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HEALTH IMPLICATIONS FORECAST FOR ELECTRONIC CIGARETTE USERS

Abstract. Electronic cigarettes have rapidly gained popularity in the tobacco market, primarily among young adults. Marketers exploit the lack of evidence regarding their health effects and label them as a safe alternative to traditional cigarettes. Our study aims to expand the existing body of evidence on their impact on the human body. Objective: To identify the most significant characteristics of individuals using electronic cigarettes based on statistical analysis of clinical and laboratory examination data. **Materials and Methods.** The study included 102 participants (main group – 66 individuals using electronic cigarettes as an alternative form of smoking; control group – 36 individuals who did not use electronic or industrial cigarettes) aged 20 to 35 years. Each participant provided written informed consent to participate. Patient examinations included the following parameters: height, weight, body mass index (BMI) calculation; measurement of blood pressure, heart rate, pulse, and respiratory rate; throat swab collection. **Results.** According to our data, individuals in the main group had higher height, weight, and BMI values. A higher BMI may be associated with excessive stimulation of salivary glands and, consequently, increased gastric secretion and appetite stimulation. Electronic cigarette users had significantly higher blood pressure levels compared to the control group. Users of nicotine delivery systems in throat swabs had significantly higher levels of mucus, coccal flora, and neutrophil percentage, indicating the presence of bacterial agents in the oral cavity mucosa. This may be related to bacterial agents' dissemination through nicotine delivery devices. We conducted multiple logistic regression analysis with potential patient characteristics. **Conclusions.** Electronic cigarette users are characterized by higher height, weight, BMI, blood pressure levels compared to non-smoking peers, as well as reduced adaptation potential and a prevalence of parasympathetic nervous system regulation. It was found that a typical electronic cigarette user is a male (OR = 15.9364) with reduced IFZ – adaptive potential of functional abilities (OR = 7.8128) and an abnormal amount of oral cavity flora (OR = 1.7748).

Keywords: smoking; nicotine delivery systems; nicotine; respiratory tract infections; immunology; adults.

INTRODUCTION

In the contemporary world, electronic cigarettes have emerged as one of the most pertinent and debated topics in the realms of public health and medical research. Thanks to their technological innovations and attractive marketing, they have swiftly gained popularity among various demographic groups. However, the absence of proper regulatory systems and a scientific consensus regarding their impact on health poses a significant threat to public well-being [1].

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Despite electronic cigarettes often being perceived as less harmful alternatives to traditional smoking, they still have the potential to pose health risks to users [2]. One of the key aspects is the influence of tobacco heating systems on the state of the oral cavity. The oral cavity serves as the initial point of contact between tobacco products and the body's tissues. It is known that when tobacco is heated in such systems, various chemical substances are emitted, which can affect the structure and functions of the oral cavity [3, 4].

It is noted that even at the manufacturer's claimed optimal temperature for heating tobacco products, partial combustion is unavoidable, accompanied by the release of harmful and carcinogenic substances [5, 6]. Furthermore, inadequate cleaning of devices after use may lead to even higher levels of harmful substances entering the body [7].

Additionally, tobacco heating systems can also impact the upper respiratory tract, such as the aerosol formed during heating, which enters the respiratory system. This can trigger various reactions and consequences for the upper respiratory tract, including inflammation and other pathological scenarios [8, 9].

Objective: Based on the statistical analysis of clinical and laboratory examination data, the aim of this study is to identify the most significant characteristics of individuals who use electronic cigarettes.

MATERIALS AND METHODS

In accordance with the objective of this study, a total of 102 individuals were examined, consisting of the main group (66 individuals who used electronic cigarettes, specifically tobacco heating products (THPs)), and the control group (36 individuals who did not use electronic or industrial cigarettes), aged between 20 and 35 years.

Inclusion criteria for the main observation group:

- Somatic health status.
- Individuals aged 18-35 years.
- Regular use of electronic cigarettes (THPs).
- Absence of acute or chronic diseases, including exacerbations of chronic upper respiratory tract infections.

