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Inclusion in an NLM database does not imply endorsement of, or agreement with, the contents by NLM or the National Institutes of Health.\nLearn more:\nPMC Disclaimer\n|\nPMC Copyright Notice\nCureus\n. 2024 Oct 22;16(10):e72109. doi: 10.7759/cureus.72109\nVaping Possible Negative Effects on Lungs: State-of-the-Art From Lung Capacity Alteration to Cancer\nFakher Rahim 1,\u2709, Karlygash Toguzbaeva 2, Dmitriy Sokolov 2, Kenesh O Dzhusupov 3, Abzal Zhumagaliuly 2, Ainur Tekmanova 2, Elmira Kussaiynova 2, Aiya Katayeva 2, Sholpan Orazbaeva 2, Aidana Bayanova 2, Mariyam Olzhas 4, Alina Zhumataeva 5, Sabina Moldabekova 5\nEditors: Alexander Muacevic, John R Adler\nAuthor information\nArticle notes\nCopyright and License information\n1\nDepartment of Medical Laboratory Technologies, Alnoor University, Mosul, IRQ\n2\nDepartment of Public Health, Asfendiyarov Kazakh National Medical University, Almaty, KAZ\n3\nPublic Health Sciences, International Higher School of Medicine, Bishkek, KGZ\n4\nBiology, Haileybury Astana School, Astana, KAZ\n5\nBiology, School-Gymnasium #22, Astana, KAZ\n\u2709\nFakher Rahim rahim.fakher@sulicihan.edu.krd\n\u2709\nCorresponding author.\nAccepted 2024 May 14; Collection date 2024 Oct.\nCopyright \u00a9 2024, Rahim et al.\nThis is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.\nPMC Copyright notice\nPMCID: PMC11580103 PMID: 39574999\nAbstract\nVaping has emerged as a popular alternative to traditional smoking. It produces smokeless vapour by heating an e-liquid mixture in an atomizer. This paper delves into the current state of knowledge surrounding electronic cigarettes, exploring the gap between the perceived safety of e-liquids and the emerging evidence of their harmful effects when inhaled. As we navigate this intricate landscape, it is crucial to unravel the complexities of vaping and its implications for public health.\nWe conducted a three-layer systematic review of the guidelines set by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) and Meta-analyses of Observational Studies in Epidemiology (MOOSE). The search was performed in three layers, including the first layer, the effect of vaping on lung function; the second layer, the effect of vaping on lung structure and inducing lung injury; and the third layer, the physiopathologic effect of vaping on the lung and a possible carcinogenic effect.\nExposure to e-cigarette vapour reduced lung ventilation in adult male Long-Evans rats, indicating impaired lung function. In male Wistar rats, vaping was associated with a decrease in lung air volume and denser lung tissue structure. Studies on guinea pigs showed that vaping caused acute bronchoconstriction, contributing to lung function impairment.\nA case study of a young man with an E-cigarette and vaping-induced lung injury (EVALI) highlighted the detrimental effects of vaping on human lung function. The EVALI outbreak in the USA was linked to harmful substances in vapes, such as vitamin E acetate and THC, leading to serious lung injuries, including pneumonia and bronchiolitis. Vaping poses significant health risks, especially to young adults, and misconceptions regarding its safety persist despite evidence of its potential to cause various lung diseases.\nWhile vaping has positioned itself as a smoking cessation aid, the discussion surrounding its impact on lung health requires careful consideration. The lack of conclusive evidence on the long-term effects of vaping underscores the need for further research. However, existing data suggest that vaping is not without risks, and its potential association with respiratory issues and cancer underscores the urgency of public health interventions.\nKeywords: cancer, electronic cigarettes, lung function, lung injury, vape\nIntroduction and background\nElectronic cigarettes, commonly referred to as vape pens, have emerged as a popular alternative to traditional smoking, producing smokeless vapour by heating an e-liquid mixture in an atomizer [ 1]. The e-liquid, while deemed safe for oral ingestion [ 2], raises concerns when inhaled as an aerosol. Since its inception in 2003, vaping has consistently increased in popularity [ 3]. Despite claims suggesting that vaping is less harmful than smoking, a growing body of evidence establishes links between vaping and various adverse health outcomes [ 4].\nContrary to the perceived safety of e-cigarettes, the Centres for Disease Control and Prevention (CDC) reported 2,807 cases of pulmonary damage associated with e-cigarette or vaping product use during hospital stays in early 2020 [ 5]. A 2019 study revealed alarming symptoms in individuals hospitalized due to e-cigarette or vaping-related lung damage, including decreased blood oxygen levels, elevated body temperature, inflammatory responses, and abnormal lung opacities observed on imaging scans [ 6].\nStudies have shown a significant increase in vaping among youth, with a National Youth Tobacco Survey finding that 4.9% of middle school students and 20.8% of high school students used e-cigarettes within the past 30 days as of 2018 [ 7]. This demographic is particularly at risk of E-cigarette and vaping-induced lung injury (EVALI), highlighting the urgent need for public health interventions. This accumulating evidence challenges the notion that vaping is a risk-free substitute for traditional cigarette smoking.\nIn this context, it is imperative to critically examine the existing literature on the chemistry and toxicology of vaping and shed light on the potential health risks associated with this rapidly growing phenomenon [ 1]. This paper delves into the current state of knowledge surrounding e-cigarettes, exploring the gap between the perceived safety of e-liquids and the emerging evidence of their harmful effects when inhaled. As we navigate this intricate landscape, it is crucial to unravel the complexities of vaping and its implications for public health.\nReview\nMethods\nDesign\nWe conducted a three-layer systematic review of the guidelines set by the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) [ 8]. This review was not pre-registered, and the study results should be considered exploratory.\nSearch Strategy\nThe search on PubMed was performed in three layers: the first layer, the effect of vaping on lung function; the second layer, the effect of vaping on lung structure and inducing lung injury; and the third layer, the physiopathologic effect of vaping on the lung and possible carcinogenic effect (Figure 1).