

mgr Anna Rulkiewicz

**Czynniki ryzyka sercowo-naczyniowego podlegające modyfikacji:
otyłość, palenie papierosów w populacji aktywnych zawodowo Polaków**

Modifiable cardiovascular risk factors: obesity, cigarette smoking
in the professionally active Polish population

Rozprawa doktorska na stopień doktora
w dziedzinie nauk medycznych i nauk o zdrowiu
w dyscyplinie nauki o zdrowiu
przedkładana Radzie Dyscypliny Nauk o Zdrowiu
Warszawskiego Uniwersytetu Medycznego

Promotor: dr n. med. i n. o zdr. Justyna Domienik-Karłowicz

Warszawa, 2023

słowa kluczowe: otyłość, palenie papierosów, choroby układu sercowo-naczyniowego,
sztuczna inteligencja

obesity, cigarette smoking, cardiovascular diseases, artificial intelligence

Wykaz publikacji stanowiących podstawę postępowania w sprawie nadania stopnia naukowego doktora:

Publikacja nr 1:

Rulkiewicz Anna, Pilchowska Iwona, Lisik Wojciech, Pruszczyk Piotr, Ciurzyński Michał, Domienik-Karłowicz Justyna. Prevalence of Obesity and Severe Obesity among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2016–2020 Study. *Journal of Clinical Medicine*. 2022; 11(13): 1-13.

Rodzaj publikacji: praca oryginalna; Punkty IF: 3,9

Punkty MEiN: 140

Publikacja nr 2:

Rulkiewicz Anna, Pilchowska Iwona, Lisik Wojciech, Pruszczyk Piotr, Domienik-Karłowicz Justyna. Prevalence of Cigarette Smoking among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2021 Study. *Journal of Clinical Medicine*. 2022; 11(14): 1-14.

Rodzaj publikacji: praca oryginalna; Punkty IF: 3,9

Punkty MEiN: 140

Publikacja nr 3:

Wójcik Simona*, **Rulkiewicz Anna***, Pruszczyk Piotr, Lisik Wojciech, Poboży Marcin, Domienik-Karłowicz Justyna. Beyond ChatGPT: What does GPT-4 add to healthcare? The dawn of a new era. *Cardiology Journal (d.Folia Cardiologica)*.2023; 1-16.

Rodzaj publikacji: praca pogładowa; Punkty IF: 2,9

Punkty MEiN:100 *równy udział

Publikacja nr 4:

Rulkiewicz Anna, Pilchowska Iwona, Lisik Wojciech, Pruszczyk Piotr, Wójcik Simona, Poboży Marcin, Domienik-Karłowicz Justyna. An Alarmingly High Number of Candidates for Bariatric Procedures among Professionally Active Poles and Its Strong Relationship with Cardiovascular Co-Morbidities—POL-O-CARIA 2022 Study . *Journal of Clinical Medicine*. 2023; 12(20): 1-14.

Rodzaj publikacji: praca oryginalna; Punkty IF: 3,9

Punkty MEiN: 140

Łącznie Impact Factor cyklu publikacji: **14,6**

Łącznie MEiN cyklu: 520

Łącznie Impact Factor wszystkich publikacji: **17,5**

Łącznie MEiN wszystkich publikacji: 620

Spis treści

Wykaz stosowanych skrótów.....	5
Streszczenie w języku polskim.....	6
Streszczenie w języku angielskim (English summary).....	9
Wstęp.....	12
Cel główny cyklu publikacji.....	13
Materiał i metody.....	14
Podsumowanie wyników i wnioski	16
Kopie opublikowanych prac i Komisja Bioetyczna	21

Wykaz stosowanych skrótów

AI - sztuczna inteligencja

BMI – body mass index – wskaźnik masy ciała

ChatGPT - chat generative pre-trained transformer

Streszczenie w języku polskim

Wstęp

W świecie współczesnej medycyny modyfikowalne czynniki ryzyka sercowo-naczyniowego, w tym otyłość i palenie papierosów stały się jednym z najbardziej palących zagadnień. Ich skomplikowane powiązania z innymi schorzeniami oraz wpływ na globalne systemy opieki zdrowotnej uczyniły je centralnym punktem badań nad zdrowiem publicznym. Szczególnie alarmujący jest stały wzrost wskaźników nadwagi, otyłości, w tym otyłości olbrzymiej oraz palenia papierosów obserwowany w wielu krajach, w tym w Polsce. W naszym kraju to zjawisko jest szczególnie widoczne wśród osób aktywnych zawodowo, gdzie otyłość nie tylko wpływa na jakość życia pacjentów, ale także stanowi poważne wyzwanie dla systemu opieki zdrowotnej i gospodarki.

W obliczu tych wyzwań, nowoczesne technologie, takie jak sztuczna inteligencja, stają się coraz bardziej obiecujące w zakresie diagnostyki, leczenia i monitorowania pacjentów z otyłością oraz palących papierosy. Jednakże zastosowanie tych innowacji niesie ze sobą również nowe wyzwania - nie tylko badawcze, ale także etyczne.

Cel

Analiza szerokiego spektrum danych z badań medycyny pracy przeprowadzonych w Polsce, w tym ocena częstości występowania nadwagi, otyłości, otyłości olbrzymiej oraz rozpowszechnienia palenia papierosów, oraz ich wpływu występowanie chorób układu sercowo-naczyniowego wśród Polaków. Dodatkowo, zwrócenie uwagi na potencjał innowacji w medycynie i ich znaczenie dla przyszłości opieki zdrowotnej w naszym kraju. Moim celem jest nie tylko dostarczenie wszechstronnego obrazu wyzwań zdrowotnych w Polsce, ale również identyfikacja kluczowych obszarów wymagających intensywnych działań i strategii interwencyjnych.

Material i metody:

W skład cyklu publikacji będących podstawą rozprawy doktorskiej weszły cztery publikacje, których łączna punktacja Ministerstwa Edukacji i Nauki wyniosła 520 punktów, zaś łączna punktacja Impact Factor wynosiła 14,6 punktu.

Publikacje 1,2,4 zostały zaplanowane i przeprowadzone jako retrospektywne analizy obejmujące okres 2016-2022, dotyczące dorosłych osób aktywnych zawodowo, które były badane w ramach medycyny pracy. W sumie przeanalizowano wyniki 2 056 861 wizyt z badań wstępnych, kontrolnych i okresowych w ramach uzyskiwania zaświadczeń o zdolności do pracy. Zebrano je od 1 342 749 unikalnych pacjentów (51,7% mężczyzn; średni wiek całej grupy: 36,81). W trakcie badania kontrolowano płeć, wiek, województwo zamieszkania, informacje o okresie ważności wydanego zaświadczenia o zdolności do pracy oraz dane zawarte w historii medycznej – masa ciała, wzrost, choroby współistniejące po kodach ICD-10 oraz samoocenę zdrowia i nawyki palenia.

Publikacja nr 3 to artykuł poglądowy przedstawiający przegląd wykorzystania sztucznej inteligencji (AI), ze szczególnym uwzględnieniem modeli językowych takich jak ChatGPT, w kontekście postępów w medycynie i opiece zdrowotnej, wraz z możliwością wykorzystania jej w zwalczaniu modyfikowalnych czynników ryzyka chorób układu sercowo - naczyniowego.

Wyniki:

Trzy dogłębne analizy dotyczących kondycji zdrowotnej osób prowadzących aktywną działalność zawodową w Polsce w latach 2016-2022 doprowadziły do następujących wyników. Obserwowano stały wzrost odsetka osób klasyfikowanych jako mające nadwagę lub otyłość przez kolejne lata obserwacji. Osoby aktywne zawodowo z prawidłową masą ciała uzyskiwały najdłuższe zaświadczenia o zdolności do pracy, średnio na około 34 miesiące. Istniała wyraźna korelacja między stopniem zaawansowania otyłości a okresem, na jaki wydawano pacjentom zaświadczenia o zdolności do pracy. Analiza statystyczna wykazała podobne trendy dla kobiet i mężczyzn w odniesieniu do dynamiki występowania indywidualnych kategorii BMI – 1/3 aktywnych zawodowo kobiet oraz 2/3 aktywnych zawodowo mężczyzn choruje na nadwagę lub otyłość, a liczba chorych rośnie z roku na rok.. Zmiany w zakresie BMI są zależne również od wieku pacjentów. Ponadto osoby z prawidłową masą ciała lub niedowagą miały niższą skłonność do palenia w porównaniu z osobami z nadwagą lub otyłością. Co więcej, osoby oceniające swoje zdrowie jako "dobrze" były rzadziej klasyfikowane jako mające normalną wagę w porównaniu z osobami oceniającymi swoje zdrowie jako "bardzo dobre". Potwierdzono, że istnieje istotny związek między BMI a występowaniem współistniejących schorzeń. Wśród pacjentów z otyłością trzeciego stopnia nadciśnienie tętnicze występowało u 56,1%, cukrzyca typu 2 u 17,1% i

zaburzenia lipidowe u 24,1%. Analiza statystyczna potwierdziła istnienie związku między wiekiem a współistniejącymi schorzeniami.

Warto podkreślić, że równoległe z tymi obserwacjami nastąpiła fundamentalna zmiana w obszarze medycyny poprzez integrację innowacyjnych technologii, w tym sztucznej inteligencji (AI). Narzędzia te, dawniej zarezerwowane dla literatury futurystycznej, obecnie mają istotny wpływ na rozwój medycyny.

W kontekście tych wyzwań, pojawienie się technologii opartych na AI, takich jak chat generative pre-trained transformer (ChatGPT), otwiera perspektywy dla innowacyjnych rozwiązań w dziedzinach prewencji oraz konsultacji.

Podsumowanie

Podsumowując, zgromadzone dowody naukowe podkreślają pilną potrzebę interwencji w zakresie modyfikowalnych czynników ryzyka tj: otyłość i palenie papierosów. Należy brać pod uwagę interwencje zarówno profilaktyczne, jak i lecznicze np.: chirurgia bariatryczna, by odpowiedzieć na rosnące wyzwania zdrowotne związane z otyłością i jej powikłaniami oraz z paleniem papierosów w Polsce.

Ponadto integracja AI w opiece zdrowotnej i medycynie i możliwości jej wykorzystania otwierają drogę do bardziej spersonalizowanej i skalowalnej opieki zdrowotnej, podkreślając konieczność pozostawania przez kadrę medyczną na bieżąco z postępami technologicznymi.

English summary of: „Modifiable cardiovascular risk factors: obesity, cigarette smoking in the professionally active Polish population”

Introduction

In the world of modern medicine, modifiable cardiovascular risk factors, including obesity and smoking, have become some of the most pressing issues. Their intricate associations with other diseases and their impact on global healthcare systems have made them a focal point in public health research. The continuous rise in rates of overweight, obesity, including morbid obesity, and smoking observed in many countries, including Poland, is particularly alarming. In our country, this phenomenon is especially noticeable among the professionally active population, where obesity not only affects patients' quality of life but also poses a significant challenge to the healthcare system and the economy. In the face of these challenges, modern technologies, such as artificial intelligence, are becoming increasingly promising in the diagnosis, treatment, and monitoring of patients with obesity and those who smoke. However, the adoption of these innovations also brings about new challenges - not just research-related, but ethical as well.

Aim of the studies

To analyze a broad spectrum of occupational medicine research data conducted in Poland, including the assessment of the prevalence of overweight, obesity, morbid obesity, and the spread of smoking habits, as well as their impact on the occurrence of cardiovascular diseases among Poles. Additionally, to highlight the potential of innovations in medicine and their significance for the future of healthcare in our country. My goal is not only to provide a comprehensive picture of health challenges in Poland but also to identify key areas that require intensive actions and intervention strategies.:

Material and Methods.

The doctoral thesis is based on a series of four publications, with a total score from the Ministry of Education and Science of 520 points, and a combined Impact Factor score of 14.6 points.

Publications 1,2,4 were designed and conducted as retrospective analyses covering the period from 2016 to 2022, concerning professionally active adults who were examined for occupational health purposes. In total, the results of 2,056,861 initial, control, and periodic visits related to obtaining occupational health certificates were analyzed. These were collected from 1,342,749 unique patients (51.7% men; the average age of the entire group: 36.81). During the research, factors such as gender, age, place of residence by province, information about the validity period of the issued occupational health certificate, and data contained in the medical history - body weight, height, coexisting diseases according to ICD-10 codes, as well as self-assessed health and smoking habits, were monitored. Publication no. 3 is a review article presenting an overview of the use of artificial intelligence (AI), with particular emphasis on language models such as ChatGPT, in the context of advancements in medicine and healthcare, combined with the potential for its use in combating modifiable risk factors for cardiovascular diseases.