Exclusion criteria from the main observation group:

- Exacerbations or presence of chronic diseases.
- Smoking of industrial ("traditional") cigarettes.
- Age below 18 or above 35 years.

The current study was conducted in accordance with the principles of bioethics outlined in the Helsinki Declaration "Ethical Principles for Medical Research Involving Human Subjects" and the "Universal Declaration on Bioethics and Human Rights (UNESCO)."

Demographic comparisons of individuals in the main group (n = 66; males – 60.6%, females – 39.4 %) and the control group (n = 36; males – 27.8 %, females - 72.2 %) are presented in Table 1.

Table 1. Characteristics of the main group and control group by age and gender

Indicator	Main group (n = 66)	Control group (n = 36)	P-Value
Age, entire group M (SD)	24.4 (3.5)	24.2 (3.1)	0.7994
Age, males M (SD)	24.8 (3.9)	26.3 (4.5)	0.17716
Age, females M (SD)	23.8 (2.8)	23.6 (2.4)	0.382251

MATERIALS AND METHODS

Informed written consent was obtained from all participants for their involvement in this study.

The general clinical examination of patients included the following parameters: determination of height and weight, calculation of the Body Mass Index (BMI), measurement of arterial blood pressure on both arms, measurement of heart rate, pulse rate, and respiratory rate.

The Kerdo index was calculated using the formula:

$$K = (SBP - DBP) / P,$$

where:

K – Kerdo index,

SBP – systolic blood pressure,

DBP – diastolic blood pressure,

P – heart rate.

The Hildebrandt index (Q) was calculated using the formula:

$$Q = HR / RR, \text{ in arbitrary units,}$$

where:

HR – heart rate in beats per minute,

RR – respiratory rate in breaths per minute.

The Functional Change Index (FCI) was determined in arbitrary units using the formula:

$$FCI = 0.011 * HR + 0.014 * SBP + 0.008 * DBP + 0.014 * W + 0.009 * WT - 0.009 * H - 0.27,$$

where:

HR – heart rate,

SBP – systolic blood pressure,

DBP – diastolic blood pressure,

H – height,

WT – body weight,

W – age.

To achieve the study objectives, the following methods were utilized: examination of throat mucous membrane imprints was carried out in the diagnostic laboratory of the therapeutic and diagnostic center of "Pharmacies of the Medical Academy" LLC.

In accordance with the methodology [10], throat swab sampling was performed on an empty stomach or not earlier than 2 hours after eating, drinking, or gargling. The collected material was applied to a glass slide, dried at room temperature, and then transported to the laboratory in a container.

Statistical analysis of the obtained results was conducted using licensed software Microsoft Excel and Statistica v.6.1. Since more than 90% of the data had a normal distribution, preference was given to parametric statistical methods. The obtained results were considered statistically significant at a significance level (p) of less than 0.05.

Table 2. Comparison of clinical fasting data of the main and control groups

Indicator	Main group (n = 66)		Control group (n = 36)		P-Value
	Mean (M)	SD	Mean (M)	SD	
Height (cm)	173.9167	9.1319	167.6875	7.556	0.0014*
Weight (kg)	75.3133	14.1179	62.5563	13.0873	0.0001*
BMI (Body Mass Index)	24.939	3.6822	21.9887	3.3256	0.0003*
Respiratory Rate (RR)	17.2069	1.8234	16.9375	2.1089	0.5276
Heart Rate (HR)	75.0667	11.1779	74.25	10.3019	0.7326
Pulse Rate	75.0667	11.1779	74.25	10.3019	0.7326
Left Systolic Blood Pressure (LSBP)	120.6667	11.7295	113.125	4.9757	0.0008*
Right Systolic Blood Pressure (RSBP)	121.4828	11.7596	112.875	6.0947	0.0002*
Left Diastolic Blood Pressure (LDBP)	78.3667	8.9309	70.875	4.7093	<0.0001*
Right Diastolic Blood Pressure (RDBP)	77.4483	9.2966	70.25	5.6511	0.0001*
Q (Hildebrandt Index)	4.4117	0.7662	4.4369	0.7257	0.8791
Kerdo Index	-6.4952	18.2447	3.1437	12.5586	0.0091*
IFZ (Functional Changes Index)	2.2908	0.3979	2.0051	0.4387	0.002*

*statistically significant at $p < 0.05$ level

According to our data (Table 2), individuals in the main group had significantly higher values for height, weight, and body mass index (BMI). In our opinion, a higher BMI may be associated with excessive stimulation of salivary glands and, as a result, increased gastric secretion and appetite stimulation.