\nFigure 1. A schematic illustration of the possible effects of vaping or e-cig on the lungs and respiratory system.\n[Open in a new tab]\nOriginal illustration, made by the author, F. Rahim\nFirst layer: This layer is concerned with the association between vaping and lung function. We used keywords including (((\"ERV\"[Title/Abstract] OR \"expiratory reserve volume\" [Title/Abstract] OR \"FEFmax\"[Title/Abstract]) AND (\"FRC\"[Title/Abstract] OR \"functional residual capacity\"[Title/Abstract])) OR (\"FVC\"[Title/Abstract] OR \"forced vital capacity\"[Title/Abstract])) AND (\"IC\"[Title/Abstract] OR \"inspiratory capacity\"[Title/Abstract]) to find all available evidence on the effect of vape or electronic cigarette on lung function and capacities.\nSecond layer: This layer was about the association between vaping and lung injury. The search was performed using specific keywords (((((vape [Title/Abstract]) OR (electronic cigarette [Title/Abstract])) OR (vaping [Title/Abstract])) OR (e-cigarette [Title/Abstract])) AND ((lung [Title/Abstract]) AND (injury [Title/Abstract]))), covering the period from July 15, 2015, to December 2023, without any language limitations. EVALI cases were first reported to the Centres for Disease Control and Prevention (CDC) in August 2019 and rapidly increased thereafter, suggesting new or increased exposure to one or more toxicants from the use of e-cigarette products [ 9].\nThird layer: This layer was about the association between vaping and lung cancer. We also used keywords such as (\"vape\"[Title/Abstract] OR \"electronic cigarette\"[Title/Abstract] OR \"vaping\"[Title/Abstract] OR \"e-cigarette\"[Title/Abstract]) AND (\"cancer\"[Title/Abstract] OR \"neoplasm\"[Title/Abstract] OR \"tumorigenic\"[Title/Abstract]) to find all available evidence on the effect of vape or electronic cigarette on pathology or physiology and ultimately possible inducing cancer.\nThe inclusion criteria were as follows: (i) Study types included are original research articles, including observational studies (cohort, case-control, and cross-sectional), randomized controlled trials, and case reports that investigate the effects of vaping on lung health; (ii) subjects: studies involving humans of any age, sex, and health status; (iii) measured parameter: articles that assess lung function, structural lung injury, physiopathological effects, and potential carcinogenic outcomes related to vaping; (iv) publication language: studies published in English; (v) date of publication: studies published between July 15, 2015, and December 2023.\nThe exclusion criteria were as follows: (i) study types: reviews, editorials, commentaries, and letters to the editor; (ii) subjects: studies on animals, unless the findings are directly related to human health implications and are used to supplement human data; (iii) measured parameters: articles that do not directly assess the impact of vaping on lung health, such as those focusing solely on the chemical composition of e-liquids without linking to health outcomes; (4) duplicate studies and studies with incomplete data or those lacking clear methodology and results.\nResults\nWe found 1365 articles in a three-layer search, including 415 on the association between vaping and lung function, 625 on the association between vaping and lung injury, and 330 on the association between vaping and lung cancer (Figure 2). Finally, after removing duplicates, reviews, and letters, 19 articles were selected, including two on the association between vaping and lung function, 14 on the association between vaping and lung injury, and 3 on the association between vaping and lung cancer.\nFigure 2. Flow diagram of search strategy.\n[Open in a new tab]\nVape and Lung Capacity\nFour studies investigated the association between vaping and lung function overall (Table 1). In a study by Stokes and Fisher, adult male Long-Evans rats exposed to e-cigarette vapour for ten minutes exhibited a reduction in both inhaled and exhaled air per minute, indicating a decrease in overall lung ventilation [ 10]. This reduction in tidal volume might be attributed to protective bronchoconstriction, as observed by Khosravi et al. in adult guinea pigs exposed to vapour [ 11]. Furthermore, Odish et al. reported the case of a 19-year-old man with EVALI, where the history and imaging findings were consistent with lung injury caused by e-cigarette use, emphasizing the negative effects of vapour on lung function [ 12]. Lee et al. conducted a study on young, male Hartley guinea pigs [ 13]. They revealed that vaping induced acute bronchoconstriction, contributing to the impairment of lung function. Yanina et al. observed changes in the morphological and optical properties of lung tissue in male Wistar rats, further supporting the notion that vaping leads to reduced lung function [ 14].\nTable 1. Comparing findings of studies on the effects of vaping on lung capacity.\nStudy ID\nStudy type\nTarget group\nFindings\nInterpretation\nStokes and Fisher [ 10]\nAnimal model\n18 adult male Long-Evans rats\nTidal volume \u2193 Minute ventilation\u2193\nVaping leads to reduced lung function\nYanina et al. [ 14]\nAnimal model\n12 sexually mature male Wistar rats\nthe volume of air in the lung \u2193 packing of lung structures \u2191\nVaping leads to reduced lung function\nOdish et al. [ 12]\nHuman\nA 19-year-old man\nTidal volume \u2193\nVaping leads to reduced lung function\nLee et al. [ 13]\nAnimal model\nYoung, male Hartley guinea pigs\ndynamic lung compliance (Cdyn) \u2193\nVaping affects lung function by evoking acute bronchoconstriction\n[Open in a new tab]\nVape and Lung Injury\nOur search returned 14 studies that discussed the association between vaping and lung injury (Table 2). Research indicates that e-cigarettes, especially those containing nicotine, disturb mitochondrial membrane potential, release ATP and mitochondrial DNA (mtDNA), and trigger inflammatory responses [ 15]. Vitamin E acetate (VEA) is implicated in EVALI. It has been discovered to be a diluting agent in illegal vapour pens. In contrast, nicotine is typically diluted with equal amounts of propylene glycol (PG) and vegetable glycerine (VG) [ 16]. Vaping has become the preferred method of nicotine consumption among young adults (15-24 years old), surpassing traditional cigarettes [ 17]. Studies conducted in a laboratory setting have shown that the survival of normal human bronchial epithelial cells decreases in a manner that is dependent on the dosage when exposed to vapour emitted by electronic vapour devices [ 18]. In 2018, the National Youth Tobacco Survey found that 4.9% of students in middle school and 20.8% of students in high school had used e-cigarettes within the past 30 days [ 18].