Results

Three in-depth analyses concerning the health condition of people actively working in Poland between 2016 and 2022 led to the following results. A continuous increase in the percentage of people classified as overweight or obese was observed over the consecutive years of observation. Professionally active individuals with a normal body weight obtained the longest occupational health certificates, averaging around 34 months. There was a clear correlation between the degree of obesity progression and the period for which patients were granted occupational health certificates. Statistical analysis revealed similar trends for both women and men regarding the dynamics of individual BMI categories - 1/3 of professionally active women and 2/3 of professionally active men suffer from overweight or obesity, and the number of affected individuals is growing year by year. Changes in BMI were also dependent on the patients' age. Moreover, individuals with standard weight or underweight showed a lower tendency to smoke compared to those who were overweight or obese. Furthermore, people rating their health as "good" were less frequently classified as having normal weight compared to those rating their health as "very good". A significant correlation between BMI and the occurrence of comorbidities was confirmed. Among patients with third-degree obesity, hypertension was present in 56.1%, type 2 diabetes in 17.1%, and lipid disorders in 24.1%. Statistical analysis confirmed the relationship between age and comorbidities. It's worth emphasizing that concurrently with these observations, there has been a fundamental

shift in the field of medicine through the integration of innovative technologies, including artificial intelligence (AI). These tools, once reserved for futuristic literature, now significantly impact the development of medicine. In the context of these challenges, the emergence of AI-based technologies, such as chat generative pre-trained transformer (ChatGPT), opens up prospects for innovative solutions in the fields of prevention and consultation.

Conclusions

In summary, the accumulated scientific evidence underscores the urgent need for intervention regarding modifiable risk factors, such as obesity and cigarette smoking. Both preventive and therapeutic interventions, such as bariatric surgery, should be considered to address the escalating health challenges associated with obesity and its complications, as well as cigarette smoking in Poland. Furthermore, the integration of AI in healthcare and medicine, and its potential applications, opens up the way for more personalized and scalable healthcare. This emphasizes the importance for medical professionals to stay updated with technological advancements.

Wstęp

Zrozumienie problemu otyłości, jej powiązań z chorobami współistniejącymi oraz jej skomplikowanego wpływu na globalne systemy opieki zdrowotnej w ostatnim czasie stało się kluczowym i niezwykle ważnym zagadnieniem dla świata medycyny oraz badań nad zdrowiem publicznym. Świadectwem tego jest niepokojący wzrost wskaźników nadwagi i otyłości, który zaobserwowano w wielu krajach na przestrzeni ostatnich dekad. Ten globalny problem nie tylko wpływa na jakość życia ludzi, ale także prowadzi do znacznego obciążenia systemów opieki zdrowotnej i stanowi poważne wyzwanie dla gospodarek narodowych. W Polsce ta kwestia jest niezwykle widoczna, zwłaszcza wśród populacji aktywnej zawodowo, gdzie coraz większa liczba osób spełnia kryteria kwalifikujące do procedur bariatrycznych, które są uważane za jedno z kluczowych narzędzi w walce z powikłaniami otyłości.

Jednocześnie z niecierpliwością obserwujemy rozwijające się innowacje i postępy w zakresie zastosowania sztucznej inteligencji w medycynie. Nowoczesne technologie oferują obiecujące możliwości w diagnostyce, leczeniu i monitoringu pacjentów, ale również niosą ze sobą nowe wyzwania badawcze oraz etyczne.

Przedstawiony przeze mnie cykl publikacji kładzie nacisk na analizę szerokiego spektrum danych z badań przeprowadzonych w Polsce. Te badania oceniają wpływ 2 modyfikowalnych czynników ryzyka: otyłości i palenia papierosów na częstość występowania chorób układu sercowo-naczyniowego wśród Polaków aktywnych zawodowo oraz jak również podkreślają potencjał innowacji w medycynie. Moim głównym celem jest dostarczenie wszechstronnego obrazu aktualnych wyzwań zdrowotnych w Polsce, a także identyfikacja kluczowych obszarów, które wymagają intensywnych działań.

Chociaż istnieje bogata literatura dotycząca związku między nadwagą a otyłością a innymi chorobami, moje badania dążą do głębszego zbadania tego zjawiska w kontekście specyfiki polskiego społeczeństwa aktywnego zawodowo. Analizując także wpływ palenia tytoniu na zdrowie publiczne oraz uwzględniając rosnący potencjał sztucznej inteligencji w medycynie, pragnę przedstawić kompleksowy obraz zdrowotnych wyzwań i możliwości stojących przed Polską.

W obliczu tych badań jestem przekonana o niezbedności skoordynowanych działań interwencyjnych i prewencyjnych, które będą skupiać się na problemie otyłości, paleniu tytoniu oraz wdrazaniu nowoczesnych technologii medycznych. Mam nadzieję, że ten cykl publikacji będzie stanowił ważny wkład w debatę na temat tych kluczowych kwestii, angażując zarówno specjalistów, decydentów politycznych, jak i szersze społeczeństwo w poszukiwaniu skutecznych rozwiązań.

Cel główny cyklu publikacji:

Głównym celem niniejszej pracy jest kompleksowa analiza problemu modyfikowalnych czynników ryzyka sercowo-naczyniowego: otyłości i palenia papierosów w kontekście aktywnych zawodowo Polaków na podstawie badań medycyny pracy przeprowadzonych w latach 2016-2022. Celem pobocznym jest zrozumienie i omówienie możliwości, które sztuczna inteligencja może przynieść w tym obszarze medycyny, ze szczególnym uwzględnieniem narzędzi opartych na dużych modelach językowych, takich jak ChatGPT.

Cele szczegółowe cyklu publikacji obejmują ocenę:

1. Jak częstość występowania otyłości ewoluuje w grupie Polaków aktywnych zawodowo?
2. Z jakimi chorobami współwystępuje otyłość w grupie aktywnych zawodowo Polaków?
3. Jaka jest grupa pacjentów kwalifikujących się do chirurgicznego leczenia otyłości?
4. Jaka jest częstość występowania palenia tytoniu wśród aktywnych zawodowo Polaków i jakie są jej powiązania z otyłością oraz chorobami układu sercowo-naczyniowego?
5. Jakie są potencjalne zastosowania sztucznej inteligencji, zwłaszcza dużych modeli językowych, w medycynie, opiece zdrowotnej, potencjalnych programach profilaktycznych?

Material i metody

Publikacja nr 1

Material i metody. Retrospektywna analiza opiera się na wynikach badania POL-O-CARIA z lat 2016-2020, dotyczącego dorosłych osób aktywnych zawodowo, które były badane w okresie od stycznia 2016 do kwietnia 2020 w ramach medycyny pracy. W sumie przeanalizowano wyniki 1 450 455 wizyt z badań wstępnych, kontrolnych i okresowych w ramach uzyskiwania zaświadczeń o zdolności do pracy. W trakcie badania kontrolowano płeć, wiek, województwo zamieszkania, informacje o okresie ważności wydanego świadectwa zdrowia oraz dane zawarte w historii medycznej – masa ciała, wzrost oraz choroby współistniejące po kodach ICD-10. W badaniu szczegółowo oceniono odsetek osób z nadwagą i otyłością oraz chorób współistniejących w perspektywie lat 2016-2020. Analiza statystyczna: obliczenia statystyczne przeprowadzono przy użyciu programu IBM SPSS Statistics 25.

Publikacja nr 2

Material i metody. W artykule dokonano retrospektywnej analizy kolejnych zapisów dorosłych osób aktywnych zawodowo, które przeszły badania medycyny pracy między styczniem 2016 a kwietniem 2020. Łącznie przeanalizowano wyniki 1 450 455 wizyt z badań wstępnych, kontrolnych i okresowych w ramach badań medycyny pracy. Podczas badania analizowano takie dane jak: płeć, wiek, wzrost, waga, województwo zamieszkania, okres ważności badań z zakresu medycyny pracy oraz informacje pochodzące z historii medycznej pacjenta (subiektywna ocena zdrowia, palenie tytoniu). Żadnych pacjentów nie wykluczono z badania. Analiza statystyczna: Analizy statystyczne przeprowadzono przy użyciu oprogramowania IBM SPSS Statistics 25 dla systemu Windows, Wersja 27.0. Armonk, NY: IBM Corp.

Publikacja nr 3

Artykuł poglądowy przedstawia przegląd wykorzystania sztucznej inteligencji (AI), ze szczególnym uwzględnieniem modeli językowych takich jak ChatGPT, w kontekście postępów w medycynie i opiece zdrowotnej. W pracy dokładnie analizujemy ChatGPT - narzędzie do przetwarzania języka naturalnego opracowane przez OpenAI, które zdobyło popularność w obszarze medycyny.

Omówiono następujące aspekty:

1. Funkcjonowanie ChatGPT - jak model działa, jakie ma możliwości oraz ograniczenia.
2. Potencjalne zastosowania AI w edukacji, badaniach i opiece zdrowotnej, ze szczególnym uwzględnieniem wykorzystania w kontekście zbierania i analizy danych w medycynie, jak również planowania .
3. Wpływ AI na relacje między pacjentem a lekarzem, w tym jak sztuczna inteligencja może przyczynić się do zwiększenia poziomu informacji dostarczanych pacjentom oraz jak może wspierać zespoły kliniczne w dostępie do aktualnych danych o pacjentach.
4. Dyskusja nad wyzwaniem i potencjalnymi zagrożeniami związanymi z integracją AI w opiece zdrowotnej.

Publikacja nr 4

Material i metody: Dane zostały zgromadzone w ramach badania POL-O-CARIA 2022, skupiającego się na charakterystyce grupy pacjentów z nadwagą i otyłością oraz na ocenie alarmująco rosnącej liczby kandydatów do procedur bariatrycznych wśród Polaków aktywnych zawodowo. W badaniu uwzględniono osoby, które poddały się badaniom medycyny pracy w Polsce w sieci placówek medycznych w latach 2016-2022 (wydłużony okres obserwacji w porównaniu do poprzedniego badania, w celu ukazania trendu). Głównym celem analizy była ocena częstości występowania nadwagi i otyłości; trendu w tym zakresie oraz ocena związku nadwagi i otyłości z chorobami układu sercowo-naczyniowego. W tym kontekście, zastosowano metody statystyczne służące do analizy trendów w czasie oraz do oceny związków pomiędzy otyłością a współistniejącymi schorzeniami, w szczególności chorobami układu sercowo-naczyniowego.

Podsumowanie wyników i wnioski

Publikacja nr 1

Podsumowanie wyników

1. Trend wzrostu wskaźnika BMI – w kolejnych latach obserwacji zauważono stały wzrost liczby osób klasyfikowanych jako pacjenci z nadwagą lub otyłością. W tym samym czasie odnotowano spadek odsetka osób utrzymujących zdrową masę ciała. Aktualnie 1/3 aktywnych zawodowo kobiet i 2/3 aktywnych zawodowo mężczyzn choruje na nadwagę lub otyłość
2. Zależność pomiędzy BMI a średnią długością wydawanych zaświadczeń medycznych o zdolności do pracy. Osoby o normalnej masie ciała, aktywne zawodowo, uzyskiwały najdłuższe zaświadczenia medyczne - około 34 miesiące. W miarę wzrostu stopnia otyłości obserwowano skrócenie okresu zdolności do pracy. Osoby z III stopniem otyłości otrzymywały zaświadczenia o zdolności do pracy na okres około 26 miesięcy.
3. Charakterystyka pacjentów w zależności od poziomu BMI. Tendencje w zakresie dystrybucji BMI były podobne zarówno dla kobiet, jak i mężczyzn. W grupie mężczyzn zauważono bardziej wyraźny wzrost wskaźnika otyłości I i III stopnia, wskazując na rosnącą liczbę potencjalnych kandydatów do operacji bariatrycznych. Osoby z prawidłowym BMI najczęściej występowały w grupie poniżej 35 roku życia, podczas gdy odsetek osób z otyłością (szczególnie I stopnia) znacząco wzrastał w każdej kategorii wiekowej.
4. Związek między paleniem papierosów a BMI. Osoby o prawidłowej masie ciała lub niedowadze rzadziej paliły papierosy niż osoby z nadwagą lub otyłością.
5. Subiektywna ocena zdrowia w odniesieniu do BMI. Osoby, które subiektywnie oceniały swoje zdrowie jako dobre, rzadziej klasyfikowały się jako osoby o normalnej masie ciała w porównaniu do tych, które oceniały swoje zdrowie jako bardzo dobre. U pacjentów z nadwagą i otyłością występowała odwrotna tendencja.

