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REVIEW
PREGLEDNI RAD

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Artificial Intelligence in Medicine and Dentistry

Umjetna inteligencija u medicini i dentalnoj medicini

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Abstract

Introduction: Artificial intelligence has been applied in various fields throughout history, but its integration into daily life is more recent. The first applications of AI were primarily in academia and government research institutions, but as technology has advanced, AI has also been applied in industry, commerce, medicine and dentistry. **Objective:** Considering that the possibilities of applying artificial intelligence are developing rapidly and that this field is one of the areas with the greatest increase in the number of newly published articles, the aim of this paper was to provide an overview of the literature and to give an insight into the possibilities of applying artificial intelligence in medicine and dentistry. In addition, the aim was to discuss its advantages and disadvantages. **Conclusion:** The possibilities of applying artificial intelligence to medicine and dentistry are just being discovered. Artificial intelligence will greatly contribute to developments in medicine and dentistry, as it is a tool that enables development and progress, especially in terms of personalized healthcare that will lead to much better treatment outcomes.

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Introduction

There is probably no human being in the world that has not, at some point in his or her life, become aware of the limits of his or her physical and/or mental abilities. In the past, these limits often meant life or death because there was no way to go beyond one's limits and simply improve one's abilities. The devices and machines invented and manufactured by man have undoubtedly made everyday life easier, especially in the physical sense. However, to combine the endurance and reliability of machines with the human characteristics of intelligence and consciousness was the desire of many inventors, researchers and philosophers who tried to describe the process of human thinking as a mechanical manipulation of symbols. A thinking artificial creation, i.e., a machine that has a kind of meta-consciousness and thinks like a human, is something that captures the imagination. The theoretical foundations of what we now call artificial intelligence (AI) were laid by Alan Turing, Claude E. Shannon, and Norbert Wiener (1). Alan M. Turing (1912 – 1954) is an English mathematician who is considered the father of theoretical computer science; Claude E. Shannon (1916 – 2001) is an American mathematician who is known as the father of the so-called "information theory"; and Norbert Wiener (1894 - 1964) is an American mathematician and philoso-

Uvod

Vjerojatno ne postoji osoba na svijetu koja u određenom trenutku nije osvijestila granice svojih tjelesnih i/ili psihičkih sposobnosti. U prošlosti ta su ograničenja često značila život ili smrt zato što nisu postojale mogućnosti za pomicanje vlastitih ograničenja i jednostavno unaprjeđenje sposobnosti. Strojevi i naprave koje je čovjek izumio nedvojbeno su olakšali svakodnevni život, osobito u fizičkom smislu. Ipak, kombiniranje izdržljivosti i pouzdanosti strojeva s inteligencijom i svjesnošću, što su primarno ljudske osobine, bila je težnja mnogobrojnih izumitelja, znanstvenika i filozofa koji su proces ljudskog razmišljanja nastojali opisati kao mehaničku manipulaciju simbolima. Razmišljajuća umjetna kreacija, odnosno stroj koji je svjestan i razmišlja poput čovjeka, nešto je što intrigira maštu. Teoretsku osnovu za današnju umjetnu inteligenciju (UI) postavili su Alan Turing, Claude E. Shannon i Nobert Wiener (1). Alan M. Turing (1912. – 1954.) engleski je matematičar kojeg smatramo ocem teorijske računalne znanosti, Claude E. Shannon (1916. – 2001.) američki je matematičar poznat kao otac takozvane "informacijske teorije", a Norbert Wiener (1894. – 1964.) američki je matematičar i filozof, utemeljitelj kibernetike. Upravo su oni zaslužni za koncept stvaranja inteligentnih strojeva (2). Ipak, koncept same umjetne inteligencije nešto je noviji. Istaknimo

pher, who is the founder of cybernetics. They are responsible for the concept of creating intelligent machines (2). However, the concept of AI itself is somewhat younger. Dating back to 1956, when a group of researchers participating in an eight-week Dartmouth Summer Research Project on Artificial Intelligence at Dartmouth College in New Hampshire, USA, proposed a research project and set the goal of creating "thinking machines" that could mimic human intelligence and behavior. This is widely regarded as the beginning of AI as a formal field of study (3,4).

In order to better understand the concept of artificial intelligence, it is necessary to clarify the difference between artificial intelligence, deep learning, machine learning and data science, Figure 1. Artificial intelligence, deep learning, machine learning, and data science are related but distinct fields. Artificial intelligence is the broadest field, of which machine learning and deep learning are subsets. Data science uses techniques from all of these fields to gain insights and knowledge from data. Artificial intelligence is a broad field that encompasses a range of techniques and methods aimed at creating intelligent machines that can perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision making, and natural language processing. Artificial intelligence can be divided into several branches, including expert systems, robotics, and natural language processing, to name a few. Deep learning is a subfield of artificial intelligence that uses neural networks inspired by the structure of the human brain to learn from large amounts of data. Deep learning algorithms can automatically identify and extract features from raw data such as images, sounds, and text and use them to make predictions or decisions. Examples of deep learning applications include image recognition, speech recognition, and natural language processing. Machine learning is a subfield of artificial intelligence that focuses on developing algorithms and statistical models that allow computers to learn from data without being explicitly programmed. Machine learning techniques can be supervised

da datira od 1956. godine kada je održan osmotjedni seminar Dartmouth Summer Research Project o umjetnoj inteligenciji na Dartmouth Collegeu u New Hampshireu koji je pohađala skupina znanstvenika te predložila istraživački projekt s naznačenim ciljem – stvoriti „razmišljajuće strojeve" koji bi mogli oponašati ljudsku inteligenciju i ponašanje. Taj se događaj uglavnom smatra početkom razvoja umjetne inteligencije kao priznatoga znanstvenog područja (3, 4).

Kako bismo bolje razumjeli koncept umjetne inteligencije potrebno je objasniti razliku između umjetne inteligencije, dubokoga učenja, strojnoga učenja i podatkovne znanosti.

Slika 1. Umjetna inteligencija, duboko učenje, strojno učenje i podatkovna znanost povezani su, ali su istodobno različita polja. Umjetna inteligencija najšire je polje u sklopu kojega se nalaze strojno i duboko učenje. Podatkovna znanost koristi se tehnikom iz gore navedenih područja kako bi stekla uvid i znanje iz dostupnih podataka. Umjetna inteligencija široko je polje koje obuhvaća niz tehnika i metoda usmjerenih na stvaranje inteligentnih strojeva koji mogu obavljati zadatke koji inače zahtijevaju ljudsku inteligenciju kao što su vizualna percepcija, prepoznavanje govora, donošenje odluka i obrada prirodnog jezika. Umjetna inteligencija može se podijeliti u nekoliko grana, uključujući stručne sustave, robotiku, obradu prirodnog jezika – da spomenemo samo neke od njih. Duboko učenje područje je unutar umjetne inteligencije koje se koristi neuralnom mrežom inspiriranom strukturom samoga ljudskoga mozga kako bi učila iz velike količine podataka. Algoritmi dubokoga učenja mogu automatski prepoznati i izdvojiti značajke iz sirovih podataka kao što su slike, zvukovi i tekst te ih primijeniti u predviđanju i donošenju odluka. Primjeri primjene dubokoga učenja obuhvaćaju prepoznavanje slike, prepoznavanje glasa i obradu prirodnog jezika.