\nTable 2. Comparing findings of studies on the association between vaping and lung injury.\nHuman pulmonary alveolar epithelial cells (haemic); electronic cigarette (e-Cig); estrogen (ER); E-cigarette and vaping-induced lung injury (EVALI); acute lung injury (ALI); Invasive pulmonary aspergillosis (IPA); ground-glass opacity (GGO); tetrahydrocannabinol (THC)\nStudy ID\nStudy design\nStudy type\nNumber of cases\nTarget group\nSymptoms\nFindings\nDiagnosis\nInterpretation\nItoh et al. [ 19]\nCase-report\nHuman\n1\nA 46-year-old man\nNight sweats, fever, weight loss, pallor\nBilateral GGO\nALI\nVaping leads to EVALI\nLayden et al. [ 20]\nCase-report\nHuman\n98\n15-53-years-old\nShortness of breath, cough, chest pain, nausea, subjective fever\nOpacities in both lungs\nLung injury\nVaping leads EVALI\nAdhikari et al. [ 21]\nCase-report\nHuman\n1\nA 23-year-old\nFever, shortness of breath, tachypnea, nausea, diarrhea\nBilateral infiltrates\nSepsis, pneumonia, lung injury\nVaping leads to EVALI\nSharma et al. [ 22]\nCase-report\nHuman\n1\nA 35-year-old\nRight-sided chest pain and dyspnea\nGround glass opacity in both lungs\nVaping-induced pneumonitis\npneumothorax due to vape/E-cigarette induced EVALI\nSzafran et al. [ 23]\nRCT\nAnimal\n33-36\n6-week-old female mice\n----------- \nMarkers associated with lung immunotoxicity \u2191 Alterations in lung cell immunophenotyping, and immunosuppression; lung tissue resistance\n------------\nExposures to only e-cig without nicotine, affect the lungs.\nWolf and Richards [ 24]\nCase-report\nHuman\n1\nA 29-year-old female\nProfound fatigue, fevers, shortness of breath, respiratory distress\nDiffuse, broncho-centric bilateral ground glass opacities with coalescence to consolidation, largely in the lung bases\nAcute eosinophilic pneumonia\nThe use of e-Cig for vaping THC affects acute eosinophilic pneumonia\nKupelian et al. [ 25]\nCase-report\nHuman\n1\nA 16-year-old man\nTemperature was 37.8 \u00b0C, respiratory rate 44 breaths per minute\nSevere respiratory distress, and auscultation of the lungs revealed bilateral decreased breath sounds, bilateral hazy ground-glass opacities\nIPA as a complication of EVALI\nTHC and other potential contaminants in vaping affect the lungs in the form of EVALI\nStein et al. [ 26]\nCase-report\nHuman\n1\nA 18-year-old man\nShortness of breath, cough or chest pain\nSubjective fever, leukocytosis and bilateral opacities of the \"frosted glass\" type on CT\nEVALI\nVaping with THC leads to EVALI\nHeinzerling et al. [ 27]\nCase report, interview\nHuman\n160\n14-70-years-old\nCough, shortness of breath, and subjective fever or chills\n------------\nEVALI\nEVALI indicates e-Cig, or vaping, produce lung injury\nSmith et al. [ 28]\nCase-report\nHuman\n1\nA 14-year-old girl\nCough, chest discomfort, abdominal pain, and rigors\nDiffuse interstitial markings with hazy patchy nodular infiltrates bilaterally\nAcute lung injury with centrilobular nodules consistent\nThe harmful effects of vaping, especially in young people\nYingchoncharoen et al. [ 29]\nCase-report\nHuman\n1\nAn 18-year-old woman in her 10th week of pregnancy\nProductive cough, and dyspnea and a one-day history of left-sided chest pain\nReduction of air intake into the upper and middle zone of the left lung. left-sided pneumothorax\nEVALI\nVaping induced lung injuries in association with pregnancy and multiple subsequent viral and bacterial infections\nBerkelhamer et al. [ 30]\nClinical trial\nAnimal\n2\nNewborn and adult sheep\n----------------\nRelaxation of bronchial rings, contraction of the smooth muscles of the respiratory tract\n---------\nGestational and postnatal exposure to electronic cigarettes represents rapidly growing threat\nThakrar et al. [ 31]\nCase report\nHuman\n12\nTen male and two female\nDyspnea, abdominal pain and constitutional symptoms\nCentrilobular ground-glass nodules, confluent ground-glass opacities, pleural effusions\nALI\nEVALI\nMessina et al. [ 32]\nCase report\nHuman\n6\n15-20-years-old\nFever, emesis, nausea, abdominal pain, chest pain, headache\nConfluent pulmonary opacities, mediastinal/hilar lymphadenopathy and/or small bilateral pleural effusions (3)\nEVALI\nVaping leads to EVALI\n[Open in a new tab]\nWe reviewed various data regarding the possible effects of vaping/e-cigarettes on lung injury. And as it turned out, in 2019 in the USA, there was an epidemic of EVALI (e-cigarette, or vaping, product use-associated lung injury). Most researchers and doctors agree on the toxic composition of these devices. Vitamin E acetate and/or tetrahydrocannabinol can affect the appearance of pneumonia, broncho-centric bilateral ground glass opacities, and general deterioration of lung function. It is important to note that a clear link has been established between the use of tetrahydrocannabinol in e-cigarettes and EVALI. In addition, as a result of the disease, some patients developed complications in the form of other diseases, such as invasive pulmonary aspergillosis and acute eosinophilic pneumonia. The CDC emphasizes bronchoalveolar lavage (BAL) fluid analysis to detect harmful substances at the presumed site of lung injury [ 9]. Vitamin E acetate in vapes/e-cigarettes presumably enters the respiratory epithelial-lining fluid, which is a suspected site for lung injury. Its effect is established by the method of detecting vitamin E acetate in BAL. Blount et al. found that 48 out of 51 patients with lung injuries had vitamin E acetate present in the BAL fluid [ 9]. It is important to note that 99 healthy participants, according to Blount et al., did not find vitamin E acetate in the BAL liquid [ 9]. Itoh et al. diagnosed e-cig-induced acute lung injury (ALI) caused by using e-cigarettes [ 19]. A 46-year-old man was diagnosed with ALI due to e-cig use [ 19]. Lung histological examination revealed lesions with acute changes, alveolar septum swelling, and eosinophil and neutrophil invasion, with intra-alveolar invasion of eosinophils and neutrophils; in addition, abundant macrophages containing blackish-brown pigment, multinucleated foreign-body giant cells, and intra-alveolar organization [ 19]. It is considered that these changes are due to the ingestion of foreign substances in the composition of the e-cigarette into the respiratory system. Layden et al. presented the results: of the 91 patients who underwent CT imaging, 6 cases of pneumomediastinum, 11 cases of pleural effusion, and 2 cases of pneumothorax were present (in 15 patients) [ 