated that daily stress could influence human health on accumulative and repetitive basis and further trigger CVD.<sup>3</sup> Moreover, social interaction pressure in modern society drives people to engage in vigorous competitive behaviors with a hostile attitude, which also has been identified as an essential cause of the acceleration of CVD, since those people will encounter more frequent increase in blood pressure, larger amounts of stress-related hormone secretion and higher storage of fat molecules in the bloodstream.<sup>40</sup>

### 3.1.3. *Stress arisen from social inequality*

The precarious situation about health risks caused by social stressors is profound for lower socioeconomic classes in countries with a higher level of social inequality.<sup>41</sup> High level of sensitivity to psychological stress responses regarding acute stress stimuli has been found to be associated with paucity of social support.<sup>37</sup> Accumulating evidence has shown the correlation between social classes and mortality rate attributed to CVD.<sup>3,13</sup> According to relevant World Health Organization (WHO) surveys, the prevalence of anxiety disorders, impulse-control and severe mental illnesses are all intimately correlated with income inequality, which supports the findings that lower social classes are more vulnerable to CVD triggered by stress and other psychosocial burdens.<sup>42</sup>

Socioeconomically deprived individuals or communities are more vulnerable to health problems like CVD, namely social inequality often further leads to health inequality. A prospective study has proved that one primary reason for the pronounced prevalence of ischemic heart disease among blue-collar male workers is the exposure to high level of work-related socio-emotional distress including status inconsistency, job insecurity, work pressure and insufficient control over job status.<sup>43</sup> A systematic

research stated that residents in socioeconomically disadvantaged communities possess a higher odds of CVD mortality and greater incidence of coronary heart disease.<sup>11</sup> This association has also been proved by other studies: when low socioeconomic status is associated with other psychosocial risk factors, the risk of suffering from cardiac diseases is often exacerbated,<sup>44</sup> while workers with lower employment level have been found suffering from higher odds of coronary heart disease, especially ischemia.<sup>45</sup>

Overall, these findings jointly suggest the significant connection between occurrence of CVD and mental stress due to income inequality, exposure to crime and violence, and other stressors associated with inferior socioeconomic status. Hence, it is of great importance to include socio-economic inequity factors in the study model of social stressors and development of CVD.<sup>46</sup>

### 3.1.4. *Stress arisen from violence or trauma exposure*

Acute and chronic traumatic exposure have also been broadly documented as triggers for post-traumatic stress reactions and risks of CVD.<sup>37</sup> The physiological mechanism about excessive activation of stress response, such as exposure to violence or trauma, can constantly disrupt homeostasis and result in overexertion of allostatic load, and further lead to CVD.<sup>22,23</sup> A cross-sectional study has found that vulnerability to acute stress stimuli is associated with previous traumatic exposures and pre-existing symptoms of traumatic stress.<sup>37</sup>

Earthquake is one of the major forms of trauma. Exposure to earthquake is an extremely stressful experience, which could directly result in CVD and fatal cardio events.<sup>5,12,25,26,47-49</sup> A prospective research regarding the Northridge earthquake in 1994 reported that a sharp increase of sudden deaths due to atherosclerotic cardiovascular disease was noted concomitant with the occurrence of the earthquake.<sup>47</sup> This finding has been concurred by another research based on the Hanshin-Awaji earthquake, with evidence of acute increase in blood pressure and blood viscosity determinants among elderlies with hypertension during the persistence of major felt-aftershocks after the earthquake.<sup>48</sup> Another longitudinal study of Wenchuan Earthquake found the consistency of hemodynamically unstable ventricular tachyarrhythmia (HUSVT) events and

seismic activities among hospitalized patients during felt-aftershocks, which are disparate from normal diurnal distribution of HUSVTs.<sup>49</sup>

Other than earthquake, stress caused by other trauma exposures such as war, terrorism and car accidents could also lead to extreme mental stress and further lead to CVD.<sup>5,10,37,50,51</sup> A cross-sectional study regarding post-traumatic stress disorder (PTSD) identified greater heart rate responses to standardized trauma-related pictures among trauma survivors with acute PTSD comparing with those without PTSD.<sup>50</sup> Another prospective study examined hair cortisol level of male soldiers before and post-deployment to Afghanistan, and got evidence of significant decrease in hormone concentration, indicating appreciable increase in stress level during exposure to traumatic experiences like war and terrorism.<sup>52</sup> Moreover, positive association between motor vehicle accident exposure and psychophysiological symptoms including acute stress disorder and PTSD has also been identified, while heart rate status has also been proved significantly correlated with peritraumatic dissociation.<sup>51</sup>

#### 4. Learning from Two Traditional Health-Enhancing Concepts in the West and East

Although we emphasize on empirical evidence-based practices, two important health-enhancing concepts should also be mentioned here to help us think out of the box. Essentially, these traditional concepts are intuitive and experiential. However, they reflect human's collective wisdom either in the West or East, which might shed a light on future research and practice.

