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Authors' Affiliation:
[1]College of Medical Sciences, University of Rzeszow Tadeusza Rejtana 16c Ave, 35-310 Rzeszów, Poland
[2]Fryderyk Chopin University Clinical Hospital in Rzeszów, ul. Fryderyka Szopen 2, 35-055 Rzeszów, Poland

ORCID List

Aleksandra Roztoczyńska	0009-0001-3340-8585
Aleksandra Jeńć-Magoń	0009-0003-2340-6505
Martyna Orzechowska	0000-0001-6366-5761
Karolina Jablonska	0000-0001-7454-5263
Piotr Paluch	0009-0001-0126-6850
Karol Lesniewski	0009-0000-5704-4483
Jakub Pudźwa	0009-0003-1025-8304
Kamil Gibczynski	0009-0006-6968-4684
Anita Król	0009-0004-4272-9403
Michal Orczyk	0000-0002-2707-7994

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DISCOVERY SCIENTIFIC SOCIETY

Analysis of awareness of the effects of electronic cigarettes on fertility

Aleksandra Roztoczyńska[1], Aleksandra Jeńć-Magoń[1], Martyna Orzechowska[1], Karolina Jablonska[1], Piotr Paluch[1], Karol Lesniewski[1], Jakub Pudźwa[1], Kamil Gibczynski[2], Anita Król[2], Michal Orczyk[1]

ABSTRACT

Every year, more and more people start using electronic cigarettes without realizing that these devices can affect their fertility. Further clinical researches are needed to understand the long-term effects of using these devices, because their full impact on reproductive health remains unclear. This study looks at on what adult men and women know about how electronic cigarettes can influence fertility. It was in September 2024 with 500 participants, but researchers excluded 185 because they did not use e-cigarettes or had incomplete data. In the end, 173 men and 142 women were included in the study. The data was analyzed using Microsoft Excel and checked with information from Google Scholar, PubMed, and Medscape. The results revealed that 57% of respondents believe electronic cigarettes can have a harmful impact on fertility,13% were uncertain, and 30% saw no connection between vaping and reproductive health. Most participants understand that these devices can be harmful, showing that reproductive health concerns are growing. Although many studies suggest negative effects, most have been conducted on animals, so there is a need for further research on humans. Experts should inform users about how vaping can affect fertility.

Keywords: Electronic cigarettes, fertility, vaping, reproductive health

1. INTRODUCTION

Infertility is the inability to become pregnant despite regular unprotected sexual intercourse for a specified period, time - typically 12 months in generally healthy couples or six months in women over the age of 35 (World Health Organization, 2018). It is a complex health problem resulting from dysfunction in the reproductive system of one or both individuals or the interaction of multiple factors that make it difficult to conceive or carry a pregnancy (World Health Organization, 2018). WHO recognizes infertility as a significant public health

problem affecting 186 million people worldwide (World Health Organization, 2018; Montjean et al., 2023; Mascarenhas et al., 2012).

Environmental influences and lifestyle choices, such as cigarette smoking, are widely known to negatively affect gamete quality and interfere with reproductive function (Montjean et al., 2023; Mascarenhas et al., 2012). The consumption of electronic cigarettes is growing dramatically, which is particularly observable among teens and young adults, as evidenced by the increase in sales of single-use flavored e-cigarettes in 2023 in comparison to 2022 (100 million units versus 32.3 million) (Hutzler et al., 2014; Dobko et al., 2023). Electronic cigarettes(e-cigarettes) are devices designed to inhale nicotine in the form of vapor instead of conventional tobacco smoke (Pisinger and Døssing, 2014).

Many people use e-cigarettes as an alternative to traditional cigarettes in an attempt to quit smoking; however, the long-term health effects are still the subject of research. The composition of e-cigarettes varies depending on the model available on the market. Nevertheless, e-liquids always contain three main ingredients: water, glycols, and nicotine, which are in other proportions. Detailed studies of e-liquid and aerosol have revealed the presence of more than 80 different chemicals Montjean et al., (2023), Thirión-Romero et al., (2019), Ochedalski et al., (1994), including but not limited to:

Propylene glycol (PG) and vegetable glycerin (VG)

Propylene glycol and vegetable glycerin are used in food and pharmaceutical products and are potentially non-toxic substances (Thirión-Romero et al., 2019; Ochedalski et al., 1994). In electronic cigarettes, these compounds are the main component of the heated liquid, which can produce toxic compounds (Montjean et al., 2023).