Wnioski:

1. Istnieje wyraźny i niepokojący trend wzrostu otyłości w analizowanej populacji.

2. Osoby z wyższym BMI mają tendencję do otrzymywania krótszych zaświadczeń o zdolności do pracy, co sugeruje, że ich zdrowie wpływa na ich zdolność do pracy.
3. Mężczyźni wydają się być bardziej narażeni na rozwój otyłości I i III stopnia w porównaniu do kobiet.
4. Młodsze osoby mają większą tendencję do utrzymania zdrowej masy ciała w porównaniu do starszych osób, które mają tendencję do rozwijania otyłości.
5. Istnieje negatywna korelacja między BMI a paleniem.
6. Subiektywna ocena zdrowia jest również związana z BMI, gdzie osoby z wyższym BMI mają tendencję do gorszej oceny swojego zdrowia.

Badanie to podkreśla znaczenie promowania zdrowego stylu życia i interwencji skierowanych na zapobieganie otyłości w celu poprawy ogólnego stanu zdrowia populacji.

Publikacja nr 2

Podsumowanie wyników

1. Analiza statystyczna pokazała stopniowy spadek odsetka osób deklarujących palenie w kolejnych latach.
2. Stwierdzono, że 11,6% kobiet i 17,1% mężczyzn deklarowało palenie. Odsetek palących kobiet malał z czasem, podczas gdy odsetek palących mężczyzn pozostał stosunkowo stały.
3. Nie zaobserwowano znaczących zmian w odsetku palaczy w poszczególnych grupach wiekowych.
4. W kolejnych latach obserwacji, wśród palaczy zaobserwowano spadek osób o prawidłowej masie ciała oraz wzrost osób z nadwagą lub otyłością I stopnia.
5. Palaczom papierosów zwykle wydawano zaświadczenia o zdolności do pracy o średnim okresie ważności około 29 miesięcy.
6. Istnieje wyraźna korelacja między paleniem papierosów a występowaniem pewnych kategorii ICD-10, zwłaszcza chorób układu sercowo-naczyniowego. W tej kategorii zaobserwowano wyższą liczbę przypadków choroby niedokrwiennej serca wśród palaczy, podczas gdy odwrotna zależność obowiązywała dla nadciśnienia tętniczego.
7. Wśród palaczy najczęstsze współistniejące schorzenia to nadciśnienie tętnicze, zaburzenia lipidowe oraz współistnienie nadciśnienia tętniczego z zaburzeniami lipidowymi. Osoby

deklarujące palenie papierosów miały diagnozowanych więcej jednostek chorobowych niż osoby niepalące.

Wnioski:

1. Odsetek palaczy papierosów w Polsce, mimo działań prewencyjnych, jest wysoki. Warto zauważyć delikatny trend spadkowy, zwłaszcza wśród palących kobiet.
2. W kolejnych latach stwierdzono wyraźny związek między paleniem a wzrostem wskaźników otyłości.
3. Palenie papierosów ma wyraźny związek z chorobami układu sercowo-naczyniowego, nadciśnieniem tętniczym, chorobą niedokrwienną serca i cukrzycą typu 2.
4. Aktywne działania prewencyjne są niezbędne, aby zmniejszyć liczbę palaczy i złagodzić negatywne skutki palenia na występowanie chorób współistniejących.

Publikacja nr 3 (praca pogładowa)

Podsumowanie i wnioski

W ostatnich latach sztuczna inteligencja (AI) znacząco przyczyniła się do poprawy opieki zdrowotnej. Wielojęzyczne modele językowe, takie jak ChatGPT, są teraz na tyle dojrzałe, że mogą wpłynąć na całą medycynę kliniczną, oferując wsparcie w takich obszarach jak notatki medyczne, edukacja, konsultacje medyczne, triage, programy prewencyjne.

Mimo imponujących osiągnięć ChatGPT, ważne jest, aby pamiętać o jego ograniczeniach. ChatGPT nie zastąpi lekarzy. Ludzkie cechy, takie jak empatia, współczucie i zdolność do skomplikowanego podejmowania decyzji, są niezbędne w świadczeniu opieki pacjentowi. Pomimo potencjału ChatGPT, nie można ignorować kluczowych kwestii etycznych, zwłaszcza w zakresie prywatności i bezpieczeństwa danych pacjentów. Wprowadzenie AI do medycyny klinicznej rodzi pytania dotyczące odpowiedzialności w przypadku błędów. Jednakże, jeśli uwzględnimy te wyzwania, AI, takie jak ChatGPT, ma ogromny potencjał do zrewolucjonizowania opieki zdrowotnej, oferując wsparcie lekarzom i poprawiając jakość opieki nad pacjentami, zwłaszcza w kontekście wyzwań cywilizacyjnych jakimi są m.in. modyfikowalne czynniki ryzyka sercowo-naczyniowego.

Publikacja nr 4

Podsumowanie i wnioski

Analogicznie jak w publikacji nr 1, w ciągu kolejnych lat obserwacji zaobserwowano stały wzrost odsetka pacjentów, u których rozpoznano nadwagę lub otyłość, oraz spadek procentowy osób o zdrowej masie ciała. Osoby o prawidłowej masie ciała, aktywnie pracujące, otrzymywały najdłuższe zaświadczenia lekarskie o zdolności do pracy - średnio 34 miesiące. Dla osób z nadwagą lub otyłością zaobserwowano korelację między stopniem otyłości a okresem zdolności do pracy. W miarę wzrostu BMI, zdolność do pracy zawodowej spadała. Badanie wykazało również, że osoby o prawidłowej masie ciała były głównie poniżej 35 roku życia, podczas gdy proporcja osób z otyłością, zwłaszcza I stopnia, rosła we wszystkich grupach wiekowych. Ponadto, osoby o prawidłowej masie ciała lub niedowadze rzadziej paliły papierosy w porównaniu do osób z nadwagą lub otyłością.

Wnioski:

1. Wzrost BMI jest związany z krótszym czasem zdolności do pracy i większą liczbą chorób współistniejących
2. Istnieje wyraźny związek między BMI a występowaniem współistniejących schorzeń, takich jak nadciśnienie tętnicze, cukrzyca typu 2 i zaburzenia lipidowe.
3. Otyłość jest kluczowym czynnikiem w rozwoju i postępie wielu chorób współistniejących. Interwencje chirurgiczne, takie jak operacje bariatryczne, mogą przynieść znaczące korzyści w leczeniu otyłości i związanych z nią chorób
4. Ważne jest przeprowadzanie corocznych ocen występowania otyłości i powiązanych chorób w celu dostosowania systemu opieki zdrowotnej do rosnącej liczby osób otyłych.
5. Wzrost BMI w Polsce stanowi wyzwanie dla systemu opieki zdrowotnej, a leczenie otyłości wymaga indywidualnego podejścia i wszechstronnej opieki, łączącej chirurgię z modyfikacjami stylu życia.

Cykl publikacji – podsumowanie

Podsumowując, zgromadzone dowody naukowe podkreślają pilną potrzebę interwencji w zakresie modyfikowalnych czynników ryzyka tj: otyłość i palenie papierosów. Należy brać pod uwagę interwencje zarówno profilaktyczne, jak i lecznicze np.: chirurgia bariatryczna, by odpowiedzieć na rosnące wyzwania zdrowotne związane z otyłością i jej powikłaniami oraz z paleniem papierosów w Polsce.

Ponadto integracja AI w opiece zdrowotnej i medycynie i możliwości jej wykorzystania otwierają drogę do bardziej spersonalizowanej i skalowalnej opieki zdrowotnej, podkreślając konieczność pozostawania przez kadrę medyczną na bieżąco z postępami technologicznymi.

Kopie opublikowanych prac



Article

Prevalence of Obesity and Severe Obesity among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2016–2020 Study

Anna Rulkiewicz, Iwona Pilchowska, Wojciech Lisik, Piotr Pruszczyk, Michał Cieurzyński and Justyna Domienik-Karłowicz

Special Issue

Advances in the Management of Cardiovascular Disease

Edited by

Prof. Dr. Michał Cieurzyński and Dr. Justyna Domienik-Karłowicz



<https://doi.org/10.3390/jcm11133720>



Article

Prevalence of Obesity and Severe Obesity among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2016–2020 Study

Anna Rulkiewicz ¹, Iwona Pilchowska ^{1,2}, Wojciech Lisik ³ , Piotr Pruszczyk ⁴ , Michał Cieurzyński ⁴ and Justyna Domienik-Karłowicz ^{1,4,*}

¹ LUX MED, Postępu 21C, 02-676 Warsaw, Poland; anna.rulkiewicz@luxmed.pl (A.R.); iwona.pilchowska@luxmed.pl (I.P.)

² Department of Psychology, SWPS University of Social Sciences and Humanities, 03-815 Warsaw, Poland

³ Department of General and Transplantation Surgery, Medical University of Warsaw, 02-014 Warsaw, Poland; wojciech.lisik@wum.edu.pl

⁴ Department of Internal Medicine and Cardiology, Medical University of Warsaw, 02-005 Warsaw, Poland; piotr.pruszczyk@wum.edu.pl (P.P.); michal.cieurzynski@wum.edu.pl (M.C.)

* Correspondence: jdomienik@tlen.pl or justyna.domienik@wum.edu.pl; Tel.: +48-(22)-502-11-44



Citation: Rulkiewicz, A.; Pilchowska, I.; Lisik, W.; Pruszczyk, P.; Cieurzyński, M.; Domienik-Karłowicz, J. Prevalence of Obesity and Severe Obesity among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2016–2020 Study. *J. Clin. Med.* **2022**, *11*, 3720. <https://doi.org/10.3390/jcm11133720>

Academic Editor: Kei Nakajima

Received: 8 May 2022

Accepted: 22 June 2022

Published: 27 June 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: For several decades, a steady increase in the percentage of overweight and obese people has been observed all over the world. There are many studies available in the literature emphasizing the relationship of overweight and obesity with the occurrence of other diseases. The aim of this study is to characterize the prevalence of obesity and severe obesity, as well as their changes over time, among professionally active adults who underwent occupational medicine examinations in Poland in 2016–2020, for the POL-O-CARIA 2016–2020 study. In total, the results of 1,450,455 initial, control and periodic visits as part of the occupational medicine certificate were analyzed. Statistical calculations were performed with the use of IBM SPSS Statistics 25. In both groups (men/women), a significant decrease was observed every year for people who had normal body weight. In addition, the tendency to increase in people with I and III degrees of obesity was more strongly observed in the male group. A significant relationship was also observed between BMI categories and the occurrence of all analyzed comorbidities: hypertension, type 2 diabetes, lipid disorders and coronary artery disease ($\chi^2(70) = 12,228.11; p < 0.001$). Detailed results showed that in the group of patients diagnosed with hypertension or lipid disorders, significant differences were observed between all groups; it turned out that as the BMI level increased (I, II, III), there was an increase in the percentage of occurrence of hypertension (38.1%, 41% and 45.3%, respectively) and type 2 diabetes (3.2%, 4.6% and 5.8%, respectively) ($p < 0.001$). Our analysis indicates that the prevalence of adult obesity and severe obesity will continue to increase nationwide, with an accompanying large increase in comorbidities.

Keywords: BMI index; professionally active adult population; cardiovascular diseases; obesity

1. Introduction

For several decades, a steady increase in the percentage of overweight and obese people has been observed all over the world. More and more countries declare problems with controlling this epidemic. This disease affects children as well as adults [1]. According to the WHO definition, obesity is abnormal or excessive accumulation of fat that negatively affects health. Obesity is diagnosed when the BMI level exceeds or is equal to 30 kg/m² [2]. According to data published by WHO in 2014, the percentage of people with obesity in Poland is 25.1% [3]. The main cause of obesity is a long-term imbalance between the amount of calories consumed and the body's demands [4]. Diet, lifestyle and genetics have a significant influence on the occurrence of obesity [5].

