

Cardiovascular Effects Of Electronic Cigarettes In Modern-Day Youth Of Pakistan': A Narrative Review

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Abstract

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Keywords:

E-cigarettes, Electronic Nicotine Delivery Systems (ENDS), Cardiovascular effects/toxicity, Vaping, Youth/Adolescents, Pakistan, Endothelial dysfunction, Oxidative stress, Nicotine, Arterial stiffness

Received on 10 Feb 2026

Accepted on 12 Mar 2026

Published on 19 Mar 2026

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Background: Significant public health impairment stems / derives from the highly exponential rise of electronic cigarettes (e-cigarettes) or electronic nicotine delivery systems (ENDS) among adolescents and young adults globally and locally. Despite aggressive marketing framing them as harmless or safer alternatives to traditional smoking, clinical evidence highlights severe acute and chronic pathologies.

Problems in Pakistan:

In Pakistan, urbanized expansion, targeted digital marketing, lax regulatory frameworks, and widespread misconceptions of safety have led to a concerning vaping epidemic among the modern youth. Recent data reveals alarming prevalence rates, with up to 49.1 % of collegegoing teenagers (ages 16–19) in certain cohorts engaging in e-cigarette use.

Cardiovascular Risks: Traditional two dimensional (2D) models and early perceptions overlooked the superior complex, multi systemic vascular damage caused by

vaping. Ecigarette aerosols, containing concentrated nicotine, heavy metals, volatile organic compounds, and reactive aldehydes, trigger systemic oxidative stress, sympathomimetic acceleration, sustained endothelial injury, and accelerated arterial hardness.

Objective: This narrative review details the growing and nourishing epidemiological trends across major Pakistani hubs and points, contrasts the physiological harm of traditional combustible smoking versus vaping, breaks down specific biomolecular mechanisms driving cardiotoxicity, and

outlines the urgent clinical and regulatory steps necessary to stop long term cardiovascular mortality in the country's youth.

Introduction

While conventional public health strategies in Pakistan have historically prioritized the mitigation / adaptation of combustible Tobacco usage, the modern landscape has shifted dramatically with the introduction of electronic nicotine delivery systems (ENDS).

E-cigarette use among adolescents / almost teen-ager and young adults in Pakistan is rising in very high rate, driven by myths of safety, Westernization, and a distinct lack of strict regulatory policies, and rule of law.

The demographic transition of Pakistan's population where a massive / very high proportion comprises youth makes it a highly lucrative / adventitious business hub for international vape manufacturers. These products are systematically glamorized / advertised across digital spaces, using vibrant flavors and discreet trending graphic designs that directly appeal to school, college, and university students.

However, emerging clinical data underlines that vaping is far from benign cancer. Although it lacks the carbon monoxide and heavy tar profiles of regular tobacco, its aerosol generates highly toxic chemical species. Chronic PNS and CNS deficiencies, pulmonary inflammation (such as e-cigarette or vaping product use associated lung injury, or EVALI), and profound cardiovascular strain are actively being recorded in young populations. Target physiological atrophy, slow regular recovery of endothelial cells, and chronic sympathetic overactivation are among the major deficits seen today.

This review provides a comprehensive look into the Pakistani youth context, detailing the socioeconomic factors driving ingestion, chemical biochemistry, cellular cardiotoxicity mechanisms, and current clinical hurdles and issues in reversing these damages before they progress to early onset ischemic heart disease, arrhythmia, and strokes.

RISING TRENDS AND EPIDEMIOLOGY IN PAKISTANI YOUTH

The surge of vaping in Pakistan represents an escalating / igniting public health crisis. What was initially perceived as a high socioeconomic urban fashion statement has aggressively trickled down across diverse student populations.

Prevalence and Demographics

Epidemiological studies indicate that vaping has expanded past traditional tobacco limits. In cross sectional assessments among Pakistani teen-agers (aged 16–19), e-cigarette use was found to reach an alarming 49.1% in sampled college cohorts. In university settings, such as multi institutional surveys in different areas and institutions of Lahore and Peshawar, vaping is highly prevalent among both undergraduate and postgraduate student bodies.

Analytical focus reveals that prevalence is heavily skewed toward non healthcare students, who exhibit a significantly higher rate of vaping initiation compared to medical and allied health students ($p < 0.01$). This disparity is attributed to the academic exposure of healthcare students, who maintain a more grounded clinical understanding of nicotine kinetics and tissue toxicity, while non-healthcare counterparts operate under heavily marketed safety illusions.