Nicotine

Nicotine as an addictive substance can negatively affect the cardiovascular system by constricting blood vessels, thereby causing higher blood pressure, as well as erectile problems (Montjean et al., 2023). This substance disrupts the hypothalamic-pituitary-gonadal axis, and as a result, smokers may experience a hormonal imbalance (Vine, 1996; Marzec-Wróblewska et al., 2011).

Heavy metals (e.g., lead, cadmium, nickel, copper)

Heavy metals can enter e-cigarette vapor through metal heaters, leading to toxicity. Although the impact of exposure to these metals in the context of e-cigarette use has yet to be proven, these nanoparticles negatively affect sperm concentration, motility, and function, with potential effects on fertility (Marzec-Wróblewska et al., 2019; Shi et al., 2021; Zhao et al., 2017). High concentrations of cadmium have deleterious effects on oocyte maturation in humans, cattle, and mice, as well as on fertilization, early cell division, and blastocyst development rates (Roychoudhury et al., 2016). Copper, in turn, negatively affects embryonic development (O'Neill et al., 2017).

Flavors

The vast majority of e-liquids contain flavorings. Long-term exposure to flavored e-cigarette vapor without nicotine decreased testicular weight, increased apoptosis, oxidative stress, and reduced expression of enzymes necessary for steroidogenesis (Montjean et al., 2023; Wang et al., 2013). Bubble gum flavor damaged germ cells in mice, while cinnamon flavor caused changes in germ cell precursors. Rats also showed increased teratozoospermia, mainly in abnormal sperm motility (Montjean et al., 2023; O'Neill et al., 2017).

Aldehydes (e.g., formaldehyde, acetone)

Aldehydes are formed when e-liquid ingredients are heated and have carcinogenic effects, especially formaldehyde (Wang et al., 2013; El-Golli et al., 2016)

Although e-cigarettes have become widely available, there is insufficient evidence of their long-term safety, health risks, or effectiveness in smoking cessation (Pisinger and Døssing, 2014).

Aim

The purpose of this study is to assess the awareness of adult women and men about the effects of electronic cigarettes on fertility.

2. MATERIAL AND METHODS

The author collected material using a specially designed questionnaire of 11 single-choice, multiple-choice, and open-ended questions. The survey took place in September 2024 and included 500 people. Researchers excluded 120 participants because they were not smokers and disqualified another 65 for being minors. In the end, they qualified 315 people for the study, including 142 women and 173 men (Figure 1). In the first part of the questionnaire, respondents provided information about their age, gender, and education (Table 1). In the second part, they answered questions about their personal experiences with smoking electronic cigarettes.

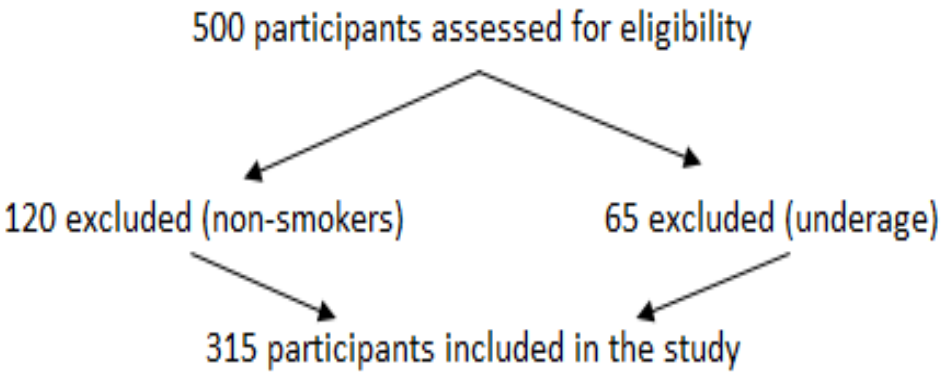

Figure 1 CONSORT Diagram analyzing the inclusion of participants in the study

Table 1 Demographic structure of survey participants by gender, age, and education level

Variable	Category	Count (n)	Percentage (%)
Gender	Male	173	53%
Gender	Female	142	47%
Education	Higher education	175	56%
Education	Secondary education	60	19%
Education	Primary education	80	25%
Age group	18-25 years	161	51%
Age group	26-40 years	126	40%
Age group	41-60 years	28	9%

3. RESULTS

The study included 315 participants, of which 47% were women and 53% were men (Figure 2). Considering the age range, the respondents were from the following age groups: 18-25 (51%), 26-40 (40%), and 41-64 (9%) (Figure 3).