1.1. Obesity and Comorbidities

There are many studies available in the literature emphasizing the relationship of overweight and obesity with the occurrence of other diseases. A meta-analysis carried out in 2015 showed that each increase in weight by 5 kg significantly increases the risk of developing post-menopausal breast (11%), endometrial (39%), ovarian cancer (13%) and male colon cancer (9%) [6]. Cohort studies conducted in Europe (Austria, Norway, Sweden) under the Me-Can 2.0 program showed that overweight people up to 40 years of age significantly increase their chance of developing endometrial, male renal cell and male colon cancer [7]. Obesity is a chronic and metabolic disease; therefore, it affects the occurrence of cardiovascular diseases [8]. It affects the structural and functional changes in the cardiovascular system, e.g., causing decreased cardiac output, increased left ventricular mass and wall thickness [9]. The association of obesity with hypertension, coronary artery disease and diabetes is also scientifically confirmed [10,11].

1.2. The Global Obesity Epidemic

For several decades, a steady increase in the percentage of overweight and obese people has been observed. Most countries in the world are affected. Current reports show that more people worldwide die from overweight and obesity than from underweight [12]. Obesity is the main reason for the development of NCDs (non-communicable diseases), which since 2010 have been responsible for 86% of deaths and 77% of other diseases in Europe. Over the past 40 years, there has been a sharp increase in the percentage of people with obesity; since 1975, the percentage of people with obesity has increased from 1% to 6–8%. Women saw an increase from 6% to 15%, while men increased from 3% to 11% [13]. There are four levels of obesity, distinguished on the basis of an analysis of the 30 most populous countries in the world [14]:

- Level 1—characterized by a higher prevalence of obesity in women than men (more often in adults than children) and in people with a higher socioeconomic status. This level is most commonly observed in South Asia and Sub-Saharan Africa.
- Level 2—at this stage there is a significant increase in obesity in the adult group and a decrease in children. The importance of gender and socioeconomic status is not as clear as in level 1. This stage is most often observed in Latin America and the Middle East.
- Level 3—the most characteristic for the inhabitants of Europe. A higher obesity rate is observed more often in the group of people with a low socioeconomic status, but it is worth noting the increase in the percentage of obese people in the group of women with high economic status and in the group of children.
- Level 4—there are few countries classified to this stage. It is characterized by a decrease in the prevalence of obesity. The research results do not allow for an unequivocal determination of the relationship between the prevalence of obesity and gender and socioeconomic status.

The two regions with a dynamic increase in obesity are North America and Europe [14].

1.3. Actions to Reduce the Obesity Epidemic

Obesity is a multidimensional disease that affects many spheres of life. Hence, it is advisable to provide long-term support for patients suffering from this disease. Current activities aimed at controlling and reducing obesity in society focus on the analysis of the occurrence of civilization diseases, followed by body weight. It seems important to focus on the many dimensions of the fight against obesity (diet, physical activity, changes in behavior), which will translate into an improvement in the quality of life. Attention is also paid to the growing interest in surgical methods of obesity treatment [15]. In Europe, the prevalence of overweight increased from 48% in 1980 to 59.6% in 2015; in the case of obesity, the incidence increased from 15.5% in 1980 to 22.9% in 2015. Moreover, a lower probability of obesity was reported among women (in the group of people aged 20 to 44); an inverse relationship was observed in the group of people over 45 years of age.

1.4. Obesity and Professional Activity

Work is recognized as a source that may influence overweight and obesity [16]. Employers take measures to promote healthy eating habits and increase physical activity among employees [17]. Employers increasingly organize free fruits and vegetables in their offices for their employees [18]. The factors that may increase the chance of overweight and obesity in the workplace are sedentary work, stress and sleep problems [19]. Office work and sedentary work increase the likelihood of obesity among employees [20]. The research by Shields and Tremlay (2008) confirmed the existence of a positive relationship between obesity and spending free time sitting (e.g., while using a computer) [21]. There are also several studies that do not confirm the relationship between sedentary work or leisure activities and the prevalence of overweight and obesity [22]. An important factor associated with overweight and obesity is also stress experienced in the workplace [23].

1.5. Aim of the Study

The aim of the study is to characterize professionally active adults who underwent occupational medicine examinations in Poland in 2016–2020. Due to the exploratory nature of the research, the article did not put forward research hypotheses. Instead, research questions were asked that define the main subject of the analysis: how the intensity of obesity changes over time and how it coexists with other diseases [24].

2. Materials and Methods

The article analyzes the results of the POL-O-CARIA 2016–2020 study, concerning adults who are professionally active and visited in the years January 2016–April 2020 as part of occupational medicine. The data for analysis was provided by the LUX MED Group. In total, the results of 1,450,455 initial, control and periodic visits as part of the occupational medicine certificate were analyzed. During the study, sex, age, province of residence, information on the period of the issued medical certificate and data contained in the medical history (subjective assessment of health, smoking) were controlled. Detailed characteristics of the studied patients are presented in Appendix A.

For several decades, a steady increase in the percentage of overweight and obese people has been observed. For this reason, it seems extremely important to monitor the prevalence of obesity in individual social groups. The study of professionally active adults is important for several reasons. It is important to monitor the health condition and forecast the occurrence of specific civilization diseases in a given society. The occurrence of certain diseases (e.g., obesity, hypertension, diabetes) translates into shorter medical certificates enabling employment.

Statistical Analysis

Statistical calculations were performed with the use of IBM SPSS Statistics 25 [25]. Percentage and number of occurrences were used to analyze qualitative data, while the following were used to characterize qualitative data: mean (M), standard deviation (SD), median, skewness, kurtosis, and the minimum and maximum values. Significant statistical results were considered to be those where the probability of making a type I error was lower than 5% ($p < 0.05$). The following were used for statistical calculations: chi-square analysis in cross tables (Bonferroni correction was used to test column proportions) and one-way analysis of variance (Scheffe's post hoc test was used for mean comparisons). The charts were made in the R program [26].

3. Results

3.1. Information on BMI

It was observed that, with successive years of measurement, the percentage of overweight and obesity (regardless of degree) increased, while the percentage of people with normal body weight significantly decreased. Detailed results are presented in Table 1.

Table 3. Cont.

	2016	2017	2018	2019	2020	Total
Men						
underweight	0.8% ^a	0.8% ^{a,b}	0.9% ^{b,c}	0.9% ^c	0.8% ^{a,b}	0.80%
normal body weight	39.3% ^a	38.9% ^b	38.3% ^c	37.9% ^d	35.5% ^e	38.40%
overweight without obesity	42.7% ^{a,b,c,d}	42.8% ^{c,d}	42.7% ^{b,d}	42.4% ^b	43.2% ^{a,c}	42.70%
I degree of obesity	13.6% ^a	14.0% ^b	14.3% ^c	14.7% ^d	15.9% ^e	14.30%
II degree of obesity	2.9% ^a	2.9% ^a	3.2% ^b	3.3% ^b	3.7% ^c	3.10%
III degree of obesity	0.6% ^a	0.7% ^a	0.8% ^b	0.8% ^c	0.9% ^c	0.70%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

Significant differences, regardless of the year of measurement, were observed using a one-way analysis of variance for the age and time for which the measurement was issued (in both cases, the significance of differences between the groups was $p < 0.001$). The exact results are discussed below.

In the case of patients' age, post hoc analysis with Scheffe's correction showed that only between people with II and III degrees of obesity were there no differences for the average age; in other cases, the significance of differences between individual groups was $p < 0.001$. The highest average age was observed for people with obesity, while the lowest was observed for people with underweight or normal weight (see Figure 1).

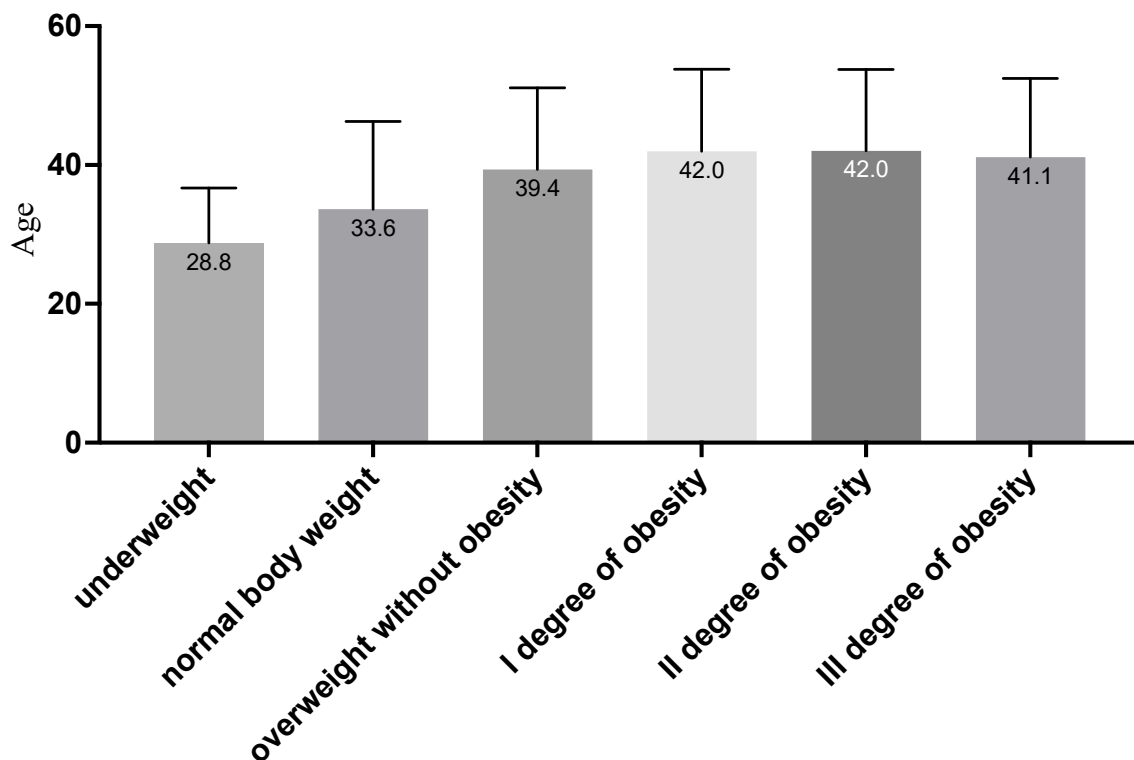


Figure 1. Average age depending on the BMI category (in the figure, all groups are statistically significantly different, at least at the $p < 0.001$ level; due to the number of groups compared, results for differences are not shown in the figure).

Patients with normal body weight most often occurred in the group under 35 years of age, while the percentage of people with obesity (especially I degree) increased significantly in each age category (see Table 4).

Table 4. Relationship between BMI and patients’ age; data presented as percentage of age group ¹.

	<18	18–35	35–54	55–69	>69	Total
underweight	14.3% a	5.1% b	1.4% c	0.5% d	0.6% d	3.30%
normal body weight	61.7% a	60.1% a	41.7% b	27.5% c	26.9% c	50.20%
overweight without obesity	17.5% a	25.6% b	37.8% c	44.8% d	49.9% e	32.00%
I degree of obesity	4.0% a	7.0% b	14.4% c	20.9% d	18.2% e	11.10%
II degree of obesity	1.9% a	1.7% a	3.7% b	5.0% c	4.0% b	2.70%
III degree of obesity	0.5% a,b,c,d	0.5% d	1.1% c	1.2% b	0.4% a,d	0.80%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

Table 5 presents the same data by changing the percentage to the BMI category. The obtained results showed that, together with the higher BMI level, the percentage of people under 35 years of age decreased in each group. In the case of people aged 35–69, it was obtained that they were more often classified into the group with obesity or overweight, compared to groups with normal body weight.

Table 5. Relationship between BMI and age of patients; data presented as percentage of the BMI category ¹.

	Underweight	Normal Body Weight	Overweight Without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity	Total
<18	0.2% a	0.1% b	0.0% c	0.0% d	0.0% c	0.0% b,c,d	0.10%
18–35	83.2% a	64.1% b	42.9% c	33.7% d	32.8% e	34.7% f	53.50%
35–54	15.0% a	30.5% b	43.3% c	47.8% d	49.3% e	50.5% f	36.70%
55–69	1.5% a	5.3% b	13.5% c	18.2% d	17.6% e	14.7% f	9.60%
>69	0.0% a	0.1% b	0.3% c	0.3% c	0.2% c	0.1% b	0.20%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

When analyzing the time periods for issuing a medical certificate, significant differences between the groups were also observed. A linear trend was obtained showing that, along with the BMI level, the average number of months of the issued decision decreased. In addition, post hoc analysis with Scheffe’s correction showed that significant differences were observed between all BMI categories. Detailed results are presented below (see Figure 2).

Patients with normal weight or underweight were less likely to smoke than overweight or obese patients. This relationship was observed regardless of the year of measurement (see Figure 3).