Socioeconomic and Digital Drivers

The rapid integration of vaping into Pakistani youth culture is driven by clear sociocultural components:

The Normalization Matrix: Increased urbanization across major cities (e.g., Karachi, Lahore, Islamabad, Peshawar) has caused a boom in specialized vape boutiques, granting unchecked physical access to minors.

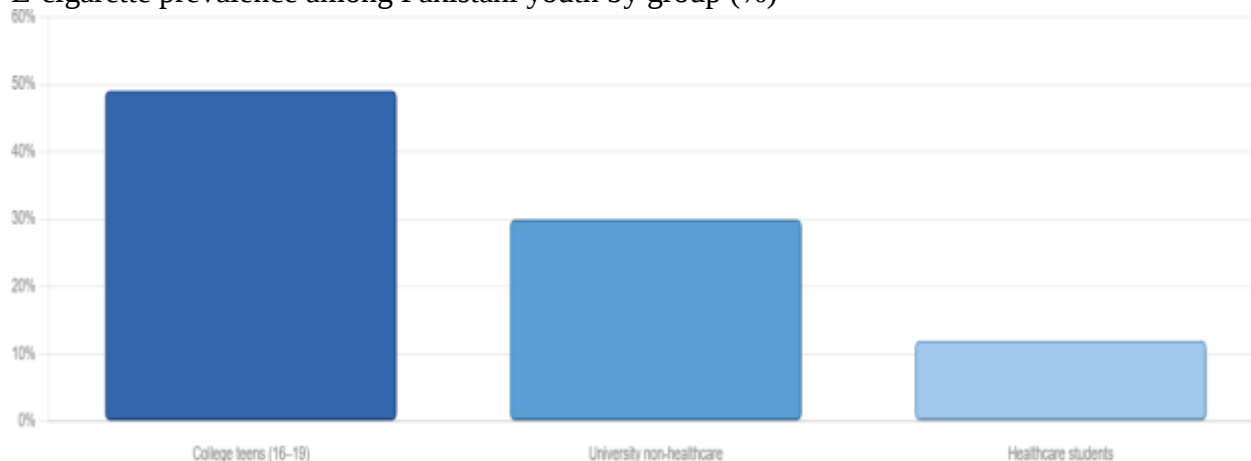
Digital Glamorization: Social media algorithms targeted at Pakistani demographics showcase vaping as a sophisticated, risk free alternative to combustible smoking.

Lax Legislative Status:

Unlike combustible cigarettes, which face public usage restrictions and heavy taxation, ecigarettes exist in a deep gray market with minimal age verification at points of sale.

GRAPHICAL EXPLANATION

E-cigarette prevalence among Pakistani youth by group (%)



BIOCHEMISTRY OF E-CIGARETTES VS. TRADITIONAL SMOKING

Evaluating the cardiovascular consequences of vaping requires an objective understanding of its aerosol chemistry. e-cigarettes do not rely on the combustion of tobacco leaves; instead, they utilize an electrical battery to heat an e-liquid matrix, transforming it into a micro-aerosol.

Chemical Composition

The base liquid consists of solvent carriers, predominantly propylene glycol (PG) and vegetable glycerin (VG), mixed with highly concentrated nicotine fractions and complex flavoring agents (e.g., menthol, ethyl vanillin, diacetyl). While PG and VG are considered safe for ingestion by food registries, their thermal degradation via sub ohm heating elements generates toxic, reactive intermediate compounds.

Chemical Category	Specific Compounds	Present	Acute Cardiovascular Ingestion Effect
Nicotine Fractions	Free base Nicotine, Nicotine Salts	Sympathetic overdrive, immediate vasoconstriction, heart rate acceleration.	
Reactive Aldehydes	Formaldehyde, Acetaldehyde, Acrole	Severe oxidative stress, cross linking of vascular DNA, endothelial inflammation.	
Volatile Organics & Metals	Benzene, Toluene, Cadmium, Nickel, Lead	Direct cardiomyocyte cytotoxicity, reduction of antioxidant defense cascades.	