Strojno učenje je područje unutar umjetne inteligencije koje je usmjereno na razvoj algoritama i statističkih modela koji omogućuju računalima učenje iz podataka iako prethodno nisu ciljano programirani u tu svrhu. Tehnike strojnog

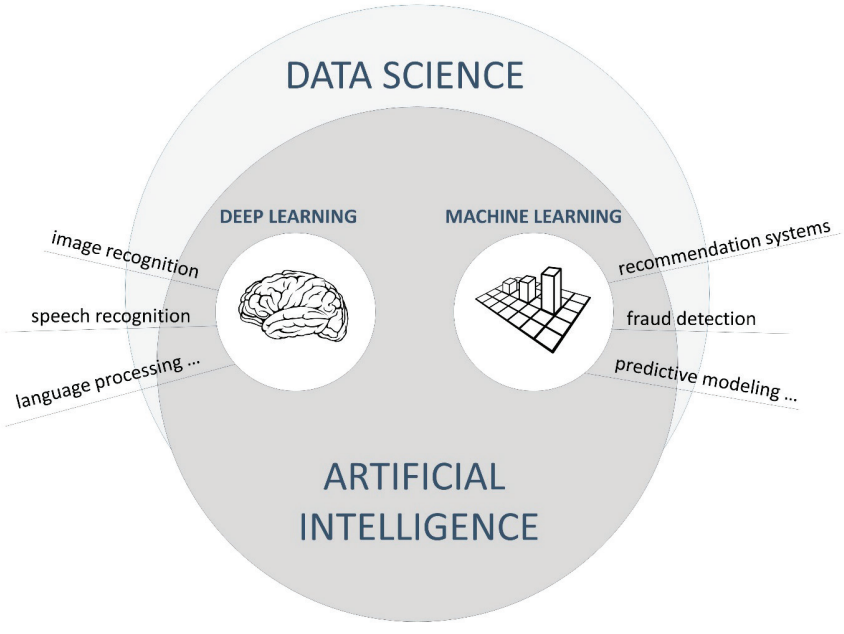

Figure 1 Artificial intelligence, deep learning, machine learning and data science
Slika 1. Umjetna inteligencija, duboko učenje, strojno učenje i podatkovna znanost

(the algorithm learns from labeled data), unsupervised (the algorithm learns from unlabeled data), or semi-supervised (the algorithm learns from a combination of labeled and unlabeled data). Applications of machine learning include recommendation systems, fraud detection, and predictive modeling. Data science is an interdisciplinary field that combines statistical and computational techniques with domain-specific knowledge to gain insights and knowledge from data. Data science encompasses a range of activities including data acquisition, cleaning and pre-processing, exploratory data analysis, statistical modeling, and machine learning. Data science is used in a variety of fields, including healthcare, finance, social media, and e-commerce.

Artificial intelligence has been applied in various fields throughout history, but its integration into daily life is more recent. The first applications of AI were primarily in academia and government research institutions, but as technology has advanced, AI has also been applied in industry and commerce (5). One of the earliest examples of AI in everyday life was the use of expert systems in the 1980s and 1990s. These were computer programs that could mimic the decision-making abilities of a human expert in a particular field, such as medicine or finance. In the 21st century, AI has been increasingly integrated into a variety of consumer products and services. Examples of AI include virtual personal assistants such as Apple's Siri and Amazon's Alexa, and recommendation systems used by companies such as Netflix and Amazon to personalize their customers' experiences. AI is also being used in areas such as self-driving cars, healthcare and finance.

Today, we can distinguish three generations of AI (3). The first generation is the so-called artificial narrow intelligence (ANI), the second is the artificial general intelligence (AGI) and the third, currently the most advanced generation, is the artificial superintelligence (ASI). From today's perspective, we can safely say that the first generation is already ubiquitous. When we talk about the first generation of AI, we mean, among other things, the facial recognition and tagging technology used by Facebook, for example, virtual voice assistants in our cell phones such as Siri, Alexa or Bixby, the technology developed by Tesla and Google for self-driving cars, and much more. The second generation of AI is expected to think, plan, and solve problems and tasks on its own. The third generation of artificial superintelligence will be a truly self-aware system that could make humans and their input obsolete in certain situations. Although it is a fictional AI-based system on AI, HAL 9000 from Arthur C. Clarke's *A Space Odyssey* is perhaps the most vivid representation of the capabilities of third-generation artificial intelligence at this time.

Considering that the possibilities of applying artificial intelligence are developing rapidly and that, according to PubMed data, this field is one of the areas with the greatest growth in the number of newly published articles (6), the aim of this paper was to provide an overview of the literature and to give an insight into the possibilities of applying artificial intelligence in medicine and dentistry. The aim was to discuss in details its advantages and disadvantages. For this purpose, the databases Pubmed and Web of science were searched. The

učenja mogu biti nadzirane (algoritmi uče iz označenih podataka), nenadzirane (algoritmi uče iz neoznačenih podataka) i djelomično nadzirane (algoritmi uče dijelom iz označenih, a dijelom iz neoznačenih podataka). Strojno učenje primjenjuje se u sustavima preporuka, otkrivanja prijevara i prediktivnim modelima. Podatkovna znanost interdisciplinarno je područje koje kombinira statističke i računalne metode sa specifičnim znanjem unutar određene domene da bi se dobio uvid u to područje i stvorilo znanje iz samih podataka. Obuhvaća niz aktivnosti, uključujući prikupljanje podataka, pročišćavanje i prethodnu obradu, istraživačku analizu podataka, statističko modeliranje i strojno učenje. Podatkovna znanost koristi se u raznim područjima – u zdravstvu, financijama, društvenim medijima i e-trgovini.

Tijekom prošlosti umjetna se inteligencija primjenjivala u različitim područjima, a njezina primjena u svakodnevnom životu nešto je novija. Njezina rana primjena odnosila se uglavnom na akademsku zajednicu i državne znanstvene institucije, ali s napretkom tehnologije počela je primjena u industriji i trgovini (5). Jedan od najranijih primjera umjetne inteligencije u svakodnevnom životu odnosi se na korištenje ekspertnih sustava 1980-ih i 1990-ih godina. To su bili računalni programi koji su oponašali sposobnost donošenja odluka stručnjaka u određenom području djelovanja kao što su medicina ili financijski sektor. U 21. stoljeću umjetna je inteligencija sve više integrirana u različite potrošačke proizvode i usluge. Primjer za to su virtualni asistenti poput Appleove Siri i Amazonove Alexe te sustavi preporuka kojima se koriste tvrtke kao što su Netflix i Amazon da bi prilagodili ponudu iskustvima svojih korisnika. Upotrebljava se i u izradi samovozećih automobila, u zdravstvu i u financijama.