The relationship between BMI categories and subjective health assessment was also examined. It was found that people who subjectively assessed their own health as good, less often than people who assessed their health as very good, were classified into the group of people with normal body weight. An inverse relationship was obtained for overweight and obese people. Detailed results are presented below Table 6.

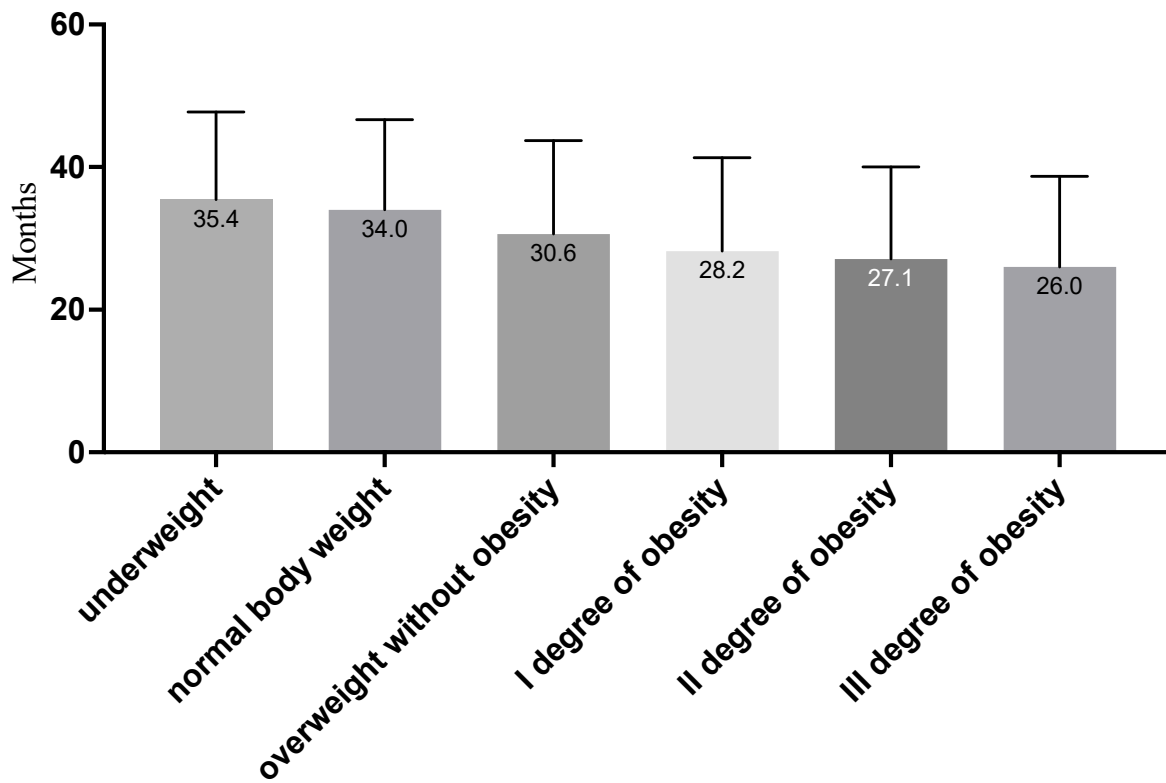


Figure 2. Average number of months for the issued medical certificate depending on the BMI category (in the figure, all groups are statistically significantly different, at least at the $p < 0.05$ level; due to the number of groups compared, results for differences are not shown in the figure).

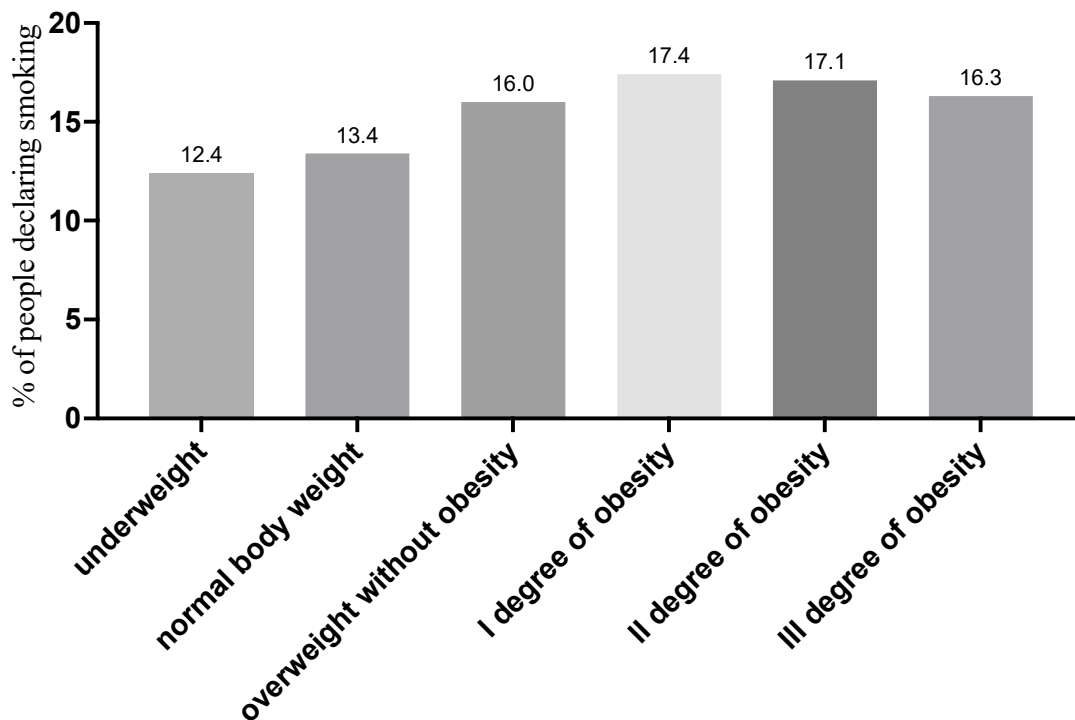


Figure 3. Percentage of people declaring smoking depending on the BMI category (due to the number of groups compared, results for differences are not shown in the figure).

Table 6. Relationship between BMI and subjective assessment of health; data presented as percentage of the health assessment.

	Subjective Health Assessment		Total
	Good	Very Good	
underweight	3.00%	3.80%	3.40%
normal body weight	47.00%	55.20%	50.70%
overweight without obesity	33.10%	30.20%	31.80%
I degree of obesity	12.60%	8.60%	10.80%
II degree of obesity	3.30%	1.80%	2.60%
III degree of obesity	1.00%	0.40%	0.70%
Total	100.00%	100.00%	100.00%

Table 7 shows the relationship between selected diseases and BMI categories. A significant relationship between variables was obtained ($p < 0.001$). The most pronounced differences were observed for hypertension (with increasing BMI level, the percentage of people with this disease increased), and for lipid disorders and type 2 diabetes.

Table 7. Relationship between BMI and the incidence of selected diseases; data presented as percentage of the BMI category ¹.

	Underweight	Normal Body Weight	Overweight without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity	Total
Hypertension	29.6% _a	38.4% _b	45.3% _c	50.5% _d	52.3% _e	55.4% _f	44.9%
Type 2 diabetes	8.6% _a	5.8% _b	6.9% _c	10.6% _d	15.6% _e	18.3% _f	8.1%
Lipid disorders	58.9% _a	52.3% _b	43.9% _c	35.1% _d	28.9% _e	23.8% _f	43.4%
Coronary disease	2.9% _{a,b,c,d}	3.4% _d	4.0% _c	3.8% _c	3.2% _{b,d}	2.5% _a	3.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

3.3. BMI and Observed Comorbidities

A significant relationship was also observed between BMI categories and the occurrence of comorbidities ($\chi^2(70) = 12,228.11; p < 0.001$). Detailed results showed that in the group of patients diagnosed with hypertension or lipid disorders, significant differences were observed between all groups; it turned out that, as the BMI level increased, the percentage of occurrence of a given disease increases. A comparison of all comorbidities depending on BMI level is shown in the Table 8 below.

Table 8. Relationship between BMI and comorbidities; data presented as percentage of BMI ¹.

	Underweight	Normal Body Weight	Overweight without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity	Total
Hypertension	26.1% _a	30.5% _b	33.7% _c	38.8% _d	41.0% _e	45.3% _f	34.1%
Type 2 diabetes	7.8% _a	4.1% _b	2.8% _c	3.2% _d	4.6% _b	5.8% _e	3.5%
Lipid disorders	57.7% _a	47.3% _b	33.0% _c	19.7% _d	11.6% _e	7.5% _f	33.8%
Coronary disease	2.0% _a	1.2% _b	1.0% _c	0.6% _d	0.4% _{d,e}	0.2% _e	0.9%
Hypertension + Type 2 diabetes	0.6% _a	0.9% _a	2.0% _b	4.3% _c	7.7% _d	10.7% _e	2.5%
Hypertension + Lipid disorders	4.2% _a	11.6% _b	19.5% _c	21.9% _d	20.1% _c	17.0% _e	17.3%
Hypertension + Coronary disease	0.3% _a	0.6% _a	0.9% _b	1.0% _b	0.9% _b	1.1% _b	0.8%
Type 2 diabetes + Lipid disorders	0.4% _a	0.7% _a	1.1% _b	1.5% _c	1.8% _d	1.4% _{b,c,d}	1.1%
Type 2 diabetes + Coronary disease	0.1% _{a,b,c}	0.0% _c	0.1% _b	0.1% _a	0.2% _a	0.1% _{a,b,c}	0.1%
Lipid disorders + Coronary disease	0.4% _{a,b,c}	0.7% _c	0.7% _c	0.4% _b	0.3% _{a,b}	0.1% _a	0.6%
Hypertension + Type 2 diabetes + Lipid disorders	0.2% _a	0.9% _b	2.7% _c	5.0% _d	8.1% _e	8.5% _e	2.9%
Hypertension + Type 2 diabetes + Coronary disease	0.1% _{a,b,c}	0.1% _c	0.2% _b	0.4% _a	0.4% _a	0.4% _a	0.2%

Table 8. Cont.

	Underweight	Normal Body Weight	Overweight without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity	Total
Hypertension + Lipid disorders + Coronary disease	0.3% _a	1.2% _{b,c}	2.0% _d	2.0% _d	1.5% _c	0.8% _{a,b}	1.7%
Type 2 diabetes + Lipid disorders + Coronary disease	0.1% _{a,b,c,d}	0.0% _{c,d}	0.0% _{b,d}	0.1% _a	0.1% _{a,b,c,d}	0.1% _{a,b,c,d}	0.1%
All		0.2% _a	0.6% _b	1.0% _c	1.3% _d	1.1% _{c,d}	0.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

The cross-tabulation chi-square analysis performed confirmed that there was an association between age and comorbidities ($\chi^2(56) = 16,758.06; p < 0.001$). In the case of hypertension, it was obtained that the prevalence of hypertension was more common in those aged 18–54 compared to other age groups. In addition, the prevalence of lipid disorders was significantly different in each of the age groups; a trend was observed showing that the diagnosis of this disease decreased with age. A detailed comparison of the age groups for the other diseases is shown below Table 9.

Table 9. Relationship between age and comorbidities; data presented as percentage of age group ¹.

	Age					Total
	<18	18–35	35–54	55–69	>69	
Hypertension	66.7% _{a,b,c}	37.7% _c	34.3% _b	31.6% _a	30.2% _a	34.3%
Type 2 diabetes	33.3% _a	6.7% _a	2.8% _b	2.6% _c	2.5% _{b,c}	3.5%
Lipid disorders		44.3% _d	35.8% _c	18.6% _b	7.1% _a	33.2%
Coronary disease		0.5% _c	0.8% _b	1.8% _a	2.0% _a	1.0%
Hypertension + Type 2 diabetes		0.9% _d	2.1% _c	4.8% _b	6.6% _a	2.6%
Hypertension + Lipid disorders		8.7% _d	18.3% _c	22.1% _b	19.0% _{a,c}	17.3%
Hypertension + Coronary disease		0.1% _d	0.5% _c	2.1% _b	4.5% _a	0.8%
Type 2 diabetes + Lipid disorders		0.6% _c	1.1% _b	1.5% _a	1.4% _{a,b}	1.1%
Type 2 diabetes + Coronary disease		0.0% _d	0.0% _c	0.2% _b	0.6% _a	0.1%
Lipid disorders + Coronary disease		0.1% _c	0.5% _b	1.3% _a	1.9% _a	0.6%
Hypertension + Type 2 diabetes + Lipid disorders		0.4% _c	2.2% _b	6.5% _a	8.1% _a	3.0%
Hypertension + Type 2 diabetes + Coronary disease		0.0% _d	0.1% _c	0.6% _b	1.9% _a	0.2%
Hypertension + Lipid disorders + Coronary disease		0.1% _d	1.1% _c	4.3% _b	9.0% _a	1.7%
Type 2 diabetes + Lipid disorders + Coronary disease		0.0% _b	0.0% _b	0.2% _a	0.4% _a	0.1%
All		0.0% _d	0.2% _c	1.8% _b	4.7% _a	0.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the age category whose column proportions do not differ significantly at the level of 5%.