20]. Two patients had both a pneumomediastinum and a pneumothorax, and two patients had both a pneumomediastinum and pleural effusion [ 20]. Adhikari et al., in the case report, presented the results of a 23-year-old man [ 21]. A chest X-ray showed bilateral pneumonia, and a computed tomography (CT) scan of the chest showed bilateral lung infiltrates [ 4]. In another case report described by Sharma et al., a chest X-ray of a 35-year-old man was examined, which showed a right-sided pneumothorax with a slight displacement of the structures of the heart and mediastinum to the left [ 22]. Szafran et al. did a study on mice, and it showed that exposure to only e-cig delivery vehicles, VG/PG, without nicotine, affects the lungs and that the addition of vanilla flavouring may enhance the lung responses [ 23]. There was also a case in the Wolf and Richards et al. report where attention was drawn to acute eosinophilic pneumonia as a potential consequence of lung injury associated with vaping with THC [ 24]. It is worth mentioning another case report where a teenager was diagnosed with invasive pulmonary aspergillosis as a complication after EVALI. Kupelian et al. reported the first case, most likely related to the use of tetrahydrocannabinol and/or vaping [ 25]. In the case report of Stein et al., an interesting case was written about a man with testicular cancer who, during the course of the disease, had bilateral opacities of the \"frosted glass\" type and intrathoracic adenopathy revealed on a CT scan [ 26]. Later, it turned out that the patient smoked THC three times a day. As mentioned, the epidemic of EVALI is associated with the use of tetrahydrocannabinol and vitamin E acetate (VEA) in e-cigarettes. Heinzerling et al. point out that most foods that contain THC also contain VEA, which reinforces the link between these chemicals and the outbreak [ 27]. Vaping with tetrahydrocannabinol significantly increases the risk of lung injury and complications after e-cigarette or vaping product use-associated lung injury (EVALI). Besides the above-mentioned EVALI outcomes, other complications may occur, such as pneumothorax and acute respiratory distress syndrome (ARDS). They are mentioned in the case reports by Smith et al. [ 28] and Yingchoncharoen et al. [ 29]. ARDS is a life-threatening lung injury characterized by the rapid onset of widespread inflammation in the lungs. Multiple risk factors, including pneumonia, non-pulmonary sepsis, aspiration of gastric contents, or inhalation injury, have been reported to cause ARDS [ 29]. Currently, unfortunately, some women use e-cigarettes during pregnancy with the opinion that they are harmless. However, due to the similar development and physiology of sheep and human lungs, Berkelhamer et al. conducted a test on adult sheep and their two-day-old lambs in their study [ 30]. Their data show that foetal and newborn lungs may have increased susceptibility to toxicity when exposed to flavoured e-cigarette solutions and that physiological responses to these common additives may also be altered in immature lungs. We concluded that the use of electronic cigarettes in the foetal period carries a high risk to the foetus. Also, many articles note the bilateral infiltrates, bilateral opacities, and/or ground glass opacity (GGO) in the lungs as a result of smoking e-cigarettes and/or vaping [ 31, 32]. The frightening thing is that in addition to this, the disease is accompanied by various respiratory symptoms and other functional abnormalities with frequent sub-pleural sparing, and small pleural effusions may also be detected. After studying all these articles to identify the link between vaping and lung injury, we conclude that e-cigarette smokers and/or vapers are susceptible to various lung diseases. In particular, due to the legalization of THC in some US states, the situation has accepted and is accepting severe outcomes of smoking electronic cigarettes as well as vaping, which contains vitamin E acetate. Currently, the vaping situation is deteriorating, and it may be a new pandemic, especially among young people and adolescents. Despite the law on the sale of smoking systems only after adulthood, vape shops are not limited to them. Many people mistakenly think that e-cigarettes and vaping are harmless compared to tobacco. However, as can be seen from our review article, the impact is significant and may increase.\nVaping and Lung Cancer\nOnly two studies were about the association between vaping and lung cancer (Table 3 [PNLP1] and [PNLP2]). Lung cancer (LC) is a diverse disease with different clinical and pathological features. It can be histologically classified into two groups: non-small-cell lung cancer (NSCLC) and small-cell lung cancer (SCLC) [ 33]. The diagnostic rate for NSCLC is 85%, while for SCLC it is only 15% [ 34]. Concerning the hereditary predisposition to lung cancer (LC), it has been acknowledged that around 85% of the risk of developing LC is associated with cigarette smoking. Therefore, lung cancer develops in 15% of smokers, suggesting a varying vulnerability to the harmful effects of tobacco carcinogens. Research has indicated that electronic cigarettes (ECs) cause harm to DNA in the lungs and hinder the process of DNA repair in lung tissues. This implicates ECs as a potential cause of lung cancer in mice.\nTable 3. Comparing findings of studies on the effects of vaping on lung cancer.\nEMT: epithelial-to-mesenchymal transition\nStudy ID\nStudy type\nTarget group\nFindings\nInterpretation\nTang et al. [ 36]\nAnimal\n6\u20138-week-old 85 male mice\nLung adenocarcinoma; bladder urothelial hyperplasia.\ne-cigarette smoke exposure induces lung tumour formation in mice\nZahedi et al. [ 37]\nCell line\nA549 CCL-185 cells, which were previously derived from a human lung adenocarcinoma\nEnhanced migration of cells\ne-cigarettes are capable of causing EMT in a cancer cell line\nEvery year, about 2.2 million cases of lung cancer are diagnosed in the world, and it ranks second after breast cancer. Electronic cigarettes have risen in popularity in recent years as a means of consuming nicotine or simulating tobacco smoking without carcinogenic combustion products [ 35]. Most vapers consider smoking electronic cigarettes and/or vaping harmless. Also, some use this type of smoking to reduce the use of tobacco cigarettes. In particular, these smoking systems are common among adolescents and young people due to the availability and lack of regulation of vaping sales. However, are they harmless, and do they affect lung cancer? In 2019, Tang et al. found that exposure to electronic cigarette smoke (ECS) induced lung adenocarcinoma in six- to eight-week-old male mice, suggesting a potential link between ECs and lung cancer [ 36]. As a result of the study, it was noted that exposure to ECS induces the formation of lung tumours in mice. In the same year, Zahedi et al. demonstrated an epithelial-to-mesenchymal transition (EMT) in lung cancer cells during exposure to e-cigarette products, indicating a possible contribution to cancer progression for those at risk for lung cancer [ 37].