Danas razlikujemo tri generacije umjetne inteligencije (3). Prva generacija je takozvana uska umjetna inteligencija (UUI), druga je opća umjetna inteligencija (OUI), a treća, trenutačno najnaprednija generacija, jest superumjetna inteligencija (SUI). Iz današnje perspektive možemo sa sigurnošću reći da je prva generacija već sveprisutna. Kad govorimo o prvoj generaciji umjetne inteligencije, mislimo, između ostaloga, na tehnologiju prepoznavanja lica i označavanje osoba, čime se, primjerice, koristi Facebook, zatim virtualne glasovne asistente na našim mobilnim uređajima, kao što su Siri, Alexa ili Bixby, samovozeće automobile koje razvijaju Tesla i Google te još mnogo toga. Od druge generacije umjetne inteligencije očekujemo samostalno razmišljanje, planiranje i rješavanje problema te zadataka za koje nikad nije bila dizajnirana. Treća generacija: superumjetna inteligencija postat će potpuno samosvjesni sustavi koji mogu u određenim situacijama učiniti ljude i njihov doprinos nepotrebnima. Premda je riječ o fiktivnom sustavu na temelju umjetne inteligencije, HAL 9000 iz *Odiseje u svemiru* Arthura C. Clarkea možda je najživopisniji prikaz mogućnosti koje treća generacija umjetne inteligencije ima u ovom trenutku.

S obzirom na to da se mogućnosti primjene umjetne inteligencije iznimno brzo šire i da je prema podatcima iz PubMeda to područje među onima s trendom najvećega uspona prema broju novoobjavljenih članaka (6), svrha ovoga rada jest dati prikaz literature i uvid u mogućnosti primjene umjetne inteligencije u medicini i dentalnoj medicini s na-

keywords artificial intelligence, medicine, healthcare, dentistry, deep learning, and machine learning were used.

Advantages and disadvantages of artificial intelligence in daily life

AI is expected to become even more prevalent in everyday life in the future as technology continues to advance and more industries adopt AI-powered systems and products. The use of AI in everyday life has several advantages, including (2,7,8):

- Improved efficiency and productivity: AI can automate repetitive tasks, making them faster, more accurate, and less error-prone.
- Personalization and customization: AI can learn from data and preferences and provide personalised recommendations, services and experiences.
- Increased security and safety: AI can be used to monitor and protect against potential threats and hazards, such as fraud, cyberattacks, and natural disasters.
- Better decision making: AI can analyse large amounts of data, identify patterns and insights, and help with decision making in various fields such as finance, healthcare, or transportation.
- Improved human capabilities: AI can complement human capabilities by providing real-time information, suggestions, and assistance.
- Improved accessibility: AI can provide services, information, and entertainment for people with disabilities or limited mobility.
- Cost efficiency: AI can help reduce the cost of many tasks and services by automating them, reducing the need for human labour.
- Predictive capabilities: AI can analyse and learn from historical data and make predictions about future events, which can be used in various fields such as weather forecasting, finance, and healthcare.

Although the application of AI has numerous advantages, facilitations and optimizations in everyday life, it also has some disadvantages (5,9). The disadvantages of using AI in everyday are as follows:

- Job displacement: AI can automate many tasks, making them faster, more accurate, and less error-prone, which can lead to job displacement and unemployment.
- Bias and discrimination: AI systems can perpetuate and even reinforce biases and discrimination present in the data on which they are trained.
- Privacy and security concerns: AI systems require large amounts of data to function, which can lead to privacy and security concerns.
- Lack of transparency and accountability: it can be difficult to understand how AI systems make decisions, which can make it difficult to explain or hold them accountable.
- Dependence on technology: AI can become a crutch that people rely on too much, and some people may no longer be able to complete tasks without AI assistance.

glaskom na njezine prednosti i nedostatke. U tu svrhu pretražene su znanstvene baze Pubmed i Web of science. Pritom su pojmovi umjetna inteligencija, medicina, zdravstvo, dentalna medicina, duboko učenje i strojno učenje korišteni kao ključne riječi.

Prednosti i nedostatci umjetne inteligencije u svakodnevnom životu

S obzirom na kontinuirani razvoj tehnologije očekuje se sve šira primjena umjetne inteligencije u svakodnevnom životu zato što različite vrste industrije sve više prilagođuju svojim potrebama sustave i proizvode temeljene na umjetnoj inteligenciji. Postoji više prednosti korištenja umjetne inteligencije u svakodnevnom životu, uključujući (2, 7, 8):

- poboljšanje radne učinkovitosti i produktivnosti: UI može automatizirati ponavljajuće poslove i učiniti ih bržima, preciznijima i manje sklonima pogreškama
- personalizacija i prilagodba: UI može učiti na temelju podataka i afiniteta te na osnovi naučenoga pružiti personalizirane preporuke, usluge i iskustva
- povećana sigurnost i osiguranje: UI se može koristiti za nadzor i zaštitu od potencijalnih prijetnji i opasnosti kao što su prijevare, kibernetički napadi i prirodne katastrofe
- poboljšano donošenje odluka: UI može analizirati velik broj podataka, utvrditi obrasce i dobiti uvide te na temelju toga pomoći pri donošenju odluka u različitim područjima kao što su financije, zdravstvo ili prijevoz
- širenje ljudskih sposobnosti: pružajući odgovarajuće informacije, prijedloge i asistenciju u stvarnom vremenu UI može nadograditi ljudske sposobnosti
- unaprjeđenja dostupnosti: UI može pružati usluge, informacije i zabavni sadržaj osobama s invaliditetom ili ograničenom pokretljivošću
- isplativost: automatizacijom i smanjivanjem potrebe za ljudskim radom UI može pomoći u smanjenju cijene raznih poslova i usluga
- mogućnost predviđanja: UI može analizirati podatke iz prošlosti, učiti iz njih i na temelju naučenoga predvidjeti buduće događaje, što je primjenjivo u različitim djelatnostima kao što su vremenska prognoza, financijski sektor i zdravstvo.

Premda primjena umjetne inteligencije ima mnogobrojne prednosti te olakšava i optimizira svakodnevni život, ima i određene nedostatke (5, 9). Prepoznati nedostatci korištenja u svakodnevnom životu jesu:

- gubitak posla: UI može automatizirati mnogobrojne zadatke, učiniti ih bržima, preciznijima i manje sklonima pogreškama, što može voditi prema gubitku posla i većoj nezaposlenosti u društvu
- pristranost i diskriminacija: UI sustavi mogu zadržati, pa čak i pojačati pristranost i diskriminaciju koje su bile prisutne u podatcima na kojima se uvježbavaju
- privatnost i sigurnosni problemi: UI sustavi zahtijevaju veliku količinu podataka da bi mogli djelovati, pa se postavljaju pitanja vezana za sigurnost i privatnost informacija
- nedostatak transparentnosti i odgovornosti: razumijevanje načina na koji UI sustavi funkcioniraju i donose od-

- Ethical concerns: AI may raise ethical concerns, such as autonomous weapons and decision making, job displacement, and privacy.
- Lack of human contact: AI systems lack the human touch and emotion that can be important for certain tasks, such as healthcare, customer service, and education.
- Limited understanding: AI systems may have limited understanding of context and have difficulty understanding nuances and subtleties of human language and behaviour.