The first concept is derived from Traditional Chinese Medicine (TCM). It has been documented in a growing body of literatures<sup>13,53-64</sup> that contact with biophilic settings can effectively buffer stress arisen from various aspects. Meanwhile, scholars in developed countries have started to take concerns in the practical domain of the knowledge about the CVD prevention credits of nature experience in recent years.<sup>65</sup> The essential intention embedded in the promotion of health-enhancing effects of biophilic settings, interestingly coincides with the ideology of TCM, which has a long history of more than 2500 years.<sup>66,67</sup> TCM takes a prophylaxis philosophy towards the cure of diseases. Rather than just looking into treatments after occurrence of

disease, it focuses on the causes of it, believing that prevention is more important.<sup>68</sup> And it is at the level of prevention that most efforts ought to be directed. This philosophy was documented in TCM classics,<sup>69</sup> a view that has been shared by increasing numbers of medical professionals and scientists alike.

Moreover, TCM takes a broader view on the causes of diseases, to include not only the internal factors, but also the external factor, such as Weather (Heaven) and environment (Earth) aspects which are outside the domain of modern medicine.

The second concept is "Salutogenesis", which was originated by Antonovsky in the 1980s and also intimately related to the concept of "sense of coherence": the psychological cornerstone of immune system against all sorts of stress stimuli.<sup>27</sup> The essential contention of "Salutogenesis", like its denotation as "health origin" in Greek and Latin, is based on the idea of rejecting traditional western medical-model of dichotomy detaching healthiness and illness, and focusing on factors enhancing human well-being instead of cause of disease, which is quite the opposite of pathogenesis.<sup>27</sup> In the salutogenic framework, the relationship among well-being, stressors and mechanism of coping is being regarded as a continuous variable. The continuity indicates the fact that battle with stimuli of stressors are ubiquitous in life, which is named as generalized resource deficits (GRD), while the coping capitals are named as generalized resistance resources (GRR).<sup>27,28</sup> By focusing on GRR, different sorts of GRD could be effectively buffered or avoided and the counterbalanced relationship will thus be controlled and managed.

#### 5. Interdisciplinary Work: Creating Healthy Physical Environment to Mitigate Impacts of Social Stressors

The emerging concept of "healthy city" in the field of urban planning and landscape architecture is raising importance on precautionary thinking. It proposes appropriate environmental interventions could avoid huge amount of health lost and costs on disease treatment.<sup>70,71</sup> However, the knowledge regarding beneficial environmental factors as the "medicine" has not been well possessed for the various interested stakeholders (Table 1).<sup>72</sup> This is still a critical issue that requires further efforts with interdisciplinary cooperation.



Table 1. List of professionals currently or potentially engaged in practice regarding association between environmental factors and health-enhancement.

Medical	In between	Environmental
General practitioners	Horticultural therapists	Horticulturalists
Cardiologists	Physiotherapists	Foresters
Endocrinologists	Psychologists	Architects
Gerontologists	Pedagogists	Landscape architects
Pediatricians	Occupational therapists	Urban planners
Nurses	Policy makers	Urban designers
Diabetologists	Public health scholars	Transportation planners
Epidemiologists		Ecologists

Source: Adapted from Van Herzele *et al.* (2011).<sup>65</sup>

The awareness of stress reduction effect of contact with nature is spreading. The evidence seems solid and applicable in practice.<sup>13,53–64,73</sup> However, the optimistic scenario could not cover up the inadequate body of knowledge and limited transformation from research findings to design solutions.<sup>65</sup>

The current challenge is to implement the knowledge in concerted manner that health-enhancing environmental features could be identified and their potential can be fulfilled. Such being the case, environmental professionals could play a role in this perspective.

When dealing with urban environment planning and design with intention of buffering social stressors, it is preliminary to keep two key principles in mind: First, opportunities should be provided for urban dwellers to take optimistic responses to acute stressors, such as providing space for green exercises and benign social interaction; second, environment should be provided in people's proximity of regular living and working environment to facilitate frequent contact with nature, which can prevent chronic stress from accumulation of acute stress.

At present, practice of "healthy" design coping with stress regarding workplace, healthcare place, and residential space has been explored to certain extent.<sup>74–78</sup> Derived from the previous research outputs,<sup>79</sup> types of urban spaces with restorative qualities could be developed, with views towards biophilic elements with traits of restoring physiological status and palliating stress by cultivating perceptions of control, sense of social support and positive distraction. Although the outcomes of such attempts still require the test of time, the heading direction is worth encouraging as congruous evidence for research.

## 6. Summary

In this paper, we mainly examine social factors that can stimulate mental stress and increase risk of CVD. Key theoretical and empirical evidence has been systematically reviewed and discussed. Finally, we have discussed health-promotion solutions through creating appropriate urban environment.

In general, research and practice progress are encouraging but some knowledge gaps are still evident. We aim to use this work to encourage interdisciplinary cooperation towards the creation of a healthy social environment for urban dwellers.

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