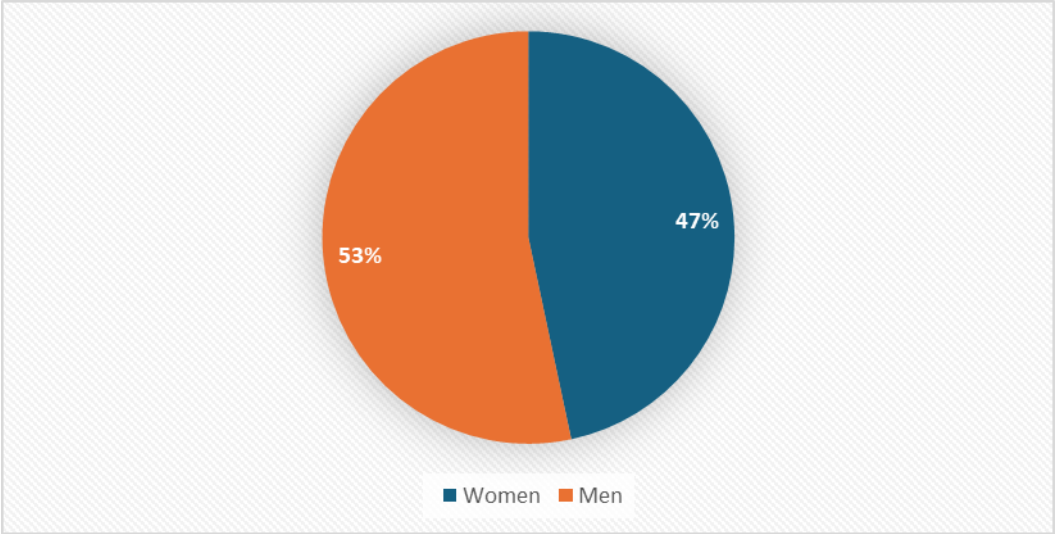

Figure 2 The gender of respondents who took part in the survey.

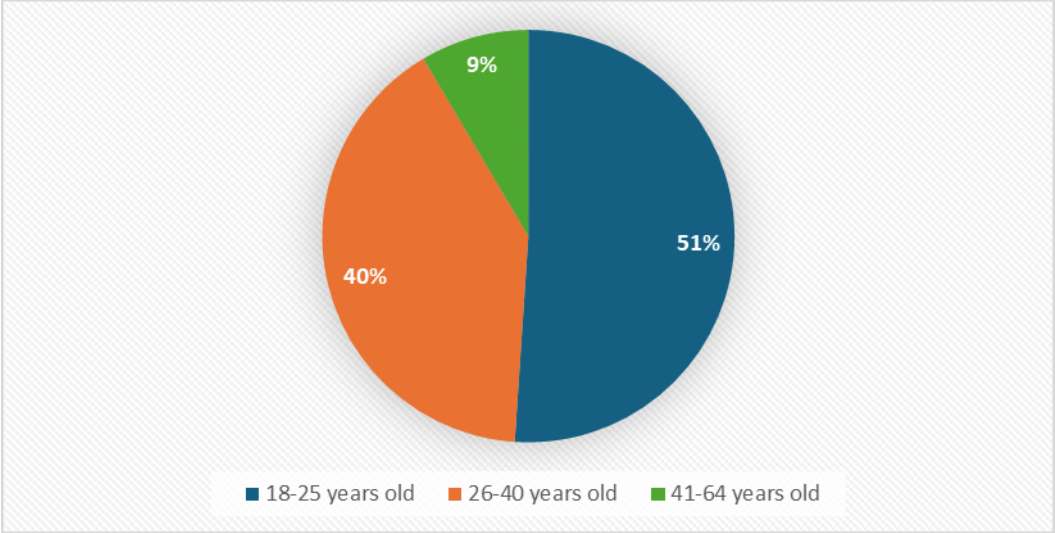

Figure 3 Age of respondents who participated in the study.

In the study, the researchers asked respondents about the duration of electronic cigarette use. Over half of the participants, 165 individuals, declared using these devices for more than 5 years. One hundred individuals had been using e-cigarettes for 2 to 5 years, while 50 participants estimated their usage time to be less than two years (Figure 4).

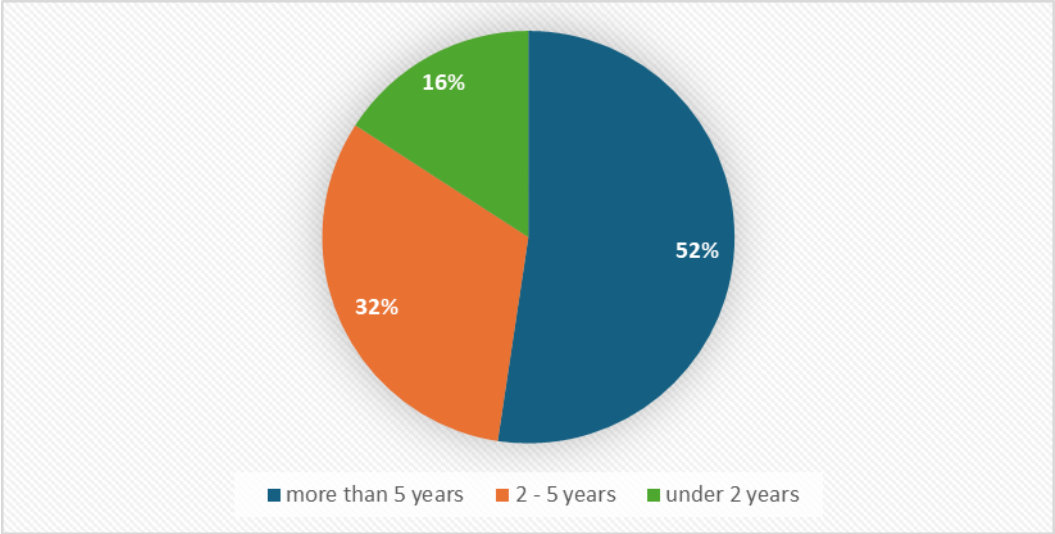

Figure 4 Duration of e-cigarette use.

The vast majority of respondents (73%) reported using e-liquids containing nicotine, while 17% used both nicotine and nicotine-free liquids. Only 10% of survey participants use nicotine-free cartridges (Figure 5).

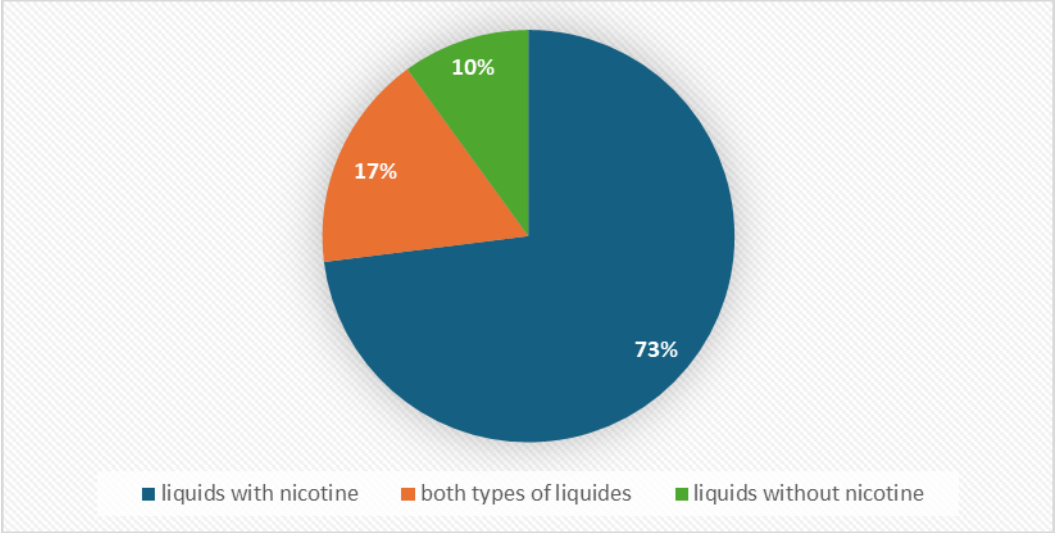

Figure 5 Type of e-liquids used.

Another part of the questionnaire examined personal experiences with e-cigarette use. The researchers asked respondents to rate the potential adverse effects of these devices on their fertility. Of the respondents, 57% felt that e-cigarettes harm fertility, 30% had no clear opinion, and 13% said that using these devices did not affect their reproductive health (Figure 6).

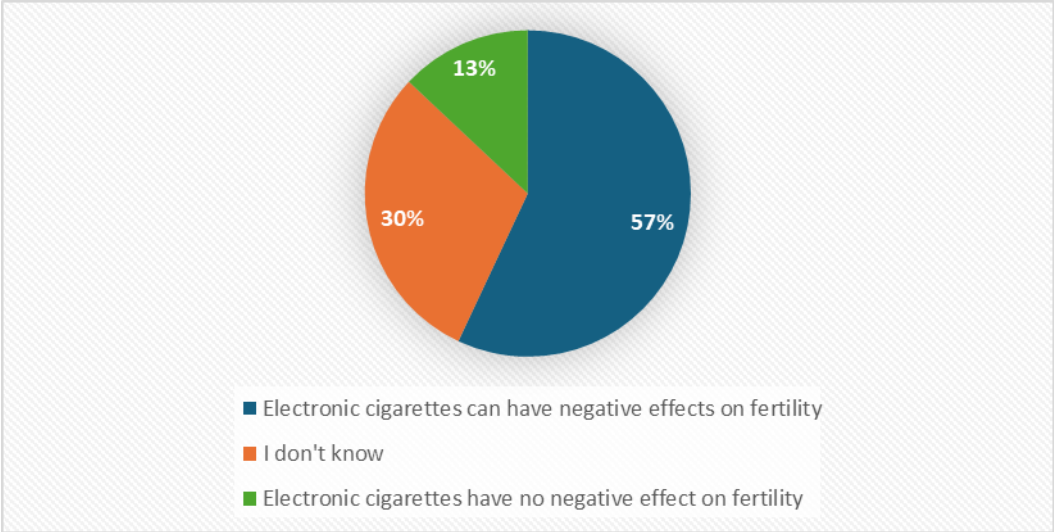

Figure 6 Do you believe that electronic cigarettes can negatively affect fertility?

Sixty-five percent of respondents experienced adverse effects from e-cigarette use, whereas 35% reported no side effects (Figure 7). Among the adverse effects mentioned by respondents were decreased sexual desire, reduced skin condition, irregular menstrual cycles (in women), decreased muscle mass, decreased energy levels, difficulty breathing, and chest pains.

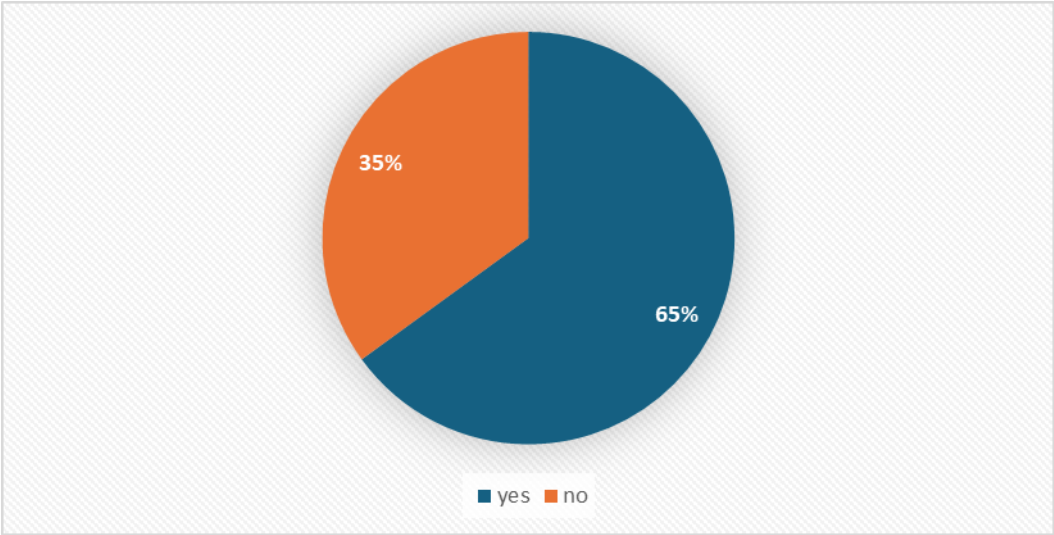

Figure 7 Reported adverse effects of electronic cigarette use

Half of the respondents did not assess that electronic cigarettes caused libido disorders and erectile difficulties (in men). Additionally, most of the respondents did not perceive that electronic cigarettes could affect their sexual behavior (Figure 8).

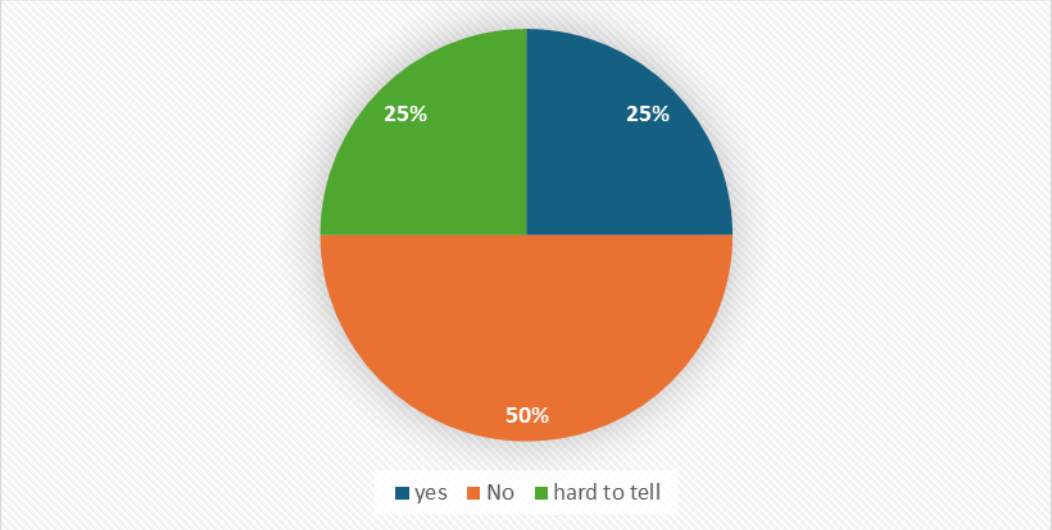

Figure 8 Have you noticed that electronic cigarettes cause erectile dysfunction (in men), lower libido, and affect your sexual behavior?

4. DISCUSSION

In recent years, electronic cigarettes, also known as electronic nicotine delivery systems (ENDS) or e-cigarettes, have significantly changed the use of nicotine products among adolescents and adults. Although developers initially created them to support adults trying to quit smoking, they became popular fast and caused addiction (Pisinger and Døssing, 2014). The survey showed that most people know electronic cigarettes might harm fertility, because 57% saying they could have a negative effect. Nevertheless, 30% of participants did not know how to answer this question clearly. The side effects reported by 65% of participants, such as lowered libido, problems with irregular menstrual cycles, respiratory failure, or reduced energy, point to individual differences in reactions to substances contained in e-liquids.

The prevalence of use of e-liquids containing nicotine (73%) may be a key factor in endocrine disruption and reproductive function, but this requires further research. El-Golli et al., (2016) conducted the first study analyzing the effects of e-cigarette refill liquids on testicular function (Wang et al., 2013; Zang et al., 2017). This study analyzed liquids with and without nicotine and examined their effects using an animal model. The study used Wistar rats, which received daily intraperitoneal injections of liquids used in e-cigarettes for four weeks. Experiment results showed that the fluids, regardless of the presence of nicotine, inducted oxidative stress, which increased the activity of antioxidant enzymes, such as superoxide dismutase, catalase, and glutathione S-transferase, in testicular tissues.

In addition, researchers observed histopathological changes in testicular morphology, including premature separation of germ cells from the seminal epithelium and disorganization of the seminal tubule structure (Wang et al., 2013; El-Golli et al., 2016; Zang et al., 2017). Studies analyzing the effects of electronic cigarettes on the male reproductive system and semen quality dominate the scientific literature. Testicular morphology and function are under the control of hormones, mainly androgens. Exposure to e-cigarette liquids, regardless of the presence of nicotine, causes a significant decrease in testosterone levels - by 50% for liquids with nicotine and 30% for liquids without nicotine, respectively (Zang et al., 2017).

In addition, studies have shown a significant reduction in the number and viability of sperm collected from the tail of the epididymis (Zang et al., 2017). Studies have analyzed both the effects of active and passive smoking on various semen parameters (Szumilas et al., 2020; Ochedalski et al., 1994). Significant decreases in sperm density, motility, antioxidant activity, and possible adverse effects on sperm morphology have been demonstrated (Harlev et al., 2015). The average decline in sperm concentration is dose-dependent at about 22% (Szumilas et al., 2020; Ochedalski et al., 1994; Harlev et al., 2015; The Practice Committee of the American Society for Reproductive Medicine, 2006). Non-smoke tobacco produces similar effects (Montjean et al., 2023).

A cross-sectional study in a group of young men found that daily use of e-cigarettes was associated with a significant reduction in total sperm count, which averaged 91 million, compared to 147 million in non-users (Holmboe et al., 2020). Researchers have reported similar findings among regular smokers of traditional cigarettes (Hądzlik et al., 2024). In addition, available evidence suggests that

smoking may disrupt the ability of sperm to bind to the transparent envelope, as observed in a hamster egg penetration test without this structure (Holmboe et al., 2020; Hądzlik et al., 2024). Additionally, researchers have noticed low testicular weight and a higher number of apoptotic cells in the testes due to e-cigarette exposure (Hądzlik et al., 2024; Ochwanowska et al., 2017).

These findings point to the need for further research, particularly on the effects of e-cigarettes on male reproductive health. In contrast to the effects of electronic cigarettes on semen parameters, there is a lack of evidence conclusively linking their use to deterioration in the inner quality of oocytes and the integrity of the oocyte genome. Nevertheless, studies in animal models suggest that exposure to e-cigarettes can negatively affect ovarian function. In female rats exposed to e-cigarette liquids, a reduced percentage of normal ovarian follicles and reduced estrogen levels have been observed (Chen et al., 2022).

Moreover, vapor from electronic cigarettes can affect embryo implantation and pregnancies (Ochwanowska et al., 2017; Chen et al., 2022). Microarray analysis showed a change in uterine receptivity transcripts in mice exposed to e-cigarettes (Chen et al., 2022; Wetendorf et al., 2019). In these females, there was a delay in embryo implantation, even though the animals had high levels of progesterone. The result was fewer offspring (Chen et al., 2022; Wetendorf et al., 2019).

5. CONCLUSIONS

The research suggests an increasing awareness of the potential impact of electronic cigarettes on fertility. There are many experimental studies that suggest e-cigarettes may adversely affect fertility in both men and women. Still, most of the data comes from animal studies. Researchers should further investigate the precise adverse effects and impact of e-cigarettes on human reproductive health. It is important to educate people about the risks of vaping and make sure users know the dangers. Prevention and education can help reduce the health risks associated with e-cigarette use.

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Author's Contribution
Conceptualization: Aleksandra Roztoczyńska
Methodology: Aleksandra Roztoczyńska, Karolina Jabłońska, Kamil Gibczyński Michał Orczyk
Formal analysis: Piotr Paluch, Aleksandra Jeńć-Magoń
Resources, data curation: Jakub Pudźwa, Aleksandra Jeńć-Magoń
Visualization: Aleksandra Roztoczyńska, Jakub Pudźwa, Piotr Paluch
Investigation: Aleksandra Roztoczyńska, Michał Orczyk, Karolina Jabłońska
Writing – original draft: Aleksandra Roztoczyńska
Writing – review & editing: Karol Leśniewski, Anita Król, Aleksandra Jeńć-Magoń
All authors have read and agreed with the final, published version of the manuscript.

Ethical approval
The ethical guidelines for Human Subjects are followed in the study.

Informed consent
Written & Oral informed consent was obtained from individual participants included in the study.

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Conflict of interest
The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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