AI has the potential to be dangerous in certain scenarios, particularly when it comes to the development and use of autonomous weapons and decision-making systems that lack proper oversight and regulation. In February 2017, the European Parliament adopted a report with recommendations for the European Commission on civil regulation of robotics. In response to public concerns and debate, Peter John Bentley, a computer scientist at University College London, Miles Brundage of the Future of Humanity Institute at Oxford University, Olle Haeggstroem, a professor of mathematical statistics at Chalmers University and author of the book Here be dragons, and philosopher Thomas Metzinger of the University of Mainz, wrote a comprehensive document under the auspices of the European Commission entitled Should We Fear Artificial Intelligence? in which they discuss in detail the potential dangers posed by the use of AI (10). The potential dangers and risks that may be associated with AI can be divided into the following groups:

- Decision-making systems: AI systems used to make decisions where the stakes are high, such as in healthcare, criminal justice, and finance, can perpetuate or reinforce societal biases or discrimination if they are not properly designed, tested, and regulated.
- Cybersecurity risks: AI systems can be vulnerable to hacking and cyber-attacks, which can have serious consequences when deployed in critical infrastructure such as power grids and transportation systems.
- Autonomous weapons: AI-controlled weapons that can select and attack targets without human intervention raise concerns about accountability and ethical decision-making in the event of unintended harm or collateral damage.
- Unintended consequences: AI systems can have unintended consequences, such as job displacement and economic disruption if not properly managed and regulated.

Artificial intelligence in medicine and healthcare

The decades-long use of computers in medicine and healthcare around the world has generated huge databases with an enormous amount of different data on patients, diagnoses, medical records and linked laboratory results, radio-

luke mogu biti izazovni i zato može biti teško objasniti ih i pozvati na odgovornost
- ovisnost o tehnologiji: UI može postati oslonac u koji se ljudi pretjerano pouzdaju, a pojedinci mogu postati manje sposobni u obavljanju posla bez pomoći tehnologije
- etički izazovi: UI može potaknuti određena etička pitanja u vezi s autonomnim oružjem i donošenjem odluka, gubitkom posla i privatnosti
- nedostatak ljudskog dodira: UI sustavi svakako ne posjeduju ljudski dodir i emocije što može biti velik nedostatak u određenim djelatnostima kao što su zdravstvo, korisnička podrška i obrazovni sustav
- ograničeno razumijevanje: UI sustavi mogu biti ograničeni u shvaćanju konteksta i mogu imati poteškoća u razumijevanju nijansi i suptilnosti ljudskoga jezika i ponašanja.

Umjetna inteligencija može biti opasna u određenim scenarijima, pogotovo onima koji uključuju razvoj i upotrebu autonomnog oružja i sustava za donošenje odluka bez adekvatnog nadzora i propisa. U veljači 2017. godine Europski je parlament odobrio Izvješće s preporukama Komisiji o pravilima građanskoga prava o robotici. S obzirom na brigu i rasprave koje su pokrenute u javnosti, Peter John Bently, računalni znanstvenik s University College iz Londona, Miles Brundage iz Instituta za budućnost čovječanstva Sveučilišta Oxford, Olle Häggström, profesor matematičke statistike na Sveučilištu Chalmers i autor knjige „Here be dragons" te filozof Thomas Metzinger sa Sveučilišta u Mainzu, napisali su opširan dokument pod pokroviteljstvom Europske komisije pod naslovom Trebamo li se bojati umjetne inteligencije? u kojemu se detaljno raspravlja o potencijalnim opasnostima pri uporabi umjetne inteligencije (10). Potencijalne opasnosti i rizike koji se mogu povezati s umjetnom inteligencijom možemo svrstati u nekoliko skupina:

- sustavi odlučivanja: UI sustavi koji se koriste za donošenje odluka s velikim ulozima kao što su zdravstvena skrb, kazneno pravosuđe i financije, mogu zadržati ili pojačati društvene predrasude ili diskriminaciju ako nisu pravilno dizajnirani, testirani i regulirani
- rizici kibernetičke sigurnosti: UI sustavi mogu biti podložni hakiranju i kibernetičkim napadima što može imati ozbiljne posljedice ako se koriste u kritičnoj infrastrukturi kao što je električno napajanje i prijevozni sustavi
- autonomno oružje: oružje na temelju umjetne inteligencije koje može odabirati i ciljati mete bez ljudske intervencije izaziva zabrinutost zbog odgovornosti i etičkog donošenja odluka u slučaju nenamjerne ili kolateralne štete
- nenamjerne posljedice: UI sustavi mogu stvoriti određene nenamjerne posljedice kao što su gubitak posla i narušena ekonomija ako se njima ne upravlja pravilno i ako nisu odgovarajuće regulirani.

Umjetna inteligencija u medicini i zdravstvu

Primjenom računala diljem svijeta stvorene su tijekom desetljeća u medicini i zdravstvu goleme baze podataka s velikom količinom različitih podataka o pacijentima, dijagnozama, zdravstvenim kartonima i povezanim laboratorijskim

logical images, clinical images, therapeutic procedures, treatment results, and much more. The existence of such large databases has created one of the main prerequisites for machine learning and the development of artificial intelligence in all areas of medicine. The number of areas in modern medicine where AI is finding practical application is growing inexorably. It is almost impossible to present all the areas in which AI is applied in medicine today, therefore this paper will present only some of them. Only 15 or 20 years ago, the application of AI in medicine was mostly experimental and geographically limited to developed and rich countries (11–18). Today, AI can be used in a variety of ways to improve healthcare and medicine:

- Medical imaging: AI can help radiologists and other medical professionals analyse medical images, such as CT scans and X-rays, to detect and diagnose diseases (19–22).
- Diagnosis and treatment: AI can analyse large amounts of patient data to help physicians make more accurate diagnoses and personalised treatment plans. Artificial intelligence is now used in almost all areas of medicine for screening, diagnosing and treating patients, including gastroenterology and digestive disorders (23,24), cancer screening, diagnosis and treatment (25–27), COVID-19 (28), heart diseases and failures (29), oncology (30), intensive care (31), dermatology (32) and many more.
- Drug discovery and development: AI can be used to analyse big data from genetic, chemical, and medical research to identify new drug candidates and speed up drug development (33–36). Artificial intelligence has also been used in the research of new drugs and vaccines against Covid-19 (37). The role of AI in oncology is particularly important for cancer research and for the discovery of new drugs, because by applying the principles of personalized medicine it is possible to find much better and more effective drugs more quickly (38).
- Clinical decision support: AI can help physicians and other healthcare professionals make better decisions by providing real-time information and alerts based on patient data (39–42). The progress of AI application is particularly pronounced in intensive care (31), surgery (43), oncology (44) and clinical decision support in infectious diseases (45) but also in other areas of medicine.
- Personalized medicine: AI can be used to analyze genetic and patient data to create personalized medical (46) plans and treatments tailored to the specific needs of individual patients especially in oncology (30,47) and cardiovascular medicine (48–50).
- Monitoring and tracking of chronic diseases: AI can help monitor vital signs, symptoms and other data to help identify potential health issues early (51,52), especially in cases of chronic diseases, helping to prevent complications such as in chronic obstructive pulmonary disease (53) or hypertension management (54).
- Predictive analytics: AI can help predict the likelihood of certain medical conditions and diseases based on a patient's data, thus contributing to their prevention and treatment (55,56). Large existing public health system

nalazima. Tu su i radiološki i klinički nalazi i slike, terapijski zahvati, ishodi liječenja i još mnogo toga. Zahvaljujući takvim opsežnim bazama podataka osiguran je jedan od temeljnih preduvjeta za strojno učenje i razvoj umjetne inteligencije u svim područjima medicine. Područja medicine u kojima počinje praktična primjena umjetne inteligencije svakodnevno nezaustavljivo raste. Gotovo je nemoguće nabrojiti sva područja u sklopu medicine u kojima se danas primjenjuje umjetna inteligencija pa ćemo se u ovom radu ograničiti na neke od njih. Prije samo 15 do 20 godina primjena umjetne inteligencije bila je u medicini još na eksperimentalnoj razini i geografski ograničena uglavnom na razvijene i bogate zemlje (11 – 18). Danas se pak može primijeniti na različite načine i tako unaprijediti zdravstvo i medicinu. To uključuje:

- medicinsko snimanje: UI može pomoći radiolozima i ostalim medicinskim stručnjacima u analizi slika kao što su CT i RTG snimke kako bi uspješnije ustanovili i potvrdili dijagnozu (19 – 22)
- dijagnoza i liječenje: UI može procesuirati veliku količinu pacijentovih podataka kako bi se mogla što preciznije postaviti dijagnoza i pripremiti personalizirani plan liječenja; danas se primjenjuje u gotovo svim područjima medicine za skrining (probir), dijagnosticiranje i liječenje pacijenata, uključujući gastroenterologiju i bolesti probavnog sustava (23, 24), skrinig, dijagnosticiranje i liječenje karcinoma (25 – 27), bolesti COVID-19 (28), srčane bolesti i mane (29), onkologiju (30), intenzivnu skrb (31), dermatologiju (32) i mnoga druga područja
- otkriće i razvoj novih lijekova: UI se može koristiti za analizu velikoga broja podataka iz genetičkih, kemijskih i medicinskih istraživanja sa svrhom otkrivanja potencijalnih novih lijekova i ubrzanje njihova razvoja (33 – 36); također se koristi u istraživanju novih lijekova i cjepiva protiv bolesti COVID-19 (37); njezina uloga u onkologiji osobito je važna u istraživanju karcinoma i otkrivanju novih lijekova zato što se primjenom principa personalizirane medicine brže može pronaći bolje i učinkovitije lijekove (38)
- podrška u kliničkom odlučivanju: UI može pomoći liječnicima i drugim zdravstvenim radnicima u donošenju odluka jer osigurava dostupnost informacija u realnom vremenu i pronalazi pacijentove podatke (39 – 42); napredak na tom planu osobito je izražen u području intenzivne skrbi (31), kirurgije (43), onkologije (44), pri donošenju kliničkih odluka u slučaju infektivnih bolesti (45), ali i u mnogim drugim djelatnostima u sklopu medicine
- personalizirana medicina: UI se može koristiti za analizu genetskih i drugih pacijentovih podataka kako bi se pripremio personalizirani medicinski plan (46) i liječenje prilagodilo specifičnim potrebama pojedinog pacijenta, osobito u onkologiji (30, 47) i kardiovaskularnoj medicini (48 – 50)
- promatranje i praćenje kroničnih bolesti: UI može pomoći u praćenju vitalnih znakova, simptoma i ostalih podataka kako bi se rano otkrili mogući zdravstveni problemi (51, 52), osobito u slučaju kroničnih bolesti, pomažući u prevenciji komplikacija kod, primjerice, kronične op-

databases are used for this purpose (57). It has been interesting to see how AI has been used to predict COVID -19 outcomes (58) or, in patients with gastrointestinal cancer, to predict response to treatment (59).
- Medical research: AI can be used to analyse large volumes of medical data, identify patterns, and gain new insights that can help us understand the pathology of diseases and ultimately develop new treatments (60–63).

Advantages and disadvantages of artificial intelligence in medicine and healthcare

In general, the advantages and disadvantages of using AI in medicine are similar to the advantages and disadvantages of using AI in daily life. The use of AI in medicine has several advantages, including:
- Improved accuracy and efficiency: AI can help doctors and other healthcare professionals analyse large amounts of medical data, such as imaging and patient records, to detect and diagnose diseases more quickly and accurately (64).
- Personalized medicine: AI can be used to analyze genetic and patient data to create personalized medical plans and treatments tailored to the specific needs of individual patients.
- Clinical decision support: AI can help physicians and other healthcare professionals make decisions by providing real-time information and alerts based on patient data (65).
- Early detection and prevention: AI can help monitor vital signs, symptoms, and other data to detect potential health problems early, especially chronic diseases, to avoid complications (66).
- Predictive analytics: AI can help predict the likelihood of certain medical conditions and diseases based on a patient's data, helping to prevent and treat them.
- Medical research: AI can be used to analyse large volumes of medical data, identify patterns, and make new discoveries that can help understand the pathology of diseases and ultimately develop new treatments.
- Reduced costs: Using AI to automate certain tasks, such as analysing imaging and patient data, can reduce the need for manual labour, resulting in cost savings (67,68).
- Remote care: AI can help monitor patients remotely, which can be particularly useful for people living in remote areas or those with mobility issues to enable access to healthcare services (53,69,70).

The use of AI in medicine has several drawbacks, including:
- Bias and discrimination: AI systems can perpetuate and

struktivne bolesti pluća (53) ili tijekom nadzora hipertenzije (54)
- prediktivna analiza: UI može pomoći u predviđanju određenih medicinskih stanja i bolesti na osnovi analize pacijentovih podataka i tako olakšati njihovu prevenciju i liječenje (55, 56), a za to se koriste velike baze podataka iz sustava javnoga zdravstva (57); osobito je bilo zanimljivo promatrati kako je korištena u predviđanju ishoda bolesti COVID-19 (58) ili kako će pacijent s karcinomom gastrointestinalnog sustava odgovoriti na primijenjenu terapiju (59)
- medicinska istraživanja: UI može se koristiti za analizu velikog broja medicinskih podataka, prepoznavanje obrazaca i pronalaženje novih otkrića koja mogu pomoći u razumijevanju patologije bolesti i na kraju rezultirati novim načinima liječenja (60 – 63).

Prednosti i nedostatci umjetne inteligencije u medicini i zdravstvu

Prednosti i nedostatci primjene umjetne inteligencije u medicini općenito su slični onima tijekom njezine primjene u svakodnevnom životu. Više je prednosti pri korištenju umjetne inteligencije u medicini, uključujući:
- poboljšanje preciznosti i učinkovitosti: UI može pomoći liječnicima i ostalome zdravstvenom osoblju u analizi velikog broja medicinskih podataka kao što su snimke i zdravstveni kartoni da bi što ranije i točnije otkrili bolest te postavili dijagnozu (64)
- personalizirana medicina: UI se može upotrijebiti za analizu genetskih i drugih podataka o pacijentu kako bi se pripremio personalizirani medicinski plan i liječenje prilagodilo specifičnim potrebama određenog pacijenta
- podrška kliničkom odlučivanju: osiguravajući informacije u realnom vremenu na temelju pacijentova stanja UI može pomoći liječnicima i ostalom zdravstvenom osoblju u donošenju odluka (65)
- rano otkrivanje i prevencija: UI može pomoći u praćenju vitalnih znakova, simptoma i ostalih podataka kako bi se rano otkrili potencijalni zdravstveni problemi, što je osobito korisno u sprječavanju komplikacija kroničnih bolesti (66)
- prediktivna analiza: UI može pomoći u predviđanju određenih zdravstvenih stanja i bolesti na temelju pacijentovih podataka i na taj način omogućiti prevenciju i liječenje
- medicinska istraživanja: UI se može koristiti za analizu velike količine medicinskih informacija, prepoznavanje obrazaca i nova otkrića, što će zajedno pomoći boljem razumijevanju patologije bolesti i naposljetku omogućiti pronalaženje novih mogućnosti liječenja
- smanjenje troškova: primjena UI-e omogućuje automatizaciju određenih poslova kao što je analiza snimki i pacijentovih podataka, čime se može smanjiti opseg ljudskog rada što smanjuje troškove (67, 68)
- skrb na daljinu: UI može pomoći u praćenju pacijenata na daljinu, što je osobito korisno za one koji žive u udaljenim područjima ili imaju poteškoće u kretanju jer im tako zdravstveni sustav postaje dostupniji (53, 69, 70).

even reinforce biases and discrimination present in the data on which they have been trained. This can lead to incorrect diagnosis or treatment for certain groups of people (71,72).
- Lack of transparency and accountability: it can be difficult to understand how AI systems make decisions, which can make it difficult to explain or hold them accountable (73–75).
- Privacy and security concerns: AI systems require large amounts of patient data to function, which can lead to privacy and security concerns, especially with the growth of electronic medical records (76,77).
- Dependence on technology: AI may become a crutch that physicians and other healthcare professionals rely on too heavily, and some may no longer be able to complete tasks without AI assistance (78).
- Limited understanding: AI systems may have limited understanding of context and have difficulty understanding nuances and subtleties of human health and disease (79,80).
- Ethical concerns: AI may raise ethical concerns, such as autonomy and decision-making in healthcare, e.g., the use of autonomous surgical robots (81,82).
- Job displacement: AI can automate certain tasks, such as analysing imaging and patient data, which can lead to job displacement and unemployment (83–85).
- Lack of human touch: AI systems lack the human touch and emotions that can be important for certain tasks such as healthcare (86–88).

It is important that these potential drawbacks be considered in the development and implementation of AI systems in the medical field and that regulation and controls are in place to mitigate potential adverse effects. It is also important to ensure that AI systems are used as tools to assist physicians and other health care professionals, rather than replacing them.

Artificial intelligence in dental medicine

The speed with which analog dentistry is being replaced by digital dentistry is comparable to the speed with which artificial intelligence is penetrating profusely through the daily work of a modern dentist. Although these changes are not always immediately recognized or associated with AI, they are neither small nor insignificant, especially when viewed in a broader context. AI can be used in a variety of ways to improve dental care and dentistry, such as segmentation and identification of teeth (89,90), planning of dental implants treatment, identification and classification of dental implant systems (91), for detection and classification of dental plague (92), for diagnosing maxillary sinusitis on panoramic radiog-

Postoje i određeni nedostatci primjene umjetne inteligencije u medicini. To su:
- pristranost (bias) i diskriminacija: UI može ponavljati, pa čak i umnožiti pogreške pristranosti i diskriminacije ako su se one nalazile u podatcima na kojima su sustavi trenirani (71, 72); to može rezultirati netočnom dijagnozom ili neadekvatnim liječenjem određenih skupina ljudi
- nedostatak transparentnosti i pouzdanosti: razumijevanje načina na koji UI funkcionira može biti izazovno zbog čega je podatke katkad teško objasniti ili smatrati pouzdanima (73 – 75)
- privatnost i sigurnosna pitanja: UI zahtijeva veliku količinu podataka o pacijentima kako bi se sustav osposobio za funkcioniranje, što može potaknuti pitanje privatnosti podataka i njihove sigurnosti, a to je osobito istaknuto pri korištenju elektroničkih zdravstvenih kartona (76, 77)
- ovisnost o tehnologiji: UI može postati oslonac na koji se liječnici i drugo zdravstveno osoblje mogu početi pretjerano oslanjati, što može smanjiti sposobnost pojedinca u obavljanju poslova bez njezine pomoći (78)
- ograničeno razumijevanje: UI sustavi mogu biti ograničeni u razumijevanju konteksta te imati poteškoće s razumijevanjem nijansi i suptilnosti ljudskoga zdravlja i bolesti (79, 80)
- etički problemi: UI može iznjedriti etičku zabrinutost kad je riječ o autonomiji i donošenju odluka u zdravstvu, primjerice, u slučaju korištenja samostalnih kirurških robota (81, 82)
- gubitak posla: UI može automatizirati određene poslove kao što su analiza snimki i pacijentovih podataka, što može rezultirati ukinućem određenih poslova i nezaposlenošću (83 – 85)
- nedostatak ljudskog dodira: UI sustavi ne posjeduju sposobnost ljudskog dodira i emocija, što može biti važno u nekim poslovima kao što je zdravstvena skrb (86 – 88).

Važno je uzeti u obzir i razmotriti sve navedene potencijalne nedostatke tijekom dizajniranja i uvođenja sustava umjetne inteligencije u medicinsko područje djelatnosti i uz to osigurati odgovarajući nadzor i propise da bi se umanjile potencijalno negativne posljedice. Uz to, važno je osigurati primjenu sustava koji će poslužiti kao oruđe koje će olakšati posao liječnicima i ostalom medicinskom osoblju, a neće ih potpuno zamijeniti.

Umjetna inteligencija u dentalnoj medicini

Brzina kojom analognu dentalnu medicinu zamjenjuje digitalna može se usporediti s brzinom kojom umjetna inteligencija prodire u svakodnevni život modernoga stomatologa. Premda te promjene nisu uvijek odmah vidljive i trenutačno povezane s umjetnom inteligencijom, nisu ni male, ni beznačajne, osobito ako ih promatramo u širem kontekstu. Umjetna inteligencija može se primijeniti na različite načine koji unaprjeđuju dentalnu medicinu kao što su segmentacija i prepoznavanje zuba (89, 90), planiranje postavljanja zubnih implantata, prepoznavanje i klasifikacija korištenih sustava zubnih implantata (91), otkrivanje i klasifikacija zubnih naslaga (92), zatim u dijagnostici maksilarnog sinusitisa

raphy (93), for cephalometric landmarks detection (94), or for root morphological classification (95), dental caries detection on periapical and bitewing X-ray images (96), and many other applications including (97–105):

- Dental imaging: AI can assist dentists and other dental professionals in analysing dental images, such as X-rays and CT scans, to help identify and diagnose conditions such as cavities and periodontal disease (6,103,106–108).
- Treatment planning: AI can be used to analyse dental images and patient data to help dentists create personalised treatment plans in almost all areas of modern dentistry (101,103,109–112).
- Orthodontics: AI can be used to analyse dental images to create 3D models of teeth and jaws that can be used for orthodontic treatment planning and simulations (103,113,114).
- Dental prosthetics: AI can be used to create 3D models of teeth and jaws that can be used to fabricate crowns and bridges, but AI can also be used in dental CAD / CAM systems to help dentists design and fabricate dental restorations such as fillings, crowns, and bridges using computer-aided design and manufacturing systems (103,115,116).
- Periodontology: AI can be used to differentiate between aggressive and chronic periodontitis and to diagnose aggressive or chronic periodontitis using relatively simple and easy to determine parameters such as the leukocyte count in the peripheral blood (103,117).
- Endodontics: AI has been introduced to determine the root canal morphology, locating minor apical foramen, detecting periapical lesions and root canal fractures and evaluating the success of treatment and retreatment (95,103,104).
- Oral pathology: AI can be a promising aid in the diagnosis of head and neck cancer lesions and offers great potential for detecting tumour tissue in tissue samples or on radiographs (103,118–120).
- Forensic dentistry: AI can be used for dental profiling including estimation of age and determination of sex of an individual using X-ray images (121–129).
- Dental robotics: AI can help dentists perform certain procedures in dental implantology, oral and maxillofacial surgery, prosthetic and restorative dentistry, endodontics, orthodontics, oral radiology, and dental education through the use of robotic systems (130–134).
- Chatbots: AI-driven chatbots can help patients make appointments, answer questions, and educate them about dental care (135,136).

na panoramskim radiografskim snimkama (93), u detekciji kefalometrijskih oznaka (94), ili za klasifikaciju morfologije korijena (95), otkrivanje zubnog karijesa na periapikalnim ili zagriznim snimkama u traku (96) te na mnogobrojne druge načine koji obuhvaćaju (97-105):

- stomatološko snimanje: UI može koristiti stomatolozima i drugom stomatološkom osoblju u analizi dentalnih snimki kao što su RTG snimke i CT skenovi kako bi se olakšalo otkrivanje i dijagnostika stanja poput karijesa i parodontne bolesti (6, 103, 106 – 108)
- planiranje liječenja: UI može poslužiti za analizu dentalnih snimki i podataka o pacijentu i tako olakšati pripremu personaliziranog plana liječenja u gotovo svim poljima moderne dentalne medicine (101, 103, 109 – 112)
- ortodoncija: UI se može koristiti u analizi dentalnih snimki i pomoći u izradi 3D modela zuba i čeljusti koji će se upotrijebiti u planiranju ortodontskog liječenja i za njegovu simulaciju (103, 113, 114)
- dentalna protetika: UI se može koristiti za izradu 3D modela zuba i čeljusti koji će poslužiti za izradu zubnih krunica i mostova, također u CAD/CAM sustavima koji olakšavaju stomatologu izradu dentalnih restauracija kao što su zubni ispuni, zubne krunice i mostovi, korištenjem računalno navođenih sustava za njihovo dizajniranje i izradu (103, 115, 116)
- parodontologija: UI se može koristiti za razlikovanje agresivnoga i kroničnoga parodontitisa i za postavljanje dijagnoze agresivnoga ili kroničnoga parodontitisa koristeći razmjerno jednostavne parametre, kao što su broj leukocita u perifernoj krvi (103, 117)
- endodoncija: UI ima primjenu u utvrđivanju morfologije korijenskih kanala, lociranju unutarnjeg apikalnog ušća, otkrivanju periapikalnih lezija i fraktura korijena te u procjeni uspješnosti endodontskog liječenja i revizije (95, 103, 104)
- oralna patologija: UI je obećavajuće sredstvo u procesu dijagnostike karcinoma glave i vrata te pokazuje izraziti potencijal u otkrivanju tumorskoga tkiva u uzorcima ili na radiografskim snimkama (103, 118 – 120)
- forenzička dentalna medicina: UI se može koristiti u dentalnom profiliranju, uključujući procjenu dobi i spola pojedinca na rendgenskim snimkama (121 – 129)
- dentalna robotika: UI se može primijeniti kao pomoć stomatolozima pri obavljanju određenih zahvata u dentalnoj implantologiji, oralnoj i maksilofacijalnoj kirurgiji, protetici i restaurativnoj dentalnoj medicini, endodonciji, ortodonciji, oralnoj radiologiji te u dentalnoj edukaciji korištenjem robotskih sustava (130 – 134)
- Chatbotovi umjetni inteligentni agenti za razgovor: robotski sustavi temeljeni na umjetnoj inteligenciji mogu poslužiti u dogovaranju termina s pacijentima i pri odgovaranju na upite te dati korisne savjete u vezi sa skrbi o oralnome zdravlju (135, 136).

Advantages and disadvantages of artificial intelligence in dentistry

Technological advances in medicine and dentistry bring numerous advantages that have a positive impact on maintaining or achieving oral health, but also certain problems and doubts. The use of AI in dentistry has several advantages, including (137,138):

- Improved accuracy and efficiency: AI can help dentists and other dental professionals analyze large volumes of dental data, such as imaging and patient records, to detect and diagnose conditions more quickly and accurately (139,140).
- Personalized treatment plans: AI can be used to analyze dental images and patient data to help dentists create personalized treatment plans tailored to the specific needs of individual patients (141).
- Predictive analytics: AI can help predict the likelihood of certain dental problems and diseases based on a patient's data, helping to prevent and treat them (142–146).
- Lower costs: using AI to automate certain tasks, such as analysis of dental imaging and patient data, can reduce the need for manual labour, leading to cost savings (147).

As in medicine, shortcomings in the use of AI in dentistry may be associated with bias and discrimination, lack of transparency and accountability, privacy and security concerns, particularly with the advent of electronic dental records, and reliance on the technology among dentists and other dental professionals. AI systems may be limited in their understanding of the context of human oral health and disease, which can cause serious problems as well as cause harm. Currently, job displacement cannot be considered an important shortcoming of AI application in dentistry, but it is possible that some tasks and procedures could be replaced by AI devices. Although patients are positive about AI in dentistry (148) , AI in dentistry, as in medicine, may raise some ethical concerns (149), mainly related to prudence, justice, privacy, responsibility, solidarity, autonomy, and health care decision making (150). In addition, AI systems may not be accessible or affordable to all people and communities, which may lead to inequities in access to health care. It is important to note that AI in dentistry is still in progress and its utility depends on the particular case of implementation. It is also important that adequate regulations ensure that AI systems are safe, effective, and ethical.

It is of utmost importance to consider these potential drawbacks when developing and deploying AI systems in the dental field and to have regulations which can mitigate potential negative impacts. Ensuring that AI systems are used as tools to assist dentists and other dental professionals is more important than replacing them.