4. Discussion

In this study, we used data from 931,985 unique adult patients and applied an analytical approach that provided estimates of BMI trends. Analyses on the prevalence of obesity in Poland were present in previous years; however, none of them were concerning the current years, and they were not based on such a large group of patients.

Unique in our analysis is also the correlation with the average number of months for the issued medical certificate, and the correlation with the coexistence of other serious diseases, mainly of the cardiovascular system. It is very worrying that, with the increase in BMI, the ability to work is limited, and we did not include patients who, due to obesity and comorbidities, do not try to work at all.

We would like to point out that, in this very large group of patients, we have confirmed the coexistence of diseases that significantly reduce the quality of life of patients, and their coexistence clearly depends on the degree of obesity.

Our data showed that one third of the professionally active women and almost two thirds of the professionally active men are overweight or obese. This result is extremely disturbing. Moreover, we demonstrated a trend showing an increase in the phenomenon over time, which raises concerns in terms of access to medical care and the cost of medical care. The data clearly indicate that the phenomenon is not uniform in all regions of the country. In additional materials, we present unique data indicating the diversification of obesity depending on the region of the country. Although grade II and grade III obesity were once a rare condition, our findings may suggest that they will soon be the most common BMI category in the patient populations. Given that physicians are not well equipped to treat obese patients, the continuing trend will be a major challenge for healthcare as a whole.

5. Conclusions

Further annual assessment of the prevalence of obesity and comorbidities seems necessary to prepare the health care system for treating growing number of obese, professionally active Poles, and to take the most effective measures to inhibit the trend.

Author Contributions: Conceptualization, A.R., W.L., P.P., M.C. and J.D.-K.; Data curation, A.R., I.P. and J.D.-K.; Formal analysis, I.P. and J.D.-K.; Investigation, I.P.; Methodology, A.R. and J.D.-K.; Project administration, A.R., I.P. and J.D.-K.; Supervision, J.D.-K.; Visualization, I.P.; Writing—original draft, I.P. and J.D.-K.; Writing—review & editing, W.L., P.P., M.C. and J.D.-K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study due to REASON: retrospective anonymized analysis.

Informed Consent Statement: Not applicable.

Conflicts of Interest: There is no conflict of interest (all cases). Anna Rulkiewicz, Iwona Pilchowska and Justyna Domienik-Karłowicz are LUX MED employees.

Appendix A. Additional Analyzes

The study included 1,450,455 visits to occupational medicine (collected from 931,985 unique patients) from 2016–2020. The exact number of collected results depending on the year of measurement is presented below.

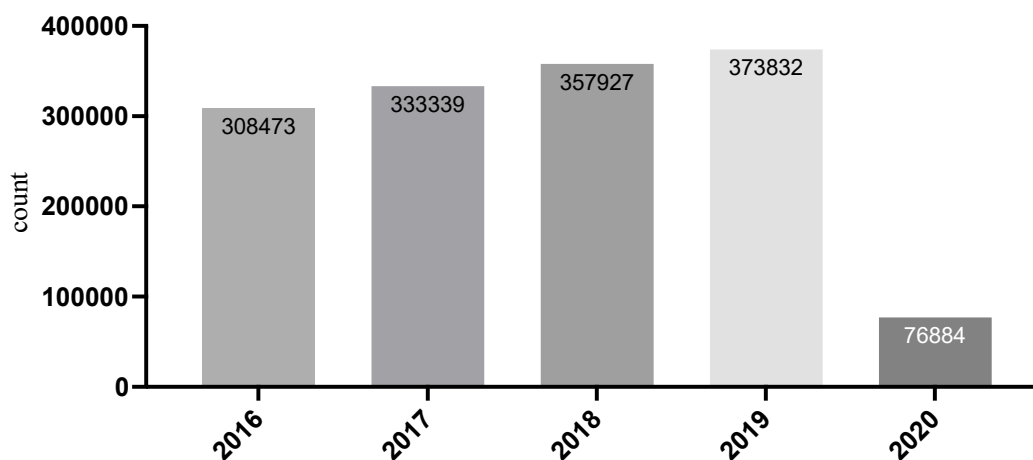


Figure A1. The number of visits analyzed versus the year of measurement.

In terms of sex, the results of the men accounted for a slightly higher percentage (51.6%). Along with the successive stages of the study, the percentage of surveyed men slightly increased (see Figure A2).

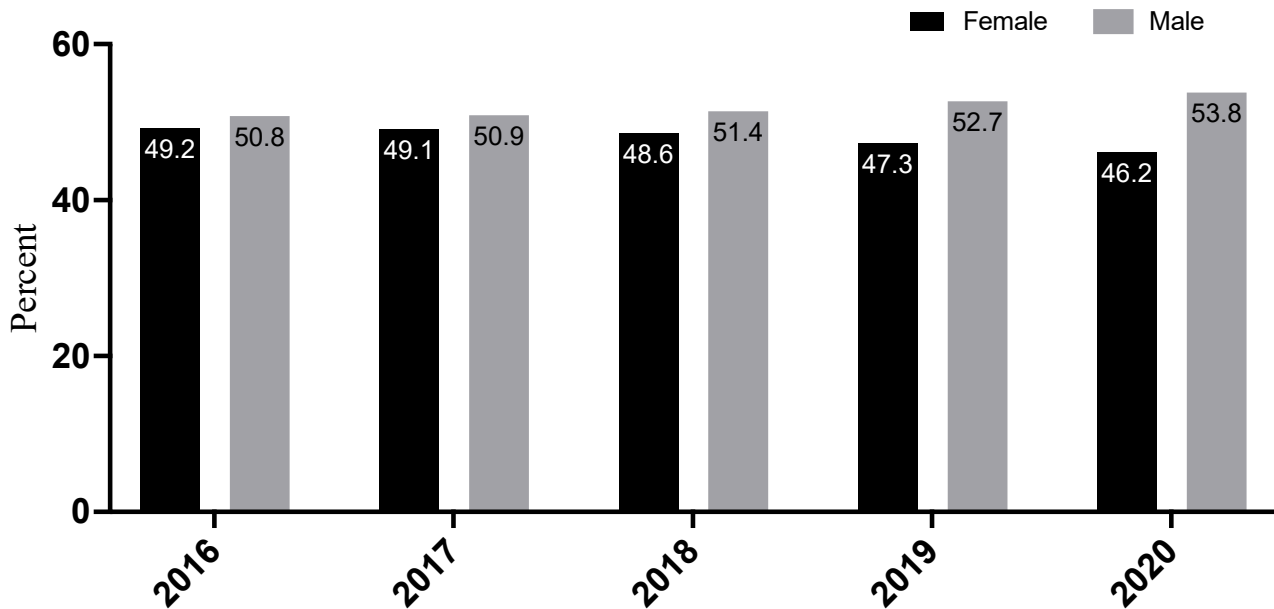


Figure A2. Sex distribution depending on the year of measurement.

The age of the respondents ranged between 14 and 90 years ($M = 36.59$; $SD = 11.56$). A slight trend was observed indicating the mean age of the examined patients slightly increased with each year of measurement (see Figure A3). Clarification: patients can change age categories if their change in age necessitates this; this is not to be misinterpreted for a tautological restatement of the patients aging with time.

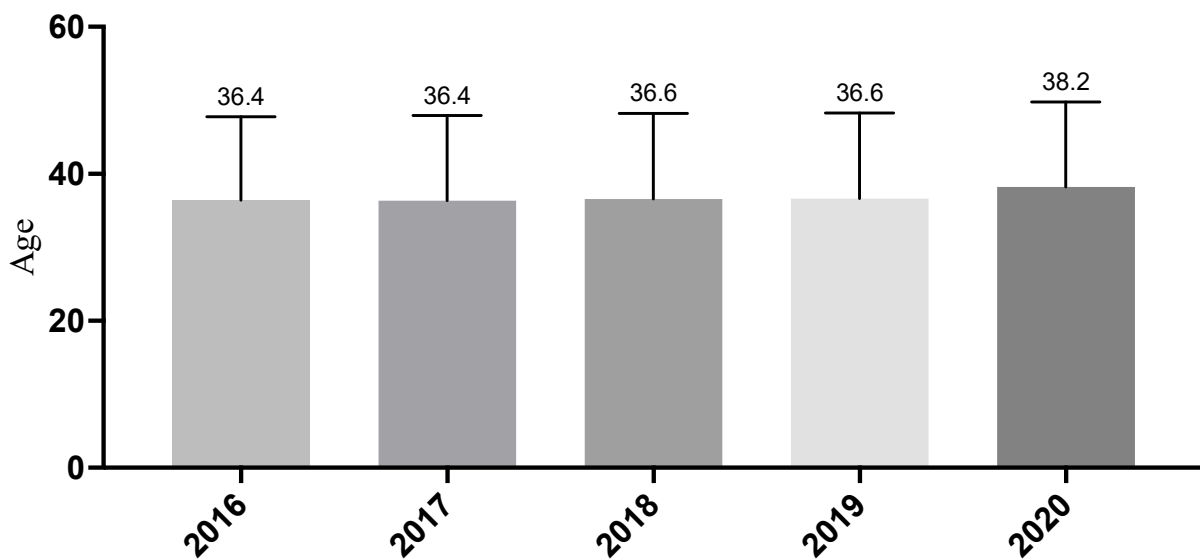


Figure A3. Patient age distribution versus the year of measurement.

The exact distribution of age groups depending on the year of measurement is presented in the table below. It was found that, with successive years of measurement, a decreased percentage of people aged 18–35 and an increased percentage in the age group 35–54 were observed. In the case of the remaining age groups, the trends were not as clear as in the case of these two age categories.

Table A1. Distribution of age groups versus the year of measurement.

	2016	2017	2018	2019	2020	Total
<18	0.00%	0.00%	0.10%	0.10%	0.00%	0.10%
18–35	54.50%	54.30%	53.30%	52.50%	46.80%	53.20%
35–54	35.70%	35.80%	36.70%	37.60%	41.90%	36.80%
55–69	9.60%	9.70%	9.80%	9.70%	11.10%	9.80%
>69	0.10%	0.10%	0.20%	0.20%	0.30%	0.20%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

There were also no significant differences in terms of the distribution of the respondents by year of measurement and the voivodeship of residence (see Table A2).

Table A2. Distribution of voivodeships depending on the year of measurement.