Electronic cigarette users had significantly higher levels of both systolic and diastolic blood pressure compared to the control group.

The average value of the Functional Change Index (FCI), which reflects the adaptational potential of the cardiovascular system, was within the range of satisfactory adaptation but was statistically lower in electronic cigarette users, unlike those who did not smoke.

When assessing the results of the Kerdo index calculation, it was found that in the group of nicotine delivery system users, a parasympathetic type of regulation of the nervous system prevailed, whereas in the control group, a sympathetic type of regulation was predominant.

Table 3. Comparison of microscopic examination data of the impression from the mucosa of the posterior wall of the throat

Indicator	Main group (n = 66)		Control group (n = 36)		p-value
	Mean (M)	SD	Mean (M)	SD	
Eosinophils %	0.09375	0.5261	0.4286	1.1362	0.0557
Epithelial cells	7.8125	3.6899	7.500	4.2120	0.7213
Leukocytes	3.1562	3.7973	3.2143	7.7381	0.9615
Neutrophil %	3.0312	17.0107	13.8571	34.5679	0.0467*
Microbiota	1.5938	0.8304	1.0000	0.5443	0.0008*
Mucus	0.6875	0.5308	0.3571	0.4880	0.006*

*statistically significant at $p < 0.05$ level

The analysis of the results in Table 3 indicated that users of nicotine delivery systems had significantly higher levels of mucus, flora (coccal), and neutrophil percentage in the throat mucous membrane imprints, which may suggest the presence of bacterial agents in the oral cavity. In our opinion, this could be associated with continuous inoculation of bacterial agents through nicotine delivery devices. The user descriptions of electronic cigarettes mentioned information about the regular cleaning of the heating element, but there were no indications regarding hygiene (antibacterial) treatment. Since tobacco heating systems have lower heating temperatures and are reusable, this may promote the growth and proliferation of persistent pathogenic microflora [11].

To assess the potential impact of nicotine delivery systems on the smoker's body, a multiple logistic regression analysis was conducted with parameters that could potentially be used as characteristics of these patients. We used stepwise inclusion of independent variables in the multiple logistic regression analysis.

Table 4. Prediction of the impact of selected variables on electronic cigarette users

Predictor variables	Regression coefficient (β) Values	Standard error of regression coefficient (β) values	Wald Chi-Square (χ ²) Values	p-value χ ²
IFZ (Functional Adaptation Index)	2.05576	0.89878	5.2317	0.0222
Flora (Microbiota)	0.57371	0.03009	1.7794	0.0018
Male Gender	2.76861	0.94112	8.6544	0.0033
Constant	-5.13045	2.04303	6.3061	0.0120

Taking into account the obtained data (Table 4), the equation for predicting the long-term impact of general clinical and laboratory research factors is as follows:

$$Y = \exp(-5,13045 + 2,05576 \times x_1 + 0,57371 \times x_2 + 2,76861 \times x_3) / [1 + \exp(-5,13045 + 2,05576 \times x_1 + 0,57371 \times x_2 + 2,76861 \times x_3)]$$

Table 5. Odds ratios for multiple logistic regression

Factors	Odds Ratios	95 % Confidence Intervals
IFZ (Functional Index)	7.8128	1.3420 to 45.4844
Flora (Microbiota)	1.7748	0.7639 to 4.1234
Male Gender	15.9364	2.5194 to 100.8055

Analysis of the data in Table 5 revealed that a typical user of electronic cigarettes is a male individual (OR = 15.9364) with a reduced Functional State Index (FSI) - an indicator of adaptive potential (OR = 7.8128) and an abnormal amount of oral cavity flora (OR = 1.7748).

The receiver operating characteristic (ROC) curve analysis and the area under the curve (AUC) were used to assess the predictive accuracy of the logistic regression equation. It was determined that the predictive model in the form of a logistic regression equation has good operational characteristics: sensitivity of 66.67 %, specificity of 81.69 %, and an area under the ROC curve of 0.846 (95 % CI 0.751 – 0.915; p < 0.0001).

CONCLUSIONS

1. Users of electronic nicotine delivery devices are characterized by higher height, weight, body mass index (BMI), and blood pressure levels compared to non-smoking peers.
2. Young individuals who use electronic cigarettes have reduced adaptive potential and are characterized by a predominance of parasympathetic nervous system regulation compared to non-smokers.
3. Based on the conducted multiple logistic regression analysis, it has been proven that a typical electronic cigarette user is a male individual (OR = 15.9364) with reduced Functional State Index (FSI) – an indicator of adaptive potential (OR = 7.8128) and an abnormal amount of oral cavity flora (OR = 1.7748).

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ПРОГНОЗ ПОРУШЕНЬ СТАНУ ЗДОРОВ'Я ОСІБ, ЩО ВИКОРИСТОВУЮТЬ ЕЛЕКТРОННІ СИГАРЕТИ

Анотація. Електронні сигарети швидко завоювали ринок тютюнових виробів, які вживає здебільшого молодь. Маркетологи маніпулюють браком доказів щодо впливу на здоров'я та називають їх безпечною альтернативою звичайним сигаретам. Наша робота покликана розширити наявну доказову базу щодо їх впливу на організм. **Мета.** На підставі статистичного аналізу даних клінічного та лабораторного обстеження визначити найбільш вагомі характеристики осіб, що використовують електронні сигарети. **Матеріали і методи.** В дослідження увійшло 102 особи (основна група – 66 осіб, які у якості альтернативного виду тютюнопаління – використовували електронні сигарети; група контролю – 36 осіб, які не використовували електронні або промислові сигарети) віком від 20 до 35 років. Кожен учасник дослідження надав письмову інформовану згоду на участь. Обстеження пацієнтів включало наступні параметри: визначення зросту, ваги, обчислення ІМТ; вимірювання артеріального тиску, частоти серцевих скорочень, пульсу, частоти дихання; взяття мазка-відбитку з задньої стінки глотки. **Результати.** Згідно з нашими даними, представники основної групи мали вищі показники зросту, ваги та індексу маси тіла. Більш високий ІМТ може бути пов'язаний з надмірною стимуляцією слинних залоз та, як результат, підвищенням шлункової секреції і стимуляції апетиту. Курці електронних сигарет мали достовірно вищі рівні артеріального тиску порівняно з групою контролю. У користувачів систем доставки нікотину у мазку-відбитку зіву виявилися достовірно вищими кількість слизу, флори (кокова) та відсоток нейтрофілів, що може вказувати на наявність бактеріальних агентів на слизовій ротової порожнини. Це може бути пов'язано з інсемінацією бактеріальними агентами через засоби доставки нікотину. Нами проведено множинний логістичний регресійний аналіз з показниками, які потенційно можна використовувати як характеристики цих пацієнтів. **Висновки.** Користувачі електронних сигарет характеризуються більш високими показниками зросту, ваги, ІМТ, рівнів артеріального тиску у порівнянні з однією групою, які не палять, а також демонструють знижений адаптаційний потенціал та характеризуються превалюванням парасимпатичного типу регуляції нервової системи проти осіб, які не є курцями. Встановлено, що типовим користувач електронних сигарет це – особа чоловічої статі (ВШ = 15,9364) зі зниженням ІФЗ – адаптаційний потенціал функціональних можливостей (ВШ = 7,8128) та має аномальну кількість флори ротової порожнини (ВШ = 1,7748).

Ключові слова: куріння; системи доставки нікотину; нікотин; інфекції респіраторного тракту; імунологія; дорослі.

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