Prednosti i nedostatci umjetne inteligencije u dentalnoj medicini

Tehnološki napredak u medicini i dentalnoj medicini omogućuje bezbrojne prednosti koje pozitivno utječu na postizanje i očuvanje oralnoga zdravlja, ali postoje i određeni problemi i sumnje. Nekoliko je prednosti pri primjeni umjetne inteligencije u dentalnoj medicini koje uključuju (137, 138):

- poboljšanu preciznost i učinkovitost: UI može poslužiti stomatolozima i drugom stomatološkom osoblju u analizi velike količine dentalnih informacija kao što su snimke i zdravstveni kartoni te tako omogućiti brže i preciznije otkrivanje bolesti i postavljanje dijagnoze (139, 140)
- personalizirani plan liječenja: UI se može koristiti za analizu dentalnih snimki i podataka o pacijentu i tako olakšati stomatologu pripremu personaliziranoga plana liječenja koji je u cijelosti prilagođen specifičnim potrebama određenog pacijenta (141)
- prediktivna analiza: UI može predvidjeti pojave određenoga dentalnoga stanja i bolesti na osnovi analize pacijentovih podataka, što olakšava prevenciju i liječenje (142 – 146)
- smanjenje troškova: korištenjem UI-ja mogu se automatizirati određeni poslovi kao što je analiza dentalnih snimki i podataka o pacijentu čime se smanjuje potreba za ljudskim radom, što smanjuje troškove (147).

Kao u medicini, i u dentalnoj medicini, nedostatci u primjeni umjetne inteligencije povezuju se s pristranošću i diskriminacijom, manjkom transparentnosti i pouzdanosti te pitanjima privatnosti i sigurnosti, osobito poslije sve šire upotrebe elektroničkih dentalnih kartona pa se upozorava na ovisnost stomatologa i drugoga stomatološkog osoblja o tehnologiji. Sustavi umjetne inteligencije mogu biti ograničeni u razumijevanju konteksta ljudskoga oralnoga zdravlja i bolesti što može stvoriti ozbiljne probleme i znatnu štetu. Zasad još uvijek ne možemo shvaćati umjetnu inteligenciju kao značajnu prijetnju koja vodi prema gubitku posla u dentalnoj medicini, ali određeni poslovi i zahvati mogu se zamijeniti uređajima vođenima umjetnom inteligencijom. Premda pacijenti imaju pozitivno stajalište prema primjeni umjetne inteligencije u dentalnoj medicini (148), kao i u medicini općenito, mogu se postaviti određena etička pitanja (149) koja se u najvećoj mjeri odnose na razboritost, pravičnost, privatnost, odgovornost, solidarnost, autonomiju i donošenje odluka u zdravstvu (150). Dodatno, sustavi umjetne inteligencije nisu dostupni, niti si ih mogu priuštiti svi pojedinci i zajednice, što može prouzročiti nejednakost u načelu pristupačnosti zdravstvene skrbi. Važno je istaknuti da je umjetna inteligencija u dentalnoj medicini još uvijek tehnologija u razvoju i da njezine prednosti uvelike ovise o pojedinom području primjene. Također je važno stvoriti odgovarajuću pravnu regulativu i nadzor kako bi se jamčila sigurnost, učinkovitost i etičnost u njezinu korištenju.

Također je važno imati na umu sve moguće nedostatke pri stvaranju i korištenju sustava umjetne inteligencije u području dentalne medicine, osigurati pravnu regulativu i nadzor kako bi se potencijalne negativne posljedice svele na mini-

Conclusions

The possibilities of applying artificial intelligence in medicine and dentistry are just being discovered. It is expected that there will be a revolution in healthcare in the coming years as there will be more and more efforts to provide personalized healthcare that will lead to much better outcomes. The main applications of artificial intelligence in medicine are: medical imaging, diagnosis and treatment, drug discovery and development, clinical decision support, chronic disease monitoring and tracking, predictive analytics, and medical research. In dentistry, artificial intelligence can be used for dental imaging, diagnosis and treatment planning in orthodontics, prosthodontics, periodontics, endodontics, oral pathology, and also in forensic dentistry for dental profiling. Artificial intelligence will be a big part of this evolution as a tool that enables development and progress. This will ultimately lead to better health; will improve one's quality of living, thus enabling longer life expectancy. Nevertheless, the shortcomings of artificial intelligence should be taken into account, especially those of ethical nature. States and individuals very easily accept the benefits that artificial intelligence brings, but they are very slow to develop and implement the rules that regulate it. This must be changed before it is too late.

Conflict of interest

None declared

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malnu razinu. I na kraju, važno je osigurati primjenu sustava umjetne inteligencije tako da bude stomatolozima i drugim stručnjacima potpora u radu, a nikako ne njihova zamjena.

Zaključak

Mogućnosti primjene umjetne inteligencije u medicini i dentalnoj medicini još se otkrivaju. Očekujemo, u godinama koje dolaze, revoluciju u zdravstvenoj skrbi zato što se sve više teži personaliziranoj zdravstvenoj skrbi koja će omogućiti mnogo bolje rezultate u usporedbi s trenutačnim stanjem. Glavna primjena umjetne inteligencije u medicini jest medicinsko snimanje, dijagnostika i liječenje, otkriće lijekova i njihov razvoj, podrška kliničkome odlučivanju, nadziranje i praćenje kroničnih bolesti, prediktivna analiza i medicinska istraživanja. U dentalnoj medicini umjetna se inteligencija može primjenjivati u stomatološkom snimanju, dijagnostici i planiranju liječenja u ortodonciji, protetici, parodontologiji, endodonciji i oralnoj patologiji te u dentalnom profiliranju u forenzičkoj stomatologiji. Umjetna inteligencija moćno je oruđe koje će omogućiti takav razvoj i napredak. To će u konačnici poboljšati zdravlje, podignuti razinu kvalitete života i produljiti očekivani životni vijek. Unatoč tomu, treba uzeti u obzir i sve nedostatke umjetne inteligencije, osobito one etičke prirode. Države i pojedinci vrlo olako prihvaćaju prednosti umjetne inteligencije, ali vrlo sporo djeluju kad je riječ o izradi i primjeni pravila kojima je reguliraju. To se mora ispraviti prije nego što bude prekasno.

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Sažetak

Uvod: Umjetna inteligencija (UI) primjenjivala se u prošlosti u različitim područjima, no njezina integracija u svakodnevni život novija je pojava. Najprije se koristila uglavnom u akademskim i vladinim istraživačkim ustanovama, no kako je tehnologija napredovala, počela se primjenjivati u industriji, trgovini, medicini i stomatologiji. **Cilj:** Uzimajući u obzir ubrzani razvoj i širenje primjene umjetne inteligencije i zato što je to jedno od područja s najvećim rastom kad je riječ o broju objavljenih članaka, svrha ovoga rada jest dati pregled literature i uvid u mogućnosti primjene umjetne inteligencije u području medicine i stomatologije, osobito s naglaskom na prednosti i nedostatke. **Zaključak:** Mogućnosti primjene umjetne inteligencije u medicini i stomatologiji tek se otkrivaju. Umjetna inteligencija važan je dio budućeg razvoja medicine i stomatologije jer je to oruđe koje osigurava razvoj i napredak, osobito kad je riječ o individualiziranoj zdravstvenoj skrbi koja obećava značajno poboljšane ishode liječenja.

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