\nWhile studying the effects of vaping on the lungs, we saw a study where smoking e-cigarettes with nicotine was used to reduce the smoking of conventional cigarettes and improve lung health among chronic smokers undergoing a cancer screening programme [ 38]. Lucchiari et al. showed that 20% of 210 smokers stopped smoking after six months [ 38]. Surprisingly, there were no side effects at the end of the study, but symptoms such as burning in the throat were found in the subjects after smoking electronic cigarettes. The best preventative measure to curb the adverse health effects associated with smoking is abstaining from smoking or tobacco cessation [ 39]. Most cancer patients who persist in smoking already recognize the adverse health effects and the importance of stopping smoking [ 39]. The effects of shaping and e-cigarettes on lung cancer have not been studied as much, although the outcomes can only be guessed. One of the important points is that these types of smoking significantly reduce the functionality of the lungs. As written earlier, exposure to e-cigarettes affects the development of lung adenocarcinoma. Although the carcinogenicity of these tobacco systems has not been fully studied, one can only assume their effect on human health.\nDiscussion\nIn recent times, the widespread adoption of vaping, particularly among youth, has been fueled by enticing advertisements, an array of flavours, and aesthetically pleasing designs. Positioned as a tool for quitting traditional smoking, vaping has indeed facilitated smoking cessation for many over the past few decades. However, the ongoing research into the harms of vaping suggests that, while potentially less harmful than traditional cigarettes, vaping is far from being considered a completely safe practice. This discussion sheds light on the adverse effects of vaping on lung health, emphasizing the need for preventive measures.\nPulmonary Impact of Vaping\nThe impact of vaping on lung health remains an evolving area of investigation, with conclusive results yet to be established. Nonetheless, the documented harm to the lungs associated with vaping is cause for concern. Studies have indicated potential links between vaping and pneumonia, shortness of breath, increased risk of respiratory infections, asthma and bronchitis, and effects on lung tissue [ 40]. Some studies have shown that vaping or e-cigarettes have the potential to increase susceptibility to pneumococcal infection [ 41- 43]. This inflammation may manifest in symptoms akin to respiratory conditions such as asthma and bronchitis. One of the suggested reasons was the effect of vapour on oxidative stress-induced, PAFR-dependent pneumococcal adhesion to airway epithelial cells and pneumococcal colonization in the mouse nasopharynx [ 41]. An alarming observation is the onset of lipoid pneumonia in an otherwise healthy patient using cannabis-containing e-cigarettes, suggesting that the composition of vape liquids plays a crucial role in respiratory complications [ 42]. Some people feel shortness of breath after using a vape [ 44]. This may be a sign of lung irritation and airway obstruction. Research indicates that vaping may compromise the lung's immune system, heightening the risk of respiratory infections [ 45]. Some studies have shown that the use of vaping can cause or affect complications such as exacerbations of asthma and bronchitis in some people [ 46]. Continuous and long-term use of vape may lead to changes in lung tissue. These changes may include inflammation and the destruction of lung tissue.\nRisks Associated With Vape Liquid Components\nThe composition of vape liquids introduces additional considerations for lung health. The inclusion of vitamin E in vape liquids, while commonly used to create vapour in a vape, poses potential risks [ 47]. The 2019 surge in severe lung diseases reported in individuals using vape liquids containing THC and vitamin E underscores the need for scrutiny [ 48]. However, the use of vitamin E in vape liquids does not apply to all vape products. These risks are especially related to the use of vitamin E extracted from natural oils that have been illegally added to vape liquids. High-quality, properly refined vitamin E is suggested to pose fewer risks and may even be used as a dietary supplement for lung health. However, research on the long-term effects of PG and glycerin vaporization is inconclusive, raising questions about the safety of these components, especially with excessive or prolonged use [ 49, 50]. This damage can include lung inflammation, increased lung secretions, cough and sputum, lung infection, and respiratory problems such as bronchitis and asthma.\nGlobal Concerns and Regulatory Considerations\nIn a report, the World Health Organization (WHO) expressed reservations about the widespread use of e-cigarettes, citing concerns about efficacy in smoking cessation and potential harm, especially among youth [PNLP1] [ 51]. Despite having fewer toxic substances than traditional cigarettes, e-cigarettes are considered harmful. The WHO emphasizes that the high-temperature vaporization of liquid nicotine in e-cigarettes can lead to addiction, warranting vigilant monitoring of these devices.\nLong-Term Effects and Comparisons With Smoking\nThe long-term effects of smoking, including a high risk of stroke, heart disease, and various types of cancer, have been well established [ 52- 54]. According to the report published by the Committee for Disease Control and Prevention (CDC), one out of five people dies due to smoking [ 55]. Meanwhile, e-cigarettes seem to be a less risky option for people who want to quit smoking. Using an electronic cigarette to quit smoking does not mean that it is safe. Even if the vape liquid does not contain nicotine, its adverse effects may bother the user. To date, little evidence has been provided about the long-term effects of vaping, as it will take at least 10 years to determine the effects of vaping on the lungs. But experience with smoking shows that vaping has similar negative health effects, such as chronic obstructive pulmonary disease (COPD), heart disease, and cancer. Inhaling vape vapour may lead to inflammation in the lungs and cause complications such as cough, phlegm, chest pain, and lung infection [ 44, 56]. Also, some research has shown that continuous use of vaping may increase the risk of developing lung diseases such as bronchitis and asthma [ 57]. Some studies have shown that using vapes can increase heart rate, increase blood pressure, and cause heart problems [ 58]. The use of vape liquids containing nicotine may lead to side effects such as addiction, an increased risk of cardiovascular diseases, nerve disorders, breathing problems, sleep disorders, and an increased risk of cancer such as lung, pancreatic, and brain cancer [ 58]. The use of vaping by young people and teenagers can lead to the development of nicotine addiction, psychological and cognitive risks, and harmful effects on growth and the brain [ 59].\nStrengths and Limitations\nStrengths: The article presents a comprehensive review of existing evidence on the adverse effects of vaping on lung health following PRISMA and Meta-analyses of Observational Studies in Epidemiology (MOOSE) guidelines and the multi-layered approach to searching, which should lend credibility to the methods used. It synthesizes findings from various studies, offering a holistic view of the current state of knowledge on this topic.\nThe discussion on public health implications goes beyond the scientific findings to highlight the urgent need for public health interventions. This adds a practical dimension to the research by emphasizing the importance of regulatory measures and awareness campaigns.\nWe made evidence-based recommendations for public health efforts that focused on dispelling misconceptions about the safety of vaping and promoting proven smoking cessation methods. This adds a pragmatic and actionable dimension to the discussion.\nWe acknowledge the current lack of conclusive evidence on the long-term effects of vaping. This recognition of uncertainty adds credibility to the review and emphasizes the importance of continued research in this evolving field.\nBy stressing the need for ongoing research to capture emerging trends, the study demonstrates a forward-looking approach. This is crucial in a field where new vaping products and formulations are continuously introduced.\nLimitations: Despite the compelling evidence presented, this review acknowledges certain limitations. The review highlights a limitation in the predominantly experimental and case-report nature of the studies reviewed, involving animal or cell line models. While these studies are crucial for understanding biological mechanisms, their findings may not always directly translate to human populations due to species differences in metabolism and physiology. This variability in study designs may pose challenges in establishing causation and generalizing findings to broader populations.\nThere is a predominance of short-term studies and case reports, which limits the ability to make definitive conclusions about the long-term carcinogenic effects of vaping. Long-term studies are essential to assess the cumulative effects of vaping on lung cancer risk.\nMany studies do not adequately control for confounding factors such as concurrent tobacco use, environmental exposures, and genetic predispositions that might influence lung cancer risk, which could lead to conflicting results. Also, significant variability in the types of vaping devices and liquids and the presence of potential contaminants complicate the establishment of a standardized exposure assessment and may lead to conflicting evidence regarding the association between vaping and lung cancer.\nSome studies may have small sample sizes, reducing the power to detect significant effects or associations and limiting the generalizability of the findings to a broader population. The studies discuss the use of e-cigarettes as a method to reduce or quit tobacco cigarette smoking, as seen in the study by Lucchiari et al. [ 38]. However, these findings could be in conflict with the potential harmful effects of vaping, as vaping is sometimes initiated as an alternative to smoking without a full understanding of its risks.\nThe vaping product market is rapidly evolving, with new products and formulations constantly emerging. This means that the substances and exposures being studied may quickly become outdated, and the findings may not apply to the products currently in use.\nFuture Directions\nGiven the points above, future research should prioritize long-term, longitudinal human studies with large and diverse populations, consider the rapidly changing landscape of e-cigarette products, and focus on comprehensive exposure assessments to elucidate the potential risks of vaping, particularly concerning lung cancer. Additionally, clear communication to the public regarding the current understanding and unknowns of vaping risks is important to address misconceptions and inform behaviour.\nConclusions\nVaping, often regarded as an alternative to smoking, presents its own set of health risks. The review reveals several critical findings: exposure to vaping has been linked to impaired lung function, as evidenced by reduced lung capacity and bronchoconstriction in animal models. Case reports and observational studies indicate a potential association with lung injury, including EVALI, and cell damage indicative of cancerous transformations. While some studies suggest vaping has positioned itself as a smoking cessation aid, this potential benefit is contrasted by the occurrence of throat irritation and other symptoms and does not offset the documented health risks. The World Health Organization (WHO) has expressed concerns regarding the addictiveness of vaping products, particularly among youth, suggesting a need for regulatory oversight. These findings collectively call for robust public health campaigns to correct misconceptions about vaping's safety and emphasize the necessity for continued, comprehensive research into its long-term health impacts.\nDisclosures\nConflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following:\nPayment/services info: All authors have declared that no financial support was received from any organization for the submitted work.\nFinancial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.\nOther relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.\nAuthor Contributions\nConcept and design: Kenesh O. Dzhusupov, Fakher Rahim, Karlygash Toguzbaeva\nDrafting of the manuscript: Kenesh O. Dzhusupov, Fakher Rahim, Dmitriy Sokolov, Abzal Zhumagaliuly, Ainur Tekmanova, Elmira Kussaiynova, Aiya Katayeva, Sholpan Orazbaeva, Aidana Bayanova, Mariyam Olzhas, Alina Zhumataeva, Sabina Moldabekova\nCritical review of the manuscript for important intellectual content: Kenesh O. Dzhusupov, Karlygash Toguzbaeva\nAcquisition, analysis, or interpretation of data: Fakher Rahim, Dmitriy Sokolov, Abzal Zhumagaliuly, Ainur Tekmanova, Elmira Kussaiynova, Aiya Katayeva, Sholpan Orazbaeva, Aidana Bayanova, Mariyam Olzhas, Alina Zhumataeva, Sabina Moldabekova\nSupervision: Karlygash Toguzbaeva\nReferences\n1.The chemistry and toxicology of vaping. Bonner E, Chang Y, Christie E, et al. Pharmacol Ther. 2021;225:107837. doi: 10.1016/j.pharmthera.2021.107837. [ DOI] [ PMC free article] [PubMed] [Google Scholar]\n2.The FEMA GRAS assessment of benzyl derivatives used as flavor ingredients. Adams TB, Cohen SM, Doull J, et al. 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 "page\_content": "By now, it seems pretty clear that using e-cigarettes, or vaping, is bad for your lungs. But research about exactly how vaping affects the lungs is in the initial stages, says Johns Hopkins lung cancer surgeon Stephen Broderick.\n\n\u201cIn the last 24 to 36 months, I\u2019ve seen an explosive uptick of patients who vape,\u201d reports Broderick. \u201cWith tobacco, we have six decades of rigorous studies to show which of the 7,000 chemicals inhaled during smoking impact the lungs. But with vaping, we simply don\u2019t know the short- or long-term effects yet and which e-cigarette components are to blame.\u201d\n\nAlthough there\u2019s no definitive answer at this point, experts do have a theory about how vaping harms lungs.\n\nWhat Happens When You Vape\n\nBoth smoking and vaping involve heating a substance and inhaling the resulting fumes. With traditional cigarettes, you inhale smoke from burning tobacco. With vaping, a device (typically a vape pen or a mod \u2014 an enhanced vape pen\u00a0\u2014 that may look like a flash drive) heats up a liquid (called vape juice or e-liquid) until it turns into a vapor that you inhale.\n\n\u201cVaping is a delivery system similar to a nebulizer, which people with asthma or other lung conditions may be familiar with,\u201d says Broderick. \u201cA nebulizer turns liquid medicine into a mist that patients breathe in. It\u2019s a highly effective way of delivering medicine to the lungs.\u201d\n\nThe Chemicals You Inhale When Vaping\n\nInstead of bathing lung tissue with a therapeutic mist, just as a nebulizer does, vaping coats lungs with potentially harmful chemicals. E-liquid concoctions usually include some mix of flavorings, aromatic additives and nicotine or THC (the chemical in marijuana that causes psychological effects), dissolved in an oily liquid base. \u201cWe think that some of the vaporized elements of the oil are getting deep down into the lungs and causing an inflammatory response,\u201d explains Broderick.\n\nThe substance at the center of investigation is vitamin E. It\u2019s often used as a thickening and delivery agent in e-liquid. And, while it\u2019s safe when taken orally as a supplement or used on the skin, it\u2019s likely an irritant when inhaled. It\u2019s been found in the lungs of people with severe, vaping-related damage.\n\nOther common substances found in e-liquid or produced when it\u2019s heated up may also pose a risk to the lungs. These include:\n\nDiacetyl: This food additive, used to deepen e-cigarette flavors, is known to damage small passageways in the lungs.\nFormaldehyde: This toxic chemical can cause lung disease and contribute to heart disease.\nAcrolein: Most often used as a weed killer, this chemical can also damage lungs.\n\n5 Truths You Need to Know About Vaping\n\nSmoking electronic cigarettes is often considered safer than regular smoking. Learn why vaping is still harmful, and why you should rethink taking it up.\n\nRead more about vaping\n\nHow Vaping Can Affect Your Lungs\n\nOver time, as e-cigarette use continues, experts will gain a better understanding of how vaping affects the lungs. What we do know right now is that several lung diseases are associated with vaping:\n\nVaping and Popcorn Lung\n\n\u201cPopcorn lung\u201d is another name for bronchiolitis obliterans (BO), a rare condition that results from damage of the lungs\u2019 small airways. BO was originally discovered when popcorn factory workers started getting sick. The culprit was diacetyl, a food additive used to simulate butter flavor in microwave popcorn.\n\nDiacetyl is frequently added to flavored e-liquid to enhance the taste. Inhaling diacetyl causes inflammation and may lead to permanent scarring in the smallest branches of the airways \u2014 popcorn lung \u2014 which makes breathing difficult. Popcorn lung has no lasting treatment. There are, however, treatments that manage BO symptoms, such as:\n\nCoughing\nWheezing\nChest pain\nShortness of breath\n\nVaping-Related Lipoid Pneumonia\n\nUnlike the classic pneumonia caused by infection, lipoid pneumonia develops when fatty acids (the building blocks of fat) enter the lungs. Vaping-related lipoid pneumonia is the result of inhaling oily substances found in e-liquid, which sparks an inflammatory response in the lungs. Symptoms of lipoid pneumonia include:\n\nChronic cough\nShortness of breath\nCoughing up blood or blood-tinged mucus\n\n\u201cThere\u2019s isn\u2019t a good treatment for lipoid pneumonia, other than supportive care, while the lungs heal on their own,\u201d says Broderick. \u201cThe single-most important thing you can do is identify what is causing it \u2014 in this case vaping \u2014 and eliminate it.\u201d\n\nPrimary Spontaneous Pneumothorax (Collapsed Lung) After Vaping\n\nPrimary spontaneous pneumothorax, or collapsed lung, occurs when there\u2019s a hole in the lung through which oxygen escapes. This can be the result of an injury \u2014 such as a gunshot or knife wound \u2014 or when air blisters on the top of the lungs rupture and create tiny tears.\n\nThose who develop these blisters are usually tall, thin people who had a period of rapid growth during adolescence, says Broderick. Because of the accelerated growth, a weak point may blister and develop at the top of the lungs. On their own, these blisters don\u2019t typically produce symptoms. You don\u2019t know you have them, unless they rupture. Smoking \u2014 and now vaping \u2014 are associated with an increased risk of bursting these blisters, leading to lung collapse.