TOXICOLOGICAL DIVERGENCE

Traditional cigarettes introduce over 7k chemicals, including tar and carbon monoxide, which severely restrict oxygen carrying capacity via carboxyhemoglobin formation.

ecigarettes, while lacking tar, generate a highly concentrated intake of ultrafine particulate matter and nicotine salts. Nicotine salts allow users to inhale vastly higher concentrations of nicotine without suffering the immediate airway irritation typically triggered by freebase formulas. This massive nicotine delivery rapidly hits the vascular endothelium, driving acute cardiovascular stresses that can equal or exceed the autonomic impact of a standard cigarette.

PATHOPHYSIOLOGICAL MECHANISMS OF CARDIOVASCULAR DAMAGE

The structural and functional damage to the cardiovascular system induced by e-cigarettes occurs through distinct cellular and molecular pathways.

Nicotine Induced Sympathetic Overactivation

Nicotine acts as a potent agonist at nicotinic acetylcholine receptors (nAChRs) located throughout the central and peripheral nervous systems. Upon binding, it triggers an immediate systemic release of catecholamines (epinephrine and norepinephrine).

Hemodynamic Changes:

This systemic surge causes immediate chronotropic and inotropic spikes, raising heart rate and blood pressure.

Arrhythmogenic Potential

In young Pakistani adults, who frequently report persistent palpitations during clinical surveys (11.25 % in highly active cohorts), this chronic state of hyper sympathetic control disrupts normal cardiac electrophysiology, lowering heart rate variability (HRV) and elevating the risk of localized ischemic events.

Endothelial Dysfunction and Oxidative Stress

The vascular endothelium is responsible for maintaining vascular tone, regular blood flow, and localized anti-inflammatory balances through the production of nitric oxide 1/NO. Ingestion of e-cigarette aerosols rapidly interrupts this homeostatic pathway.

ROS Generation

Thermal degradation products like acrolein and formaldehyde trigger a massive intracellular surge of Reactive Oxygen Species (ROS).

Pro Inflammatory Cascade: ROS directly reduces the bioavailability of 1/NO by uncoupling endothelial nitric oxide synthase 1/NOS. This cellular damage is marked by a systemic rise in inflammatory biomarkers, including C-reactive protein (CRP), Interleukin 6 (IL-6), and Tumor Necrosis Factor alpha (TNF\alpha).

Vascular Remodeling:

Deprived of 1/NO blood vessels are locked in a constricted/ tightened state, enabling the expression of adhesion or cohesion molecules that recruit inflammatory Macrophages, initiating early stage atherosclerotic plaques.

Accelerated Arterial Stiffness

Long term structural monitoring of young e-cigarette users indicates structural modifications in the arterial tree. The chronic presence of circulating aldehydes combined with sub clinical vascular inflammation induces a phenotypic shift in vascular smooth muscle cells. This shift accelerates the degradation of elastin fibers and drives the abnormal deposition of collagen within the medial layer of large conduit arteries, causing premature arterial stiffness. This stiffening elevates pulse

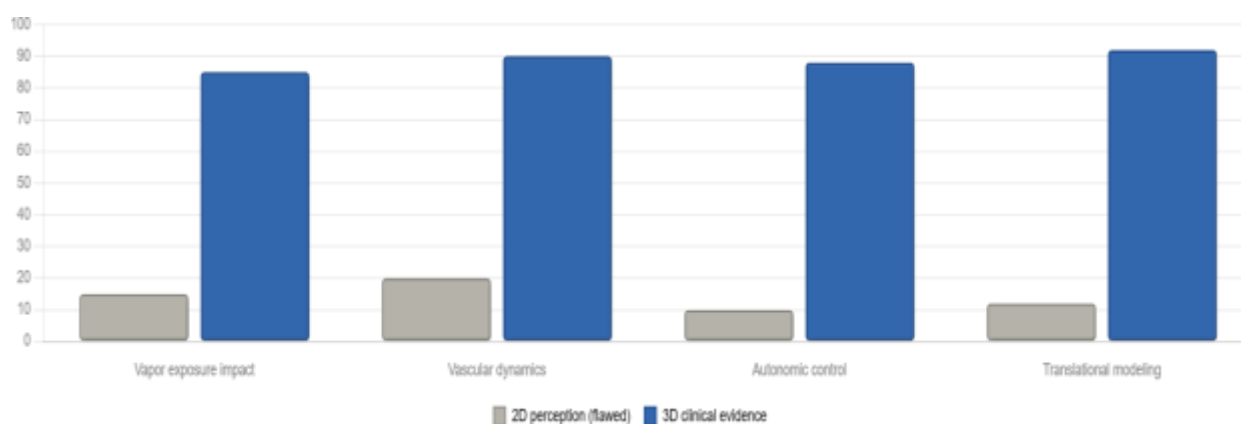
wave velocity, placing an unnatural, premature workload on the left ventricle of the developing heart

COMPARATIVE SYSTEMIC PATTERNS: 2D PERCEPTIONS VS. 3D REALITIES

To better contextualize how healthcare research evaluates these toxicological hazards, it is useful to compare older research frameworks with modern translational insights.

Historically, safety assumptions were based on flat, isolated "2 Dimensional" risk paradigms (evaluating single chemicals or brief exposures). Modern translational medicine utilizes multidimensional "3D" structural paradigms to map out real world physiological impacts.

2.2D vs 3D understanding: perceived vs actual cardiovascular impact.



Model Perspectives on Vaping Cardiotoxicity: □

The following outlines shows how clinical and structural understanding has evolved:
Analysis Dimension Traditional 2D Perceptions (Flawed Assumptions) Modern 3D Realities (Clinical Evidence) Key Cardio-vascular Outlook

Vapor Exposure Impact Evaluated as a simple water vapor matrix with temporary, isolated effects on target tissues. Confirmed as a complex chemical aerosol generating sustained systemic cellular mutations. Triggers chronic oxidative stress, altering DNA and cell viability.

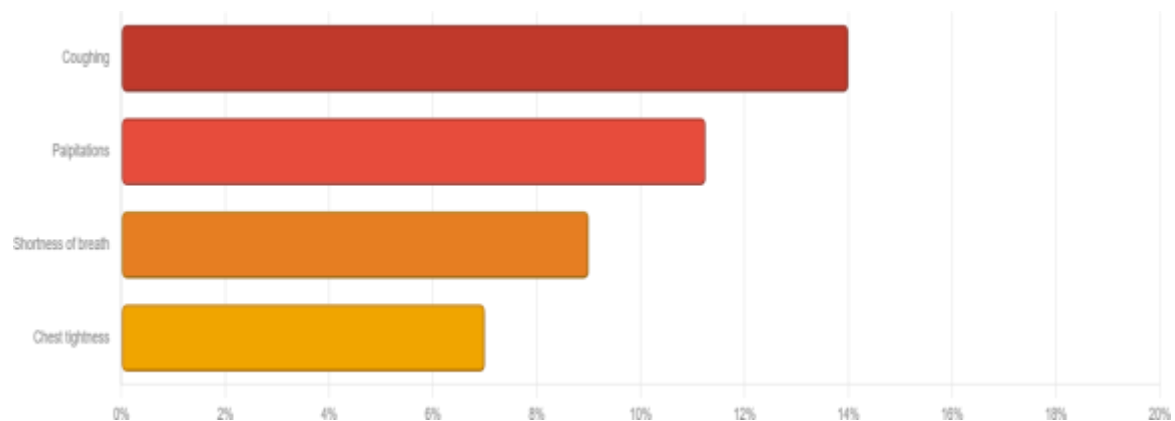
Vascular Dynamics Assumed localized transient blood pressure fluctuations that normalize immediately after use. Documented persistent endothelial injury with long term vascular stiffening. Leads to sustained reductions in 1/NO bioavailability and chronic vessel strain.

Autonomic Control Perceived as a mild, short term stimulant effect comparable to caffeine intake. Clinically proven long term sympathetic hyper activation and reduced heart rate variability. Increases baseline susceptibility to arrhythmias and early myocardial infarctions.

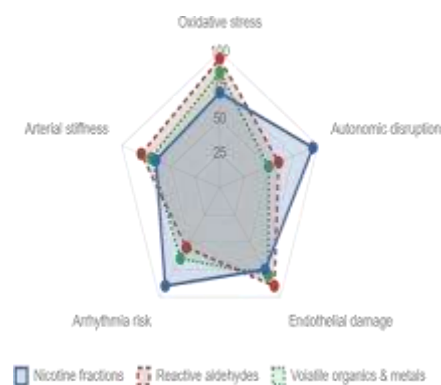
Translational Modeling Relied on isolated cell monolayers, ignoring multi system organ interactions. Employs advanced human -organ on a chip- and integrated biomarker matrices. Allows real time evaluation of vascular tissue degradation and systemic inflammation.

GRAPHICAL EXPLANATION

Cardiovascular symptom reports in active young vapers (%)



Chemical cardiotoxicity severity score by compound class (relative scale)



Nicotine fractions Reactive aldehydes Volatile organic and metals

CURRENT CHALLENGES IN THE PAKISTANI CONTEXT

Addressing the vaping epidemic among Pakistani youth presents several complex challenges:

The Harm Reduction Illusion: A significant portion of the undergraduate student population firmly believes E-cigarettes are completely safe or useful cessation tools. This misconception/ myths delays early clinical intervention and masks the emergence of cardiovascular symptoms.

Diagnostic Data Scarcity: While short term symptoms like palpitations, coughing, and shortness of breath are widely acknowledged by young users in clinical surveys, long term diagnostic tracking remains limited. Most Pakistani medical centers lack standardized, longitudinal screening methods such as flow-mediated dilation or pulse wave analysis specifically designated for young, asymptomatic vapers.

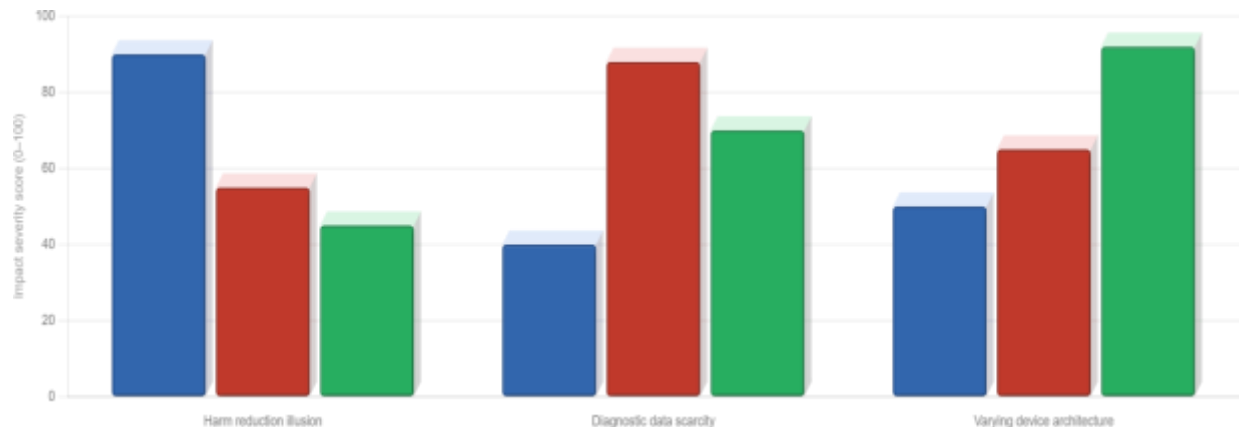
Varying Device Architecture: The Pakistani market is flooded with diverse, unregulated hardware devices ranging from refillable open systems to high voltage disposable pods. This immense variation makes it difficult for researchers to

standardize exposure levels, as different operating temperatures and voltage configurations alter the toxicity and concentration of the inhaled aerosols.

GRAPHICAL EXPLANATION

Current challenges in the Pakistani vaping context — severity & impact score
Each challenge rated across three impact dimensions (0–100 scale, based on review evidence)

Public awareness gap Clinical/ diagnostic deficit Regulatory/ research barrier



□ Socio Cultural Normalization: □

Vaping has become deeply embedded in urban social routines. This rapid cultural normalization creates strong resistance to smoking cessation programs, as peer/ colleagues influence frequently overrides public health warnings.

CONCLUSION AND FUTURE DIRECTIONS

Electronic cigarettes present an escalating, documented threat to the cardiovascular health of Pakistan's youth. The widespread belief that vaping is a safe alternative to combustible smoking is thoroughly refuted by clear biochemical and clinical evidence. Chronic use of these systems triggers persistent autonomic strain, endothelial degradation, and premature vascular aging, creating a high risk environment for future cardiovascular disease in a crucial segment of the country's population.

To protect future generations, immediate public health interventions must be implemented. Pakistan must establish strict regulatory frameworks governing the import, manufacture, and digital marketing of electronic nicotine delivery devices. Educational programs must be broadened beyond medical campuses to clear up safety misconceptions among non healthcare student bodies. Finally, clinical trial designs must prioritize long term, multi system tracking of youth cohorts to accurately map out and address the cardiovascular damage caused by this modern epidemic.

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