	2016	2017	2018	2019	2020	Total
Lower Silesia	12.60%	13.10%	12.70%	13.00%	13.60%	12.90%
Kuyavian-Pomeranian	3.90%	4.10%	4.10%	3.80%	3.70%	4.00%
Lublin	0.90%	0.90%	0.90%	0.80%	0.70%	0.80%
Lubusz	1.40%	1.40%	1.50%	1.60%	1.90%	1.50%
Lodz	7.20%	7.10%	6.60%	6.70%	6.30%	6.90%
Lesser	10.90%	11.20%	11.80%	11.30%	11.60%	11.30%
Mazowieckie	33.60%	32.00%	30.80%	28.60%	29.00%	31.00%
Opole	1.10%	1.10%	1.10%	1.20%	1.20%	1.10%
Subcarpathian	2.00%	2.40%	3.40%	3.10%	2.80%	2.80%
Podlasie	1.80%	1.90%	1.70%	1.60%	1.50%	1.70%
Pomeranian	6.20%	6.30%	6.80%	7.30%	6.50%	6.70%
Silesian	6.10%	6.20%	6.20%	8.20%	8.30%	6.80%
Świętokrzyskie	0.70%	0.70%	0.70%	0.70%	0.70%	0.70%
Warmia-Masurian	2.10%	1.90%	2.00%	2.10%	2.10%	2.00%
Greater	7.00%	6.80%	6.70%	6.40%	6.70%	6.70%
West Pomeranian	2.60%	3.00%	3.00%	3.50%	3.50%	3.10%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

References

1. Ng, M.; Fleming, T.; Robinson, M.; Thomson, B.; Graetz, N.; Margono, C.; Gakidou, E. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet* **2014**, *384*, 766–781. [[CrossRef](#)]
2. Prospective Studies Collaboration. Body-mass index and cause-specific mortality in 900,000 adults: Collaborative analyses of 57 prospective studies. *Lancet* **2009**, *373*, 1083–1096. [[CrossRef](#)]
3. Blundell, J.E.; Baker, J.L.; Boyland, E.; Blaak, E.; Charzewska, J.; De Henauw, S.; Frühbeck, G.; Gonzalez-Gross, M.; Hebebrand, J.; Holm, L.; et al. Variations in the Prevalence of Obesity Among European Countries, and a Consideration of Possible Causes. *Obes. Facts* **2017**, *10*, 25–37. [[CrossRef](#)] [[PubMed](#)]
4. Blüher, M. Obesity: Global epidemiology and pathogenesis. *Nat. Rev. Endocrinol.* **2019**, *15*, 288–298. [[CrossRef](#)]
5. Yarborough, C.M., III; Brethauer, S.; Burton, W.N.; Fabius, R.J.; Hymel, P.; Kothari, S.; Roslin, M.S. ACOEM Guidance Statement: Obesity in the Workplace: Impact, Outcomes, and Recommendations. *J. Occup. Environ. Med.* **2018**, *60*, 97. [[CrossRef](#)]
6. Keum, N.; Greenwood, D.C.; Lee, D.H.; Kim, R.; Aune, D.; Ju, W.; Giovannucci, E.L. Adult weight gain and adiposity-related cancers: A dose-response meta-analysis of prospective observational studies. *J. Natl. Cancer Inst.* **2015**, *2015*, 107. [[CrossRef](#)]
7. Bjørge, T.; Häggström, C.; Ghaderi, S.; Nagel, G.; Manjer, J.; Tretli, S.; Ulmer, H.; Harlid, S.; Rosendahl, A.H.; Lang, A.H.; et al. BMI and weight changes and risk of obesity-related cancers: A pooled European cohort study. *Int. J. Epidemiol.* **2019**, *48*, 1872–1885. [[CrossRef](#)]
8. Poirier, P.; Eckel, R.H. Obesity and cardiovascular disease. *Curr. Atheroscler. Rep.* **2002**, *4*, 448–453. [[CrossRef](#)]
9. Bastien, M.; Poirier, P.; Lemieux, I.; Després, J.-P. Overview of Epidemiology and Contribution of Obesity to Cardiovascular Disease. *Prog. Cardiovasc. Dis.* **2013**, *56*, 369–381. [[CrossRef](#)]
10. Wilson, P.W.; D'Agostino, R.B.; Sullivan, L.; Parise, H.; Kannel, W.B. Overweight and obesity as determinants of cardiovascular risk: The Framingham experience. *Arch. Intern Med.* **2002**, *162*, 1867–1872. [[CrossRef](#)]
11. Bastard, J.-P.; Maachi, M.; Lagathu, C.; Kim, M.J.; Caron, M.; Vidal, H.; Capeau, J.; Feve, B. Recent advances in the relationship between obesity, inflammation, and insulin resistance. *Eur. Cytokine Netw.* **2006**, *17*, 4–12. [[PubMed](#)]

12. World Health Organization. Obesity and Overweight. 2016. Available online: <https://www.who.int/mediacentre/factsheets/fs311/en/> (accessed on 1 July 2020).
13. Jaacks, L.M.; Vandevijvere, S.; Pan, A.; McGowan, C.; Wallace, C.; Imamura, F.; Mozaffarian, D.; Swinburn, B.; Ezzati, M. The obesity transition: Stages of the global epidemic. *Lancet Diabetes Endocrinol.* **2019**, *7*, 231–240. [[CrossRef](#)]
14. Chooi, Y.C.; Ding, C.; Magkos, F. The epidemiology of obesity. *Metabolism* **2019**, *92*, 6–10. [[CrossRef](#)] [[PubMed](#)]
15. Ryan, D.H.; Kahan, S. Guideline Recommendations for Obesity Management. *Med. Clin. N. Am.* **2018**, *102*, 49–63. [[CrossRef](#)] [[PubMed](#)]
16. Sorensen, G.; McLellan, D.L.; Sabbath, E.L.; Dennerlein, J.T.; Nagler, E.M.; Hurtado, D.A.; Pronk, N.P.; Wagner, G.R. Integrating worksite health protection and health promotion: A conceptual model for intervention and research. *Prev. Med.* **2016**, *91*, 188–196. [[CrossRef](#)] [[PubMed](#)]
17. Katz, D.; O’Connell, M.; Yeh, M.-C.; Nawaz, H.; Njike, V.; Anderson, L.M.; Cory, S.; Dietz, W. *Public Health Strategies for Preventing and Controlling Overweight and Obesity in School and Worksite Settings: A Report on Recommendations of the Task Force on Community Preventive Services*; Mortality and Morbidity Weekly Report; Department of Health and Human Services, Centers for Disease Control and Prevention: Atlanta, GA, USA, 2005. Available online: <http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5410a1.htm> (accessed on 1 July 2020).
18. Beresford, S.A.; Thompson, B.; Feng, Z.; Christianson, A.; McLerran, D.; Patrick, D.L. Seattle 5 a Day Worksite Program to Increase Fruit and Vegetable Consumption. *Prev. Med.* **2001**, *32*, 230–238. [[CrossRef](#)]
19. Iii, C.M.Y.; Brethauer, S.; Burton, W.N.; Fabius, R.J.; Hymel, P.; Kothari, S.; Roslin, M.S. Obesity in the Workplace: Impact, Outcomes, and Recommendations. *J. Occup. Environ. Med.* **2018**, *60*, 97–107.
20. Lin, T.-C.; Courtney, T.; Lombardi, D.A.; Verma, S.K. Association between Sedentary Work and BMI in a U.S. National Longitudinal Survey. *Am. J. Prev. Med.* **2015**, *49*, e117–e123. [[CrossRef](#)]
21. Shields, M.; Tremblay, M.S. Sedentary behaviour and obesity. *Health Rep.* **2008**, *19*, 19.
22. Mitchell, J.A.; Bottai, M.; Park, Y.; Marshall, S.J.; Moore, S.C.; Matthews, C.E. A prospective study of sedentary behavior and changes in the body mass index distribution. *Med. Sci. Sports Exerc.* **2014**, *46*, 2244–2252. [[CrossRef](#)]
23. Kottwitz, M.U.; Grebner, S.I.; Semmer, N.K.; Tschan, F.; Elfering, A. Social Stress at Work and Change in Women’s Body Weight. *Ind. Health* **2014**, *52*, 163–171. [[CrossRef](#)] [[PubMed](#)]
24. Bandalos, D.L.; Finney, S.J. *Exploratory and Confirmatory. The Reviewer’s Guide to Quantitative Methods in the Social Sciences*; Routledge: New York, NY, USA, 2010; Volume 93.
25. Field, A. *Discovering Statistics Using IBM SPSS Statistics*; Sage Publications: Thousand Oaks, CA, USA, 2013.
26. Field, A.; Miles, J.; Field, Z. *Discovering Statistics Using R*; Sage Publications: Thousand Oaks, CA, USA, 2012.



Article

Prevalence of Cigarette Smoking among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities- POL-O-CARIA 2021 Study

Anna Rulkiewicz, Iwona Pilchowska, Wojciech Lisik, Piotr Pruszczyk and Justyna Domienik-Karłowicz

Special Issue

Advances in the Management of Cardiovascular Disease

Edited by

Prof. Dr. Michał Ciużyński and Dr. Justyna Domienik-Karłowicz



<https://doi.org/10.3390/jcm11144111>



Article

Prevalence of Cigarette Smoking among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2021 Study

Anna Rulkiewicz ¹, Iwona Pilchowska ^{1,2}, Wojciech Lisik ³ , Piotr Pruszczyk ⁴
and Justyna Domienik-Karłowicz ^{1,4,*}

¹ LUX MED, Postępu 21C, 02-676 Warsaw, Poland; anna.rulkiewicz@luxmed.pl (A.R.); iwona.pilchowska@luxmed.pl (I.P.)

² Department of Psychology, SWPS University of Social Sciences and Humanities, 03-815 Warsaw, Poland

³ Department of General and Transplantation Surgery, Medical University of Warsaw, 02-014 Warsaw, Poland; wojciech.lisik@wum.edu.pl

⁴ Department of Internal Medicine and Cardiology, Medical University of Warsaw, 02-005 Warsaw, Poland; piotr.pruszczyk@wum.edu.pl

* Correspondence: jdomienik@tlen.pl or justyna.domienik@luxmed.pl; Tel.: +48-22-502-11-44



Citation: Rulkiewicz, A.; Pilchowska, I.; Lisik, W.; Pruszczyk, P.; Domienik-Karłowicz, J. Prevalence of Cigarette Smoking among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2021 Study. *J. Clin. Med.* **2022**, *11*, 4111. <https://doi.org/10.3390/jcm11144111>

Academic Editor:
Emmanuel Androulakis

Received: 8 May 2022
Accepted: 14 July 2022
Published: 15 July 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: Smoking is a leading cause of preventable mortality. It affects both the health and economic situation within societies. The aim of the study is to perform an epidemiological analysis of smoking among professionally active adults in Poland in the years 2016–2020 and its Strong Relationship with Cardiovascular Co-morbidities. The article retrospectively analyzed the records of 1,450,455 who underwent occupational medicine examinations between 2016 and 2020. Statistical analyses performed using IBM SPSS Statistics 25 software were performed. In general, irrespective of the year of measurement, 11.6% of women and 17.1% of men declared smoking. After sorting by year of measurement, we found that the percentage of female smokers was decreasing, while that of males remained relatively consistent. In the case of BMI, it was found that among tobacco smokers the percentage of people with normal body weight decreases with successive years of measurement, while the percentage of overweight and level I obesity increases. Moreover, we analyzed in detail the occurrence of particular comorbidities in the group of people who declared smoking. The most common diseases in this group were: arterial hypertension (39%), lipid disorders (26.7%), and hypertension and lipid disorders (16.5%). Active preventive measures are necessary to reduce the number of smokers and the negative impact of smoking on the occurrence of comorbid diseases.

Keywords: cardiovascular diseases; cigarette smoking; professionally active adult population

1. Introduction

The proportion of cigarette smokers in Europe remains high, with around 21% of adults reporting that they are active smokers [1]. However, cohort studies performed in Europe present the percentage of smokers in the group of 16–20-year-olds as being in decline. This phenomenon is observed in all parts of Europe (Northern, Eastern, and Western Europe) except Southern Europe, where smoking has remained at levels since 1990. The initiation rate in early adolescence (11–15 years) has increased since 1990, especially in Western Europe. The lowest rates of tobacco initiation are observed in Western Europe [2].

In recent years, there has been a decline in the percentage of people who declare themselves smokers. This is attributed to restrictions introduced by individual European countries [3,4]. The Framework Convention on Tobacco Control is a further impetus in the global fight against smoking [5]. However, studies on the age of initiation of smoking are still missing—according to the 2015 Eurobarometer, 19% of Europeans started smoking before the age of 15 [6].

Since 2015, active smoking has been linked to more than five million deaths per year coming from an estimated one billion smokers, while around 600,000 deaths are explained by exposure to passive smoking [7].

Smoking is a leading cause of preventable mortality. It is one of the factors that increase the risk of respiratory diseases, allergies, cardiovascular diseases, and cancer [8]. Young people whose organs are still developing are particularly vulnerable to these diseases. There are many studies that show that exposure to the effects of smoking during the growth period can have a significant impact on health between generations [9–11]. In addition, smoking cessation significantly reduces the risk of cancer and heart disease after 12 months of not smoking [12]. Ultimately, people who smoke tobacco products for many years have a lower willingness to quit smoking [13], which results from addiction and low motivation to change their habits [13,14].

Smoking tobacco affects both the health and economic situation within a society. Research by Baker [15] confirmed that tobacco smoking increases absenteeism and decreases professional activity at work among employees from the USA, Europe, and China. These trends improved significantly after cessation of smoking—workers who quit smoking up to four years prior experienced both significant increases in work productivity and fewer days of absence from work. Other studies have shown that US workers who smoke cigarettes lose an average of 2–3 working days per year due to health consequences when compared to workers who have never smoked [16–18]. Studies conducted in the Netherlands, Germany, and China gave similar results [19–21].

Apart from individual health disorders and occupational troubles, smoking entails very high collateral monetary costs. These are mainly felt as the added costs of providing health care to workers for treatment of diseases resulting from long-term smoking. Still, farther-reaching costs arise from aggregate losses to countries as a result of early smoking mortality [22].

Proper communication between the doctors and patients disclosing their smoking is a very significant factor. Doctors rarely recommend quitting smoking among older adults [23], mainly because the patient is highly addicted or lacks tangible health benefits. However, it is worth noting that quitting smoking in old age may still bring significant health benefits, extend life expectancy and quality [24], and reduce the risk of disability [25]. In addition, quitting smoking can significantly increase the potential benefits for employers, employees, and society as a whole [26].

One of the primary difficulties in developing programs to change the habits of smokers is understanding the more fundamental causes of tobacco addiction; analysis of the ages at which smoking initiation takes place also seems to be important—it should be noted, however, that most publications focus only on the sheer prevalence of smoking in societies. Understanding the reasons underlying tobacco use would almost certainly allow for the development of more effective prevention strategies. Current research indicates that undertaken actions are most effective in lower socioeconomic groups [27].

There have been multiple approaches taken to broadly curb tobacco use. One preventive approach was increasing the price of a pack of cigarettes. Analyses show that this mainly affected young people whose budgets tend to be more sensitive to price increases [28]. Another approach—limiting exposure to tobacco product advertising—was also introduced [29]. The most direct measure—introducing bans on smoking in public places—failed to yield any clear conclusions supporting its efficacy in reducing the percentage of people using tobacco products. European studies conducted in 2019 [30] show that raising prices for tobacco products and limiting places where it is permissible to smoke reduces the number of active smokers mainly in adults up to 65 years of age; the reverse relationship is visible in people over 65 years of age.

Post-quit productivity gains have prompted many employers to support workers in quitting smoking by investing in tobacco cessation programs and behavioral interventions [31]. Employers incurring the costs of implementing smoking cessation programs

also see measurable benefits—the average duration of professional activity of non-smokers is longer than that of active smokers [32].

The aim of the study is to perform a cross-sectional study of smoking among professionally active adults in Poland in the years 2016–2020 and its Strong Relationship with Cardiovascular Co-morbidities.

2. Materials and Methods

The article retrospectively analyzed the subsequent records of professionally active adults who underwent occupational medicine examinations between January 2016 and April 2020. In total, the results of 1,450,455 initial, control, and periodic visits as components of occupational medicine certifications were analyzed. During the study, sex, age, height, weight, voivodship of residence, period of validity of medical certification, and data from medical history (subjective assessment of health, smoking) were controlled. We did not exclude any patients. We present data of all subsequent patients. Detailed characteristics of the studied patients are presented in Appendix A.

Statistical Analysis

Statistical analyses performed using IBM SPSS Statistics 25 software for Windows, Version 27.0. Armonk, NY:IBM Corp were performed [26]. The percentages (with 95% CI) and numbers of observations were used to analyze qualitative data; to characterize the quantitative data: mean (M), standard deviation (SD), median (Me), skewness, kurtosis, and the minimum and maximum statistics were used. Significant statistical results were considered where the probability of making a type I error was less than 5% ($p < 0.05$). For statistical calculations we used: chi-square analysis (Bonferroni’s correction was used to test column proportions) and U Mann–Whitney test.

3. Results

The chi-square analysis in the cross tables showed that the percentage of declared smokers slightly decreased with each passing year. It is worth noting, however, that the largest decrease in the percentage of declared smokers occurred between 2016 and other years, taken individually (see Table 1).

Table 1. Relationship between smoking and measurement time—data as percentage for the year of measurement (with 95% CI) ¹.

	2016	2017	2018	2019	2020	Total
No	85.2% _a (±0.2%)	85.5% _b (±0.1%)	85.8% _c (±0.2%)	85.7% _{b,c} (±0.2%)	85.8% _{b,c} (±0.3%)	85.6% (±0.2%)
Yes	14.8% _a (±0.2%)	14.5% _b (±0.1%)	14.2% _c (±0.2%)	14.3% _{b,c} (±0.2%)	14.2% _{b,c} (±0.3%)	14.4% (±0.2%)
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

3.1. Characteristics of Declared Smokers

In general, irrespective of the year of measurement, 11.6% of women and 17.1% of men declared smoking. After sorting by year of measurement, we found that the percentage of female smokers was decreasing, while that of males remained relatively consistent (see Figure 1).

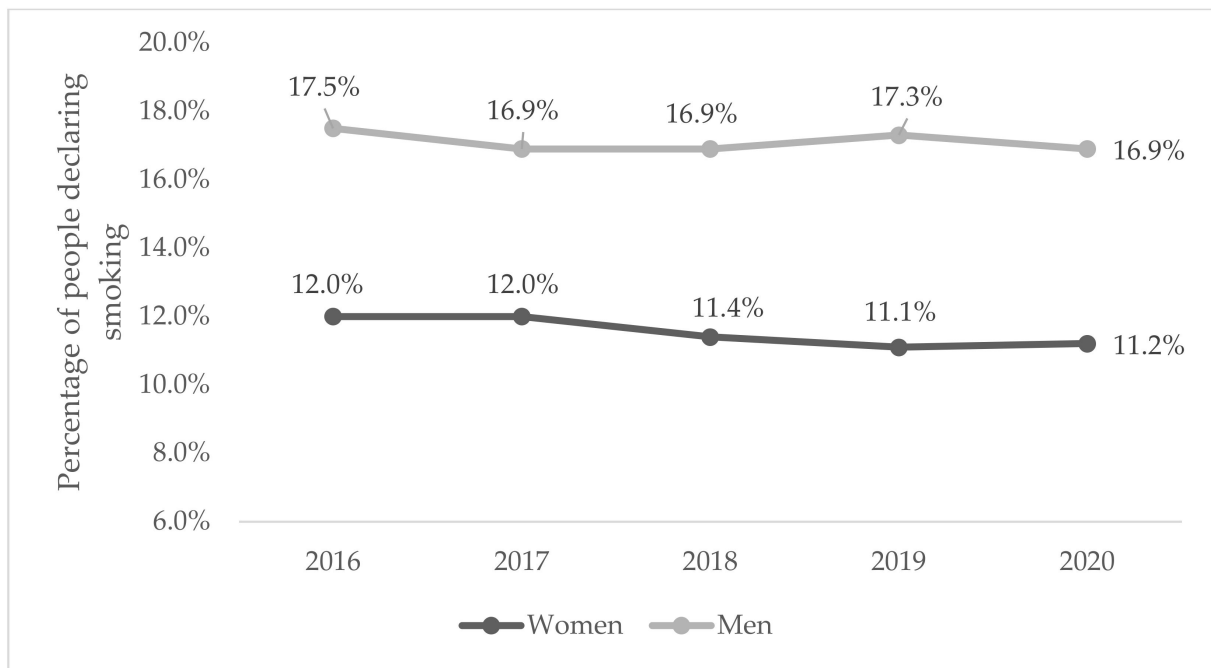


Figure 1. Percentage of declared smokers by sex and year of measurement (95% CI: women group: ±0.3%, men group: ±0.5%).

The age of people declaring smoking ranged from 15 to 88 years (M = 37.52; SD = 12.37). There were no considerable changes in declared tobacco smoking in individual age groups in the analyzed years—only in 2020 was there a slight increase in the percentage of smokers in the 35–54 and 55–69 age groups, along with a slight increase in the 18–35 age group (see Table 2).

Table 2. Relationship between age and measurement time—percentages (with 95% CI) by year of measurement (analysis only for people declaring smoking)¹.

	2016	2017	2018	2019	2020	Total
<18	0.1% _a (±0.1%)	0.1% _a (±0.1%)	0.1% _a (±0.1%)	0.0% _a (±0.1%)	n/a	0.1% (±0.1%)
18–35	51.1% _a (±0.4%)	50.9% _a (±0.3%)	51.2% _a (±0.3%)	50.8% _a (±0.3%)	45.9% _b (±0.2%)	50.7% (±0.3%)
35–54	35.9% _a (±0.3%)	36.1% _a (±0.2%)	35.8% _a (±0.3%)	36.3% _a (±0.2%)	39.5% _b (±0.3%)	36.2% (±0.3%)
55–69	12.8% _a (±0.2%)	12.8% _a (±0.2%)	12.7% _a (±0.2%)	12.6% _a (±0.2%)	14.4% _b (±0.2%)	12.8% (±0.2%)
>69	0.1% _a (±0.1%)	0.1% _a (±0.1%)	0.2% _b (±0.1%)	0.2% _b (±0.1%)	0.2% _b (±0.1%)	0.2% (±0.1%)
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

In the case of BMI, it was found that among tobacco smokers the percentage of people with normal body weight decreases with successive years of measurement, while the percentage of overweight and level I obesity increases (see Table 3).

Table 3. Relationship between BMI and measurement time—percentages (with 95% CI) by the year of measurement (analysis only for people declaring smoking)¹.

	2016	2017	2018	2019	2020	Total
Underweight	2.8% _a (±0.2%)	2.8% _a (±0.2%)	2.7% _{a,b} (±0.3%)	2.8% _a (±0.3%)	2.4% _b (±0.2%)	2.8% (±0.2%)
Normal body mass	47.0% _a (±0.5%)	46.3% _b (±0.4%)	45.5% _c (±0.4%)	44.8% _d (±0.4%)	43.1% _e (±0.4%)	45.7% (±0.4%)
overweight	34.2% _a (±0.7%)	34.2% _a (±0.6%)	34.8% _{a,b} (±0.6%)	34.5% _{a,b} (±0.7%)	35.4% _b (±0.7%)	34.5% (±0.6%)
Obesity type I	12.2% _a (±0.2%)	12.8% _b (±0.3%)	13.1% _{b,c} (±0.3%)	13.4% _c (±0.2%)	14.6% _d (±0.2%)	13.0% (±0.2%)
Obesity type II	2.9% _a (±0.2%)	3.0% _a (±0.1%)	3.1% _a (±0.2%)	3.4% _b (±0.2%)	3.5% _b (±0.2%)	3.1% (±0.2%)
Obesity type III	0.8% _a (±0.1%)	0.8% _a (±0.1%)	0.8% _a (±0.1%)	1.0% _b (±0.1%)	0.9% _{a,b} (±0.1%)	0.8% (±0.1%)
Total		100.00%	100.00%	100.00%	100.00%	100.00%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

The average number of months for the occupational medicine certificates was approximately 29 months (M = 29.09; SD = 13.47).

3.2. Smoking and Diagnosis According to ICD-10

Table 4 shows the relationship between those who declared cigarette smoking and the occurrence of individual ICD-10 categories ($p < 0.001$). It turned out that in the case of selected categories (such as factors influencing health status and contact with health care and cardiovascular diseases) a higher percentage of diagnoses was associated with people who declared smoking.

Table 4. The relationship between cigarette smoking and the occurrence of individual ICD-10 categories—percentages (with 95% CI) of the smoking category¹.

	Smoking		Total
	No	Yes	
Selected infectious and parasitic diseases	0.6% _a (±0.05%)	0.5% _b (±0.04%)	0.6% (±0.05%)
Cancers	0.6% _a (±0.06%)	0.4% _b (±0.05%)	0.5% (±0.05%)
Diseases of blood and hematopoietic organs and selected diseases involving immunological mechanisms	0.1% _a (±0.01%)	0.1% _b (±0.01%)	0.1% (±0.01%)
Disorders of endocrine secretion, nutritional status, and metabolic changes	10.3% _a (±0.5%)	8.8% _b (±0.4%)	10.0% (±0.4%)
Mental and behavioral disorders	0.3% _a (±0.04%)	0.4% _b (±0.04%)	0.3% (±0.04%)
Nervous system diseases	0.5% _a (±0.07%)	0.5% _a (±0.06%)	0.5% (±0.06%)
Diseases of the eye and eye appendages	8.9% _a (±0.10%)	9.4% _b (±0.09%)	9.0% (±0.10%)
Diseases of the ear and mastoid process	0.9% _a (±0.03%)	1.0% _b (±0.04%)	0.9% (±0.3%)
Cardiovascular disease	9.0% _a (±0.10%)	9.5% _b (±0.08%)	9.0% (±0.10%)
Respiratory system diseases	5.4% _a (±0.12%)	4.7% _b (±0.14%)	5.3% (±0.12%)
Digestive system diseases	2.4% _a (±0.15%)	2.1% _b (±0.09%)	2.4% (±0.11%)

Table 4. *Cont.*

	Smoking		Total
	No	Yes	
Diseases of the skin and subcutaