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UTICAJ INFEKCIJE VIRUSOM SARS-COV-2 19 I VAKCINACIJE PROTIV COVID-19 NA POJAVU HIPERTENZIJE

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Sažetak: Uvod: Hipertenzija je jedan od najznačajnijih faktora rizika za kardiovaskularne bolesti i vodeći uzrok morbiditeta i mortaliteta u svetu. Tokom pandemije COVID-19 primećeno je povećanje broja osoba sa novootkrivenom hipertenzijom, što ukazuje na moguću povezanost između infekcije SARS-CoV-2 virusom, imunološkog odgovora i vaskularnih promena. **Cilj rada:** Ispitati moguću povezanost između infekcije COVID-19, vakcinacije protiv SARS-CoV-2 i pojave hipertenzije kod odrasle populacije. **Materijal i metode:** Istraživanje je sprovedeno putem anonimnog upitnika koji je obuhvatio 203 ispitanika oba pola i sa tri starosne kategorije. Deskriptivno su analizirani faktori životnog stila, prethodna infekcija COVID-19, vakcinacioni status i pojava hipertenzije. **Rezultati:** Od ukupno 203 ispitanika, 72,9% je ženskog, a 27,1% muškog pola. COVID-19 infekciju je preležalo 144 ispitanika (70,9%), a 43 osobe (21,2%) su imale dijagnostikovanu hipertenziju. Od tih 42, čak 17 osoba (40,5%) započelo je terapiju za hipertenziju unutar poslednjih 5 godina, posle preležane infekcije COVID-19. Vakcinisano je 59,1% ispitanika, a većina nije prijavila nuspojave. **Zaključak:** Rezultati ukazuju na statistički značajnu povezanost između COVID-19 infekcije i povećane incidence hipertenzije u postpandemijskom periodu ($\chi^2 = 21,3$; $p < 0,001$), dok vakcinacija protiv COVID 19 infekcije nije statsitički značajno povena sa novonastalOm hipertezijom.
Ključne reči: COVID-19, hipertenzija, vakcinacija, SARS-CoV-2, kardiovaskularni rizik.

UVOD

Hipertenzija (HTA) je najčešća hronična bolest savremenog društva i vodeći faktor rizika za razvoj koronarne bolesti srca, cerebrovaskularnih incidenata i hronične bubrežne bolesti [1]. Globalna pandemija COVID-19, uzrokovana virusom SARS-CoV-2, pokrenula je brojna istraživanja o uticaju infekcije na kardiovaskularni sistem. Mehanizmi uključuju upalne procese, endotelnu disfunkciju i disregulaciju renin-angiotenzin-aldosteron sistema (RAAS) [2,3].

Tokom pandemije primećeno je da osobe koje su preležale COVID-19, čak i u blažoj formi, često razvijaju povišen krvni pritisak nakon nekoliko meseci [4]. Takođe, uloga vakcinacije u pojavi ili pogoršanju hipertenzije predmet je brojnih diskusija, iako većina podataka ukazuje da koristi vakcinacije značajno prevazilaze potencijalne rizike [5].

Dosadašnja istraživanja sugerišu da infekcija virusom SARS-CoV-2 može povećati rizik za nastanak nove hipertenzije ili pogoršanje postojeće, posebno kod hospitalizovanih pacijenata i osoba sa komorbiditetima. Studije koje ispituju efekat vakcinacije protiv COVID-19 pokazuju retke i uglavnom prolazne epizode povišenog krvnog pritiska, bez dokaza o trajnom uzroku hipertenzije. Ukupno, postoji značajan broj dokaza o povezanosti COVID-19 infekcije sa hipertenzijom, dok je uticaj vakcinacije još uvek slabo istražen i zahteva dalje dugoročne studije. U velikoj retrospektivnoj kohorti (~64.000 pacijenata) iz sistema Stony Brook Health System, nova dijagnoza hipertenzije je bila značajno veća kod hospitalizovanih COVID-19 pacijenata u odnosu na COVID-negativne kontrole (HR≈1,57; CI 1,35-1,81) i kod ne-hospitalizovanih inficiranih (HR≈1,42; CI 1,24-1,63) [6]. Rezultat ukazuje da infekcija može biti okidač za "new-onset" hipertenziju, naročito kod teže obolelih. U studiji Trimarco et.al. (2024) (7-godišnja kohorta, >200.000 odraslih) pokazano je da se incidenca nove hipertenzije povećala u periodu pandemije (2020-2022) sa ~2,11% na ~5,20% godišnje (RR = 2,46) u odnosu na pre-pandemijski period (2017-2019) [7]. To implicira da pandemija – uključujući i infekcije, ali moguće i indirektne faktore (stres, smanjena fizička aktivnost) – može doprineti porastu hipertenzije. U publikaciji Ebinger et.al. (2022) pokazano je da i kada su ljudi vakcinisani (≥3 doze mRNA vakcine) i dalje imaju povišen rizik

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IMPACT AND ASSESSMENT OF NUTRITIONAL STATUS IN PATIENTS UNDERGOING TREATMENT FOR COLORECTAL CANCER

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Summary: Introduction: Hypertension is one of the most significant risk factors for cardiovascular diseases and a leading cause of morbidity and mortality worldwide. During the COVID-19 pandemic, an increase in the number of individuals with newly diagnosed hypertension was observed, suggesting a possible association between SARS-CoV-2 infection, immune response, and vascular changes. Aim: To examine a possible association between COVID-19 infection, SARS-CoV-2 vaccination, and the occurrence of hypertension in the adult population. Materials and Methods: The study was conducted using an anonymous questionnaire that included 203 respondents of both sexes and three age categories. Lifestyle factors, previous COVID-19 infection, vaccination status, and the occurrence of hypertension were descriptively analyzed. Results: Of the total 203 respondents, 72.9% were female and 27.1% male. A total of 144 respondents (70.9%) had a history of COVID-19 infection, and 43 individuals (21.2%) had diagnosed hypertension. Among them, 17 individuals (40.5%) initiated antihypertensive therapy within the last 5 years, following COVID-19 infection. A total of 59.1% of respondents were vaccinated, and the majority did not report adverse effects. Conclusion: The results indicate a statistically significant association between COVID-19 infection and increased incidence of hypertension in the post-pandemic period (χ^2 = 21.3; p < 0.001), while vaccination against COVID-19 was not statistically significantly associated with newly developed hypertension..

Keywords: COVID-19, hypertension, vaccination, SARS-CoV-2, cardiovascular risk.

INTRODUCTION

Hypertension (HTN) is the most common chronic disease of modern society and a leading risk factor for the development of coronary artery disease, cerebrovascular events, and chronic kidney disease [1]. The global COVID-19 pandemic, caused by the SARS-CoV-2 virus, has prompted numerous studies on the impact of infection on the cardiovascular system. Proposed mechanisms include inflammatory processes, endothelial dysfunction, and dysregulation of the renin–angiotensin–aldosterone system (RAAS). [2,3].

During the pandemic, it was observed that individuals who had recovered from COVID-19, even in mild forms, often developed elevated blood pressure several months later [4]. The role of vaccination in the onset or worsening of hypertension has also been the subject of numerous discussions, although most data indicate that the benefits of vaccination significantly outweigh potential risks. [5].

Current research suggests that infection with SARS-CoV-2 may increase the risk of developing new-onset hypertension or worsening pre-existing hypertension, particularly in hospitalized patients and individuals with comorbidities. Studies investigating the effects of COVID-19 vaccination report rare and mostly transient episodes of elevated blood pressure, with no evidence of a causal relationship with persistent hypertension. Overall, there is a substantial body of evidence supporting an association between COVID-19 infection and hypertension, whereas the impact of vaccination remains insufficiently studied and requires further long-term research.

In a large retrospective cohort (~64,000 patients) from the Stony Brook Health System, new-onset hypertension was significantly more frequent in hospitalized COVID-19 patients compared with COVID-negative controls (HR ≈ 1.57; CI 1.35 – 1.81) and in non-hospitalized infected individuals (HR ≈ 1.42; CI 1.24 – 1.63) [6]. This finding suggests that infection may act as a trigger for new-onset hypertension, particularly in more severely ill patients. In the study by Trimarco et al. (2024), a 7-year cohort of over 200,000 adults demonstrated that the incidence of new hypertension increased during the pandemic period (2020–2022) from

od hospitalizacije ako imaju hipertenziju kao komorbiditet. Iako nije direktno o "nastanku" hipertenzije, studija potvrđuje da hipertenzija ostaje važan faktor lošeg ishoda kod COVID-19 [8]. Potencijalni mehanizmi uključuju: endotelna disfunkcija nakon SARS-CoV-2 infekcije, inflamacija, aktivacija renin-angiotenzin-aldosteron sistema (RAAS), povećana arterijska rigidnost. Studija Marozzi et. al. (2025) ukazuje na povećanu arterijsku rigidnost kod osoba nakon infekcije SARS-CoV-2 [9]. U pregledu relevantne literature može se zapaziti da postoji umereno do značajno utemeljeno istraživanje koje pokazuje da infekcija SARS-CoV-2 može biti povezana s povećanim rizikom za razvoj novih slučajeva hipertenzije, ili pogoršanjem postojećih slučajeva.

U pogledu uticaja vakcinacije protiv COVID-19 na pojavnost, odnosno pogoršanje hipertenzije, postoji meta-analiza koja je obuhvatila ~357.387 ispitanika i koja je pokazala da je oko 3,20% (95% CI: 1,62-6,21) ispitanika imalo neki oblik povišenja krvnog pritiska nakon vakcinacije protiv COVID-19. Udeo slučajeva koji su dostigli stadijum III hipertenzije ili hipertenzivne urgencije/emergencije bio je oko 0,6% (95% CI 0,1-5,1%) [10]. U istraživanju Syrigos et. al. (2022), 797 zdravstvenih radnika (prosek 48 godina) koji su primili BNT162b2 (Pfizer) su pratili svoj krvni pritisak nakon vakcinacije. Rezultati su pokazali da je sedam osoba imalo značajan porast pritiska (hipertenzija 2. ili 3. stepena) koji je bio prolazan i trajao 3-4 dana [11]. Studija Ecina i Okura (2024) ispituje novu hipertenziju ("new-onset") u vakcinisanim u poređenju sa nevakcinisanim kontrolama. Autori naglašavaju da se ne može sa sigurnošću pripisati samo vakcini, jer su ispitanici s hipertenzijom bili stariji, sa većim BMI, više komorbiditeta [12]. Iako postoje izveštaji o povećanju krvnog pritiska nakon vakcinacije, proces je redak, najčešće prolazan i trenutno nedovoljno istražen da bi se tvrdilo da vakcinacija značajno doprinosi pojavi hipertenzije u populaciji. Uporedna razmatranja dosadašnjih rezultata istraživanja u dostupnoj literaturi pokazuju da su istraživanja infekcije brojnija u pogledu broja ispitanika i vremenskog praćenja nego istraživanja vakcinacije u kontekstu hipertenzije. Kod infekcije je jasno da postoji povećan rizik za novu hipertenziju i pogoršanje već postojeće. U slučaju vakcinacije moguće su izuzetno retke epizode povišenja krvnog pritiska, ali nema čvrstih dokaza da vakcina uzrokuje trajnu hipertenziju.

Na osnovu toga je u budućim istraživanjima neophodno usmeriti fokus na doprinos same infekcije u poređenju sa indirektnim faktorima pandemije (smanjena fizička aktivnost, povećani stres, promene u ishrani) kod porasta hipertenzije. Dodatno treba utvrditi da li postoji specifična pop-subpopulacija kod koje vakcinacija (npr. osobe sa već postojećom hipertenzijom) ima značajniji uticaj na hipertenziju. Takođe, potrebna su longitudinalna istraživanja koja će pratiti krvni pritisak pre vakcinacije, neposredno nakon i kroz duže praćenje (meseci/godine), utvrditi koja je uloga imunoinflamacije, endotelne disfunkcije, RAAS-aktivacije, promena vaskularne funkcije nakon infekcije i/ili vakcinacije.

CILJ RADA

Cilj ovog istraživanja bio je da se analizira potencijalna povezanost između COVID-19 infekcije, vakcinacije protiv SARS-CoV-2 i pojave hipertenzije kod odraslih osoba, uz procenu dodatnih faktora rizika (pol, starost, pušenje, fizička aktivnost, ishrana).

MATERIJAL I METODE

Istraživanje je sprovedeno tokom 2025. godine na uzorku od 203 ispitanika. Upitnik je obuhvatio 25 pitanja koja se odnose na sociodemografske karakteristike, navike u ishrani, fizičku aktivnost, pušenje, konzumiranje alkohola, kao i podatke o COVID-19 infekciji i vakcinaciji. Analiza je urađena deskriptivno, pomoću procentualne distribucije i uz pomoć testiranja hipoteza. Poseban akcenat stavljen je na ispitanike sa hipertenzijom, datum početka terapije i eventualnu povezanost sa preležanim COVID-19. - Podaci su obrađeni deskriptivno i analitički u programu SPSS v.26. Testiranje statističke značajnosti sprovedeno je pomoću hi-kvadrat (χ^2) testa za promenljive po kategorijama. Statistička značajnost je prihvaćena za vrednosti $p < 0,05$.

Vakcinacija protiv COVID-19 i hipertenzija - starosna dob i hipertenzija. Iako srednje vrednosti starosti nisu bile dostupne za svaku grupu, preliminarna analiza pokazuje da je hipertenzija češća u srednjoj starosnoj kategoriji (> 45 godina).

approximately 2.11% to 5.20% annually (RR = 2.46) compared with the pre-pandemic period (2017–2019) [7]. This implies that the pandemic itself—including infection as well as indirect factors such as stress and reduced physical activity—may contribute to the rise in hypertension incidence. In the publication by Ebinger et al. (2022), it was shown that even individuals vaccinated with ⩾3 doses of mRNA vaccines had an increased risk of hospitalization if they had hypertension as a comorbidity. Although this does not directly address the onset of hypertension, the study confirms that hypertension remains an important risk factor for adverse COVID-19 outcomes [8]. Potential mechanisms include endothelial dysfunction following SARS-CoV-2 infection, systemic inflammation, activation of the renin–angiotensin–aldosterone system (RAAS), and increased arterial stiffness. A study by Marozzi et al. (2025) demonstrated increased arterial stiffness in individuals after SARS-CoV-2 infection [9]. A review of the relevant literature indicates that there is moderate to substantial evidence supporting an association between SARS-CoV-2 infection and an increased risk of new-onset hypertension or worsening of existing hypertension.

Regarding the impact of COVID-19 vaccination on the incidence or worsening of hypertension, there is a meta-analysis including approximately 357,387 participants which showed that about 3.20% (95% CI: 1.62–6.21) of subjects experienced some form of elevated blood pressure following COVID-19 vaccination. The proportion of cases that reached stage III hypertension or hypertensive urgency/emergency was about 0.6% (95% CI: 0.1–5.1%) [10]. In the study by Syrigos et al. (2022), 797 healthcare workers (mean age 48 years) who received the BNT162b2 (Pfizer) vaccine were monitored for blood pressure changes after vaccination. The results showed that seven individuals experienced a significant increase in blood pressure (grade 2 or 3 hypertension), which was transient and lasted 3–4 days [11]. The study by Ecina and Okura (2024) examines new-onset hypertension in vaccinated individuals compared to unvaccinated controls. The authors emphasize that it cannot be attributed to the vaccine alone with certainty, as participants with hypertension were older, had higher BMI, and more comorbidities [12]. Although there are reports of increased blood pressure following vaccination, the phenomenon is rare, most often transient, and currently insufficiently studied to claim that vaccination significantly contributes to the occurrence of hypertension in the population. Comparative consideration of existing research findings in the available literature shows that studies on infection are more numerous in terms of sample size and follow-up duration than studies on vaccination in the context of hypertension. In the case of infection, there is clear evidence of an increased risk of new-onset hypertension and worsening of pre-existing hypertension. In the case of vaccination, extremely rare episodes of elevated blood pressure may occur, but there is no strong evidence that vaccines cause persistent hypertension.

Based on this, future research should focus on distinguishing the contribution of the infection itself from indirect pandemic-related factors (reduced physical activity, increased stress, dietary changes) in the rise of hypertension. Additionally, it is necessary to determine whether there is a specific subpopulation in which vaccination (e.g., individuals with pre-existing hypertension) has a more pronounced effect on blood pressure regulation. Furthermore, longitudinal studies are needed that track blood pressure before vaccination, immediately after, and over longer follow-up periods (months/years), in order to clarify the role of immunoinflammation, endothelial dysfunction, RAAS activation, and changes in vascular function following infection and/or vaccination.

AIM

The aim of this study was to analyze the potential association between COVID-19 infection, SARS-CoV-2 vaccination, and the occurrence of hypertension in adults, while also assessing additional risk factors (sex, age, smoking, physical activity, and diet).

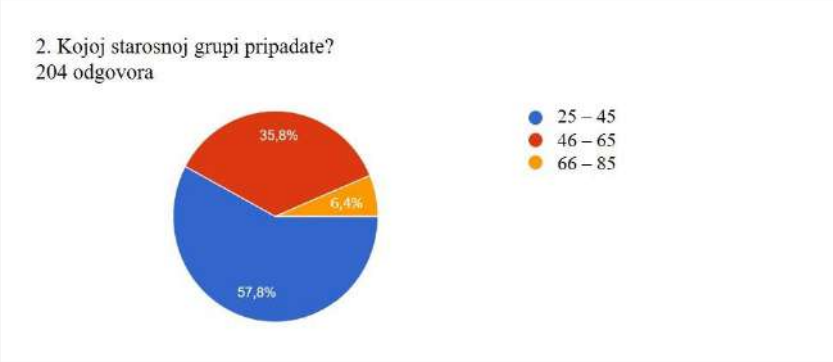
MATERIAL AND METHODS

The study was conducted during 2025 on a sample of 203 participants. The questionnaire consisted of 25 questions covering sociodemographic characteristics, dietary habits, physical activity, smoking, alcohol consumption, as well as data related to COVID-19 infection and vaccination. The analysis was performed descriptively using percentage distributions and hypothesis testing. Special emphasis was placed on participants with

REZULTATI

Starosna struktura ispitanika (Grafikon 1): Od 203 ispitanika, najbrojnija je mlađa populacija od 25–45 godina (57,6%), srednja starosna kategorija od 46 do 65 godina je bila zastupljena sa 35,8%, starija populacija od 66 do 85 godina je bila najanje zastupljena sa 6,4%.

Grafikon 1. Raspodela starosne strukture ispitanika



Polna struktura i hipertenzija

Postoji dominacija ženskog pola, 148 (72,9%) ispitanica, dok je bilo skoro 3 puta manje muškaraca -55 (27,1%). Nije pronađena statistički značajna razlika u učestalosti hipertenzije između muškaraca i žena ($p > 0,05$).

Životne navike (Tabela 1.)

Pušenje je prisutno kod manjeg broja ispitanika-30,5% ispitanika, dok alkohol konzumira nešto manje od polovine ispitanika - 47,3%. Većina ispitanika ima umerenu fizičku aktivnost (3–4 puta nedeljno ili svakodnevno 73,4%, što je ohrabrući podatak u smislu kardiovaskularne prevencije.

Tabela 1. Navike i faktori rizika

Navika	Da (%)	Ne (%)
Pušenje	30,5	69,5
Konzumacija alkohola	47,3	52,7
Redovna fizička aktivnost	73,4	26,6

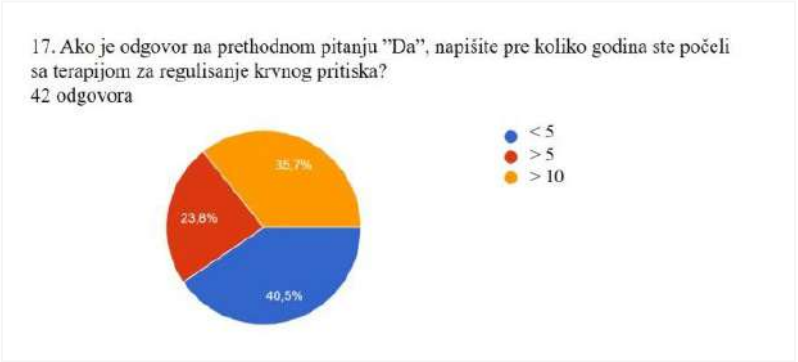
Ishrana i antropometrijski podaci

Najveći broj ispitanika svakodnevno konzumira povrće (88,2%) i voće (65%), U pogledu telesne mase, 33% ima telesnu težinu 71–90 kg, a predgojazni i gojazni (> 90 kg) čine 45,3%. BMI nije izračunavan, kao ni obim struka, marker abdominalne gojaznosti.

Hipertenzija i porodična anamneza

Hipertenziju ima 43 ispitanika (21,2%), dok je porodična anamneza za hipertenziju pozitivna kod 68,5%. Od obolelih sa hipertenzijom 43 (100%) njih 17 (40,5%) koristi terapiju u skorije vreme(do 5 godina) a 35,7% se leči medikamentozno više od 10 godina (Grafikon 2.).

Grafikon 2. Raspodela ispitanika u funkciji vremena početka terapije za regulisanje krvnog pritiska



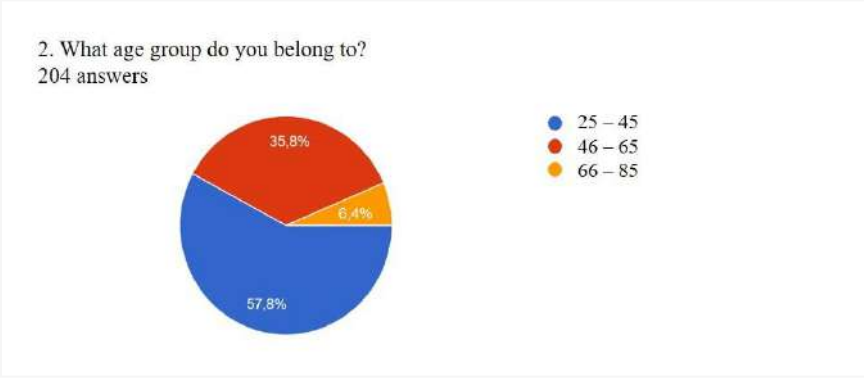
hypertension, the date of initiation of therapy, and a possible association with previous COVID-19 infection. The data were processed descriptively and analytically using SPSS v.26 software. Statistical significance testing was performed using the chi-square (χ^2) test for categorical variables. Statistical significance was accepted at $p < 0.05$..

COVID-19 vaccination and hypertension – age and hypertension. Although mean age values were not available for each group, preliminary analysis suggests that hypertension is more common in the middle-aged category (>45 years).

RESULTS

Age structure of participants (Figure 1): Out of 203 respondents, the most represented group was the younger population aged 25–45 years (57.6%), followed by the middle-aged group of 46–65 years (35.8%), while the older population aged 66–85 years was the least represented (6.4%).

Graph 1. Distribution of the age structure of respondents



Gender structure and hypertension:
The study showed a predominance of female participants, with 148 (72.9%) women, while there were almost three times fewer men—55 (27.1%). No statistically significant difference was found in the prevalence of hypertension between men and women ($p > 0.05$).
Lifestyle habits (Table 1):
Smoking was present in a smaller proportion of participants—30.5%, while alcohol consumption was reported by slightly less than half of the respondents (47.3%). Most participants reported moderate physical activity (3–4 times per week or daily; 73.4%), which is a reassuring finding in terms of cardiovascular prevention.

Table 1. Habits and risk factors

Habit	Yes (%)	No (%)
Smoking	30.5	69.5
Alcohol consumation	47.3	52.7
Regular physical activity	73.4	26.6

Diet and anthropometric data:
The majority of respondents reported daily consumption of vegetables (88.2%) and fruit (65%). Regarding body weight, 33% of participants had a body weight between 71–90 kg, while overweight and obese individuals (>90 kg) accounted for 45.3%. BMI was not calculated, nor was waist circumference, a marker of abdominal obesity.
Hypertension and family history:
Hypertension was present in 43 participants (21.2%), while a positive family history of hypertension was reported in 68.5% of respondents. Among those with hypertension, 17 individuals (40.5%) had been on therapy for a shorter period (up to 5 years), while 35.7% had been receiving pharmacological treatment for more than 10 years (Figure 2)..

COVID-19 infekcija i hipertenzija

COVID-19 infekciju preležalo je 144 ispitanika (70,9%), dok je samo 13 (9,0%) imalo teži oblik bolesti. Hospitalizovana su samo 4 ispitanika. Od 43 hipertenzivnih bolesnika (100%) njih 17 (40,5%) sa novootkrivenom hipertenzijom posle preležanog COVID-19, što ukazuje na moguću povezanost (Tabela 2). Posebno je značajno da je 40,5% hipertoničara započelo terapiju posle pandemije

Tabela 2. Povezanost COVID-19 infekcije i HTA

Parametar	Broj ispitanika	%
Preležali COVID-19	144	70,9
HTA ukupno	43	21,2
HTA de novo i COVID+	17	8,4

Statistički značajna povezanost između preležane COVID-19 infekcije i prisustva hipertenzije je analizirana putem χ^2 testa: povezanost COVID-19 infekcije i pojave hipertenzije**.** Kontingenciona tabela (COVID +/– × HTA +/–) pokazala je značajnu korelaciju: $\chi^2 = 21,3$; df = 1; $p < 0,001$, što ukazuje da su osobe koje su preležale COVID-19 značajno češće imale novonastalu i započei su lečenje posle pandemijehipertenziju u odnosu na one koje nisu bile inficirane (Tabela 3).

Tabela 3. Kontingenciona tabela

	Hipertenzija (+)	Hipertenzija (–)	Ukupno
COVID-19 preležali	43	101	144
Nisu imali COVID-19	0	59	59
Ukupno	43	160	203

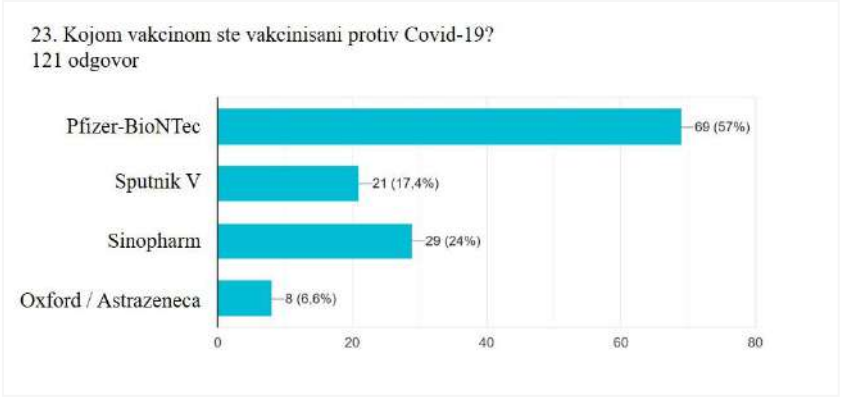
(Ovde se uključuje i 17 novootkrivenih sa COVID-19, jer svi HTA + su u ovom redu.)

Postoji statistički značajna povezanost između COVID-19 infekcije i novootkrivene hipertenzije (p < 0.001).

Vakcinacija i nuspojave

Vakcinisano je 59,1% ispitanika (120 osoba), najčešće Pfizer vakcinom (56,7%). Nuspojave su zabeležene kod samo 8,3%, najčešće blage prirode (umor, bol na mestu uboda).

Grafikon 3. Grafički prikaz udela aplikovanih vakcina protiv Covid-19 prema proizvođaču



Povezanost vakcinacije i hipertenzije

Poređenje vakcinisanih (n = 120) i nevakcinisanih (n = 83) ispitanika pokazalo je da nema značajne razlike u učestalosti hipertenzije ($\chi^2 \approx 0,33$; $p > 0,5$). Dobijeni rezultat potvrđuje da vakcinacija ne utiče značajno na pojavu povišenog krvnog pritiska u ispitivanoj populaciji (Tabela 4).

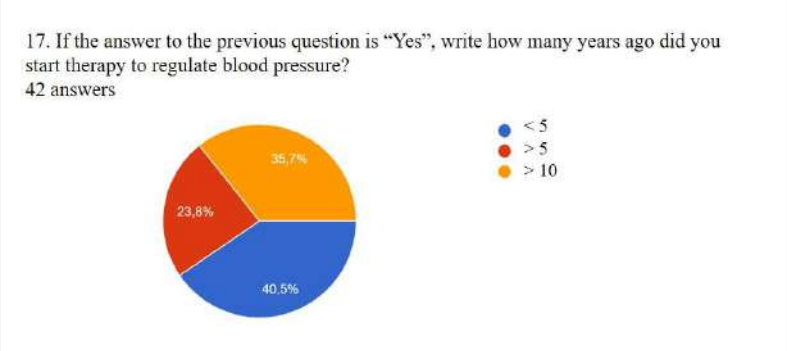
Tabela 4. Kontingenciona tabela (pretpostavljena iz teksta)

	HTA (+)	HTA (–)	Ukupno
Vakcinisani	26	94	120
Nevakcinisani	17	66	83
Ukupno	43	160	203

(Distribucija procenjena prema proporcijama; nije bilo razlike u učestalosti nuspojava.)

Pol i starost nisu mogli biti analizirani numerički.

Chart 2. Distribution of respondents as a function of time of initiation of therapy for blood pressure regulation



COVID-19 infection and hypertension: A total of 144 participants (70.9%) had previously had COVID-19 infection, while only 13 (9.0%) experienced a more severe form of the disease. Hospitalization was reported in only 4 participants.

Among the 43 participants with hypertension (100%), 17 (40.5%) had newly diagnosed hypertension after recovering from COVID-19, suggesting a possible association (Table 2). It is particularly noteworthy that 40.5% of hypertensive patients initiated therapy after the pandemic.

Table 2. Association between COVID-19 infection and hypertension (HTA

Parameter	Number of respondents	%
Recovered from COVID-19	144	70.9
HTA total	43	21.2
HTA <5 years and COVID+	17	8.4

A statistically significant association between previous COVID-19 infection and the presence of hypertension was analyzed using the χ^2 test: the relationship between COVID-19 infection and the occurrence of hypertension. The contingency table (COVID +/− × HTA +/−) showed a significant correlation: $\chi^2 = 21.3$; df = 1; $p < 0.001$, indicating that individuals who had previously had COVID-19 were significantly more likely to develop new-onset hypertension and initiate treatment after the pandemic compared to those who were not infected (Table 3).

Table 3. Contingency table

	Hypertension (+)	Hypertension (–)	Total
COVID-19 recovered	43	101	144
No history of COVID-19 infection	0	59	59
Total	43	160	203

(This includes the 17 newly diagnosed cases after COVID-19 infection, as all HTA+ participants are included in this row.).)

There is a statistically significant association between COVID-19 infection and newly diagnosed hypertension ($p < 0.001$).

Vaccination and adverse effects: A total of 59.1% of participants (120 individuals) were vaccinated, most commonly with the Pfizer vaccine (56.7%). Adverse effects were reported in only 8.3% of participants, most of which were mild in nature (fatigue, pain at the injection site).

DISKUSIJA

Rezultati ukazuju na to da postoji statistički značajna veza između preležane COVID-19 infekcije i pojave hipertenzije odnosno novonastale arerijske hipertenzije (varijabla pojava hipertenzije pre manje od 5 godina). To se poklapa sa rezultatima drugih istraživanja koja navode da virus SARS-CoV-2 utiče na ACE2 receptore, izazivajući endotelnu disfunkciju i povišenje krvnog pritiska [13,14]. Posebno je značajno da je 40,5% hipertoničara započelo terapiju posle pandemije, što je statistički značajno i može ukazivati na post-COVID hipertenziju. Većina ispitanika iz grupe novonastale post COVID hipertenzije imala je blaži oblik bolesti, što sugeriše da i subklinička oštećenja mogu imati dugoročne posledice [15]. Vakcinacija, prema podacima ankete, nije imala statistički značajan uticaj na pojavu hipertenzije - većina vakcinisanih nije prijavila nuspojave, niti je zabeležen porast pritiska nakon imunizacije. To je u skladu sa publikovanim metaanalizama koje pokazuju da vakcine protiv COVID-19 ne povećavaju rizik za HTA [16,17]. Rezultati sprovedenog istraživanja ukazuju na jasnu tendenciju povećane učestalosti novootkrivene hipertenzije u periodu nakon pandemije COVID-19. Činjenica da je 40% ispitanika sa hipertenzijom započelo terapiju u poslednjih pet godina, a da su svi imali preležanu COVID-19 infekciju, podržava hipotezu o mogućoj patofiziološkoj vezi između SARS-CoV-2 i dugoročnih promena vaskularne funkcije. Ovaj nalaz je u skladu sa sve većim brojem studija koje potvrđuju da infekcija može izazvati trajne promene u regulaciji krvnog pritiska, uključujući inflamaciju endotela, oštećenje ACE2 receptora, aktivaciju RAAS sistema, povećanje arterijske rigidnosti i autonomnu disfunkciju. Ovakvi nalazi podržavaju koncept tzv. “tihog oštećenja endotela”, gde virus izaziva subklinička oštećenja koja se manifestuju tek nakon određenog vremena. Dodatno, istraživanja ukazuju da post-COVID sindrom može uključiti autonomnu disregulaciju, koju karakterišu varijacije krvnog pritiska, palpitacije i tahikardija, što takođe može doprineti razvoju hipertenzije. U pogledu vakcinacije, naši podaci ukazuju da u populaciji ispitanika nije zabeležen značajniji porast hipertenzije nakon imunizacije. Ovo je u skladu sa većinom publikovanih metaanaliza koje pokazuju da su epizode povišenog krvnog pritiska nakon vakcinacije najčešće prolazne, blage i bez dugoročnih posledica. Posebno treba istaći i značajan uticaj životnih navika i antropometrijskih faktora. U našem uzorku gojaznost je bila učestala, a fizička aktivnost prisutna kod većine, ali često samo umerenog intenziteta. Ovi parametri, zajedno sa pozitivnom porodičnom anamnezom, poznati su rizični faktori za hipertenziju i mogu delimično doprineti objašnjenju porasta prevalence, posebno u periodima smanjene fizičke aktivnosti i povećanog stresa tokom pandemije. Kada se svi faktori sagledaju u celini, moguće je pretpostaviti da je kod mnogih osoba došlo do kombinovanog efekta infekcije, stresa, promenjenih životnih navika i već postojeće predispozicije, što je potencijalno dovelo do manifestacije hipertenzije. Nalazi našeg istraživanja dopunjuju postojeću literaturu i ukazuju na potrebu za daljim multidisciplinarnim pristupom, uključujući kardiološku, endokrinološku i imunološku perspektivu.

ZAKLJUČAK

Rezultati ovog istraživanja potvrđuju da postoji statistički značajna povezanost između preležane COVID-19 infekcije i povećane učestalosti novootkrivene hipertenzije u postpandemijskom periodu. Kod značajnog broja ispitanika hipertenzija se javila nakon 2020. godine, što vremenski korespondira sa pandemijom i potvrđuje nalaze iz međunarodnih istraživanja o dugoročnim kardiovaskularnim posledicama infekcije SARS-CoV-2. Po našim rezultatima , vakcinacije nema ulogu u nastanku hipertenzije Ovi rezultati su u skladu sa aktuelnim dokazima koji ukazuju da je rizik od hipertenzije povezan sa vakcinacijom nizak i najčešće prolazan. U kontekstu faktora rizika, prisustvo gojaznosti, pozitivne porodične anamneze i nezdravih životnih navika poput pušenja i povećanog unosa alkohola , kao što je odavno poznato, mogu dodatno doprinositi pojavi hipertenzije Sveukupno, podaci ukazuju da je COVID-19 infekcija značajan zdravstveni događaj koji kod predisponiranih osoba može ubrzati ili precipirati pojavu hipertenzije. Neophodna su dalja, obimnija i longitudinalna istraživanja kako bi se preciznije definisale veze između virusne infekcije, imunološkog odgovora, vaskularne regulacije i dugoročnih kardiovaskularnih ishoda.

Zahvalnica: Autori zahvaljuju Gordani Mundrić, profesoru engleskog jezika i književnosti na lekturi engleske verzije rukopisa.

Figure 3. Graphical representation of the distribution of administered COVID-19 vaccines by manufact

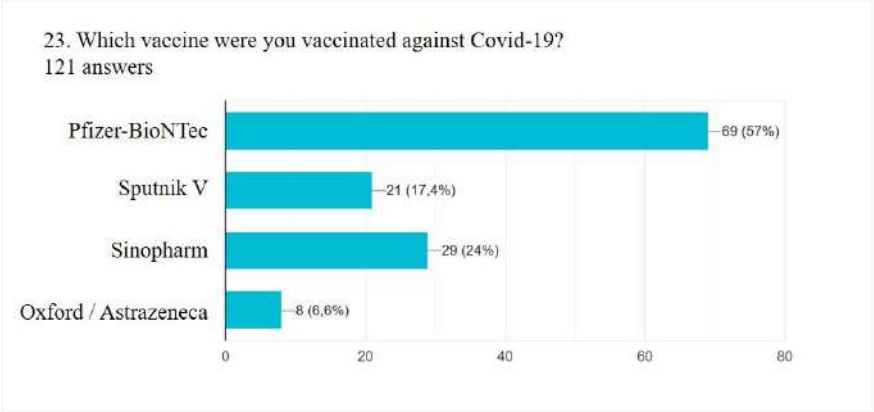


Table 4. Contingency table (derived from text)

	HTA (+)	HTA (–)	Total
Vaccinated	26	94	120
Unvaccinated	17	66	83
Total	43	160	203

(The distribution was estimated based on proportions; no difference in the frequency of adverse effects was observed.)

Gender and age could not be analyzed numerically.

DISCUSSION

Results indicate that there is a statistically significant association between previous COVID-19 infection and the occurrence of hypertension, particularly new-onset arterial hypertension (defined as hypertension diagnosed within less than 5 years). These findings are consistent with other studies suggesting that the SARS-CoV-2 virus affects ACE2 receptors, leading to endothelial dysfunction and increased blood pressure [13,14]. Notably, 40.5% of hypertensive patients initiated therapy after the pandemic, which is statistically significant and may indicate post-COVID hypertension. Most participants in the newly developed post-COVID hypertension group had a mild form of the disease, suggesting that even subclinical damage may have long-term consequences [15]. According to the survey data, vaccination did not have a statistically significant impact on the occurrence of hypertension—most vaccinated participants did not report adverse effects, nor was an increase in blood pressure observed following immunization. This is consistent with published meta-analyses showing that COVID-19 vaccines do not increase the risk of hypertension [16,17]. The results of this study indicate a clear trend toward increased incidence of newly diagnosed hypertension in the post-COVID period. The fact that 40% of hypertensive participants initiated therapy within the last five years, all of whom had a history of COVID-19 infection, supports the hypothesis of a possible pathophysiological link between SARS-CoV-2 and long-term vascular changes. This finding aligns with an increasing body of evidence suggesting that infection may induce persistent alterations in blood pressure regulation, including endothelial inflammation, ACE2 receptor disruption, RAAS activation, increased arterial stiffness, and autonomic dysfunction. Such findings support the concept of “silent endothelial injury,” where viral infection causes subclinical damage that becomes clinically evident over time. Additionally, studies indicate that post-COVID syndrome may include autonomic dysregulation, characterized by blood pressure variability, palpitations, and tachycardia, which may also contribute to the development of hypertension. Regarding vaccination, our data suggest that no significant increase in hypertension was observed following immunization in the studied population. This is consistent with the majority of published meta-analyses showing that episodes of elevated blood pressure after vaccination are most often transient, mild, and without long-term consequences. It is also important to emphasize the significant influence of lifestyle and anthropometric factors. In our sample, obesity was relatively common, while physical activity was present in most participants but often only of moderate intensity. These parameters, along with a

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positive family history, are well-known risk factors for hypertension and may partially explain the increased prevalence, particularly during periods of reduced physical activity and increased stress during the pandemic. When all factors are considered together, it may be assumed that in many individuals a combined effect of infection, stress, altered lifestyle habits, and pre-existing predisposition contributed to the manifestation of hypertension. The findings of this study complement existing literature and highlight the need for further multidisciplinary approaches, including cardiological, endocrinological, and immunological perspectives.

CONCLUSION

The results of this study confirm that there is a statistically significant association between previous COVID-19 infection and an increased incidence of newly diagnosed hypertension in the post-pandemic period. In a substantial number of participants, hypertension developed after 2020, which temporally corresponds to the pandemic and supports findings from international studies on the long-term cardiovascular consequences of SARS-CoV-2 infection. According to our results, vaccination does not play a role in the development of hypertension. These findings are consistent with current evidence indicating that the risk of hypertension associated with vaccination is low and most often transient. In the context of risk factors, the presence of obesity, a positive family history, and unhealthy lifestyle habits such as smoking and increased alcohol consumption, as is well established, may further contribute to the development of hypertension. Overall, the data suggest that COVID-19 infection is a significant health event that, in predisposed individuals, may accelerate or precipitate the onset of hypertension. Further, larger-scale and longitudinal studies are necessary to more precisely define the relationships between viral infection, immune response, vascular regulation, and long-term cardiovascular outcomes.

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