\n\n\u201cAt Johns Hopkins, we\u2019re seeing a rash of collapsed lungs in younger people,\u201d reports Broderick. \u201cWe always ask if they\u2019ve been smoking, and they\u2019ll often say, \u2018No, I don\u2019t smoke. But I do vape.\u2019 Now we tell patients not to smoke or vape if they want to avoid another lung collapse and surgery in the future.\u201d\n\nSigns of a collapsed lung include:\n\nSharp chest or shoulder pain\nShortness of breath\nDifficulty breathing\n\nOxygen treatment and rest may be all that\u2019s need for a collapsed lung to heal. But more advanced cases require a chest tube to drain leaked oxygen from the body cavity or surgery to repair the hole in the lung.\n\nCan Vaping Cause Lung Cancer?\n\nCancer is definitely a concern, given that vaping introduces a host of chemicals into the lungs. But vaping products haven\u2019t been around long enough for us to learn whether or not they cause cancer.\n\n\u201cWe do know that smoking tobacco forces tiny particles to be deposited deep in the bronchial tree and can lead to the development of cancer. The same may be true for vaping,\u201d says Broderick.\n\nSecondhand Vapor Isn\u2019t Safe Either\n\nIt\u2019s a myth that secondhand emissions from e-cigarettes are harmless. Many people think the secondhand vapor is just water, but this couldn\u2019t be farther from the truth. The vapor emitted when someone exhales contains a variety of dangerous substances, which may include:\n\nNicotine\nUltrafine particles\nDiacetyl\nBenzene (a chemical found in car exhaust)\n\nAlthough secondhand vapor may not affect the lungs the same way as vaping, it is better to avoid it, if possible.\n\nWhat to Do If Your Lungs Hurt\n\nIf you smoke or vape, don\u2019t brush off chest or lung pain as something that\u2019s normal. If you have pain or other symptoms associated with breathing difficulties, such as shortness of breath and chronic cough, it\u2019s important to see a doctor.\n\nDoes Vaping Lead to Cigarette Smoking?\n\nWatch on YouTube\n\nRequest an Appointment\n\nFind a Doctor\n\nFind a Doctor\n\nSee More\n\nFind a Doctor\n\nSpecializing In:\n\nCardiovascular Risk Stratification\nCardiovascular Disease\nPreventive Cardiology\nAtrial Fibrillation\n\nSee More\n\nFind a Treatment Center\n\nCiccarone Center for the Prevention of Heart Disease\n\nFind Additional Treatment Centers at:\n\nHoward County Medical Center\nSibley Memorial Hospital\nSuburban Hospital\n\nRelated\n\nVaping\n5 Vaping Facts You Need to Know\n\nVaping\nWill Vaping Lead Teens to Smoking Cigarettes?\n\nKnow Your Risks\nVape Flavors: What You Need to Know\n\nRelated Topics\n\nHeart Health\nKnow Your Heart Risks",  
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 "page\_content": "E-cigarettes are a relatively new tobacco product that have been sold in the U.S. for about a decade The e-cigarettes currently in the U.S. marketplace have not been systemically reviewed by the Food and Drug Administration to determine their impact on lung health. While much remains to be determined about the lasting health consequences of these products, the American Lung Association is very troubled by the evolving evidence about the impact of e-cigarettes on the lungs.\nIn January 2018, the National Academies of Science, Engineering and Medicine1 released a consensus study report that reviewed over 800 different studies.\nThat report made clear: using e-cigarettes causes health risks. It concluded that e-cigarettes both contain and emit a number of potentially toxic substances. The Academies' report also states there is moderate evidence that youth who use e-cigarettes are at increased risk for cough and wheezing and an increase in asthma exacerbations.\nA study from the University of North Carolina found that the two primary ingredients found in e-cigarettes\u2014propylene glycol and vegetable glycerin\u2014are toxic to cells and that the more ingredients in an e-liquid, the greater the toxicity.2\nE-cigarettes produce a number of dangerous chemicals including acetaldehyde, acrolein, and formaldehyde. These aldehydes can cause lung disease, as well as cardiovascular (heart) disease.3\nE-cigarettes also contain acrolein, a herbicide primarily used to kill weeds. It can cause acute lung injury and COPD and may cause asthma and lung cancer.4\nBoth the U.S. Surgeon General and the National Academies of Science, Engineering and Medicine have warned about the risks of inhaling secondhand e-cigarette emissions, which are created when an e-cigarette user exhales the chemical cocktail created by e-cigarettes.\nIn 2016, the Surgeon General concluded that secondhand emissions contain, \"nicotine; ultrafine particles; flavorings such as diacetyl, a chemical linked to serious lung disease; volatile organic compounds such as benzene, which is found in car exhaust; and heavy metals, such as nickel, tin, and lead.\"\nThe Food and Drug Administration has not found any e-cigarette to be safe and effective in helping people who use tobacco products to quit. If people are ready to quit smoking and using other tobacco products for good, they should call 1-800-QUIT NOW or talk with their doctor about finding the best way to quit using proven methods and FDA-approved treatments and counseling.\nResources\nReferences\nImpact of E-cigarettes on the Lung\nDownload\nEl Efecto de los Cigarrillos Electr\u00f3nicos sobre los Pulmones\nDownload\n1. NAM Report - https://www.nap.edu/resource/24952/012318ecigaretteConclusionsbyEvidence.pdf\n2. Sassano MF, Davis ES, Keating JE, Zorn BT, Kochar TK, Wolfgang MC, et al. (2018) Evaluation of e-liquid toxicity using an open-source high-throughput screening assay. PLoS Biol 16(3): e2003904. https://doi.org/10.1371/journal.pbio.2003904\n3. Ogunwale, Mumiye A et al. (2017) Aldehyde Detection in Electronic Cigarette Aerosols. ACS omega 2(3): 1207-1214. doi: 10.1021/acsomega.6b00489\n4. Bein K, Leikauf GD. (2011) Acrolein - a pulmonary hazard. Mol Nutr Food Res 55(9):1342-60. doi: 10.1002/mnfr.201100279.\nPage last updated: April 8, 2025\nShow\nShow\nMake a Donation\nYour tax-deductible donation funds lung disease and lung cancer research, new treatments, lung health education, and more.\nMake a Donation\nBecome a Lung Health Insider\nJoin over 700,000 people who receive the latest news about lung health, including research, lung disease, air quality, quitting tobacco, inspiring stories and more!\nSign Up For Newsletter\nPlease leave this field empty\nGET UPDATES\nPlease enter a valid email address, or wait for Cloudflare validation.\nCloudflare currently validating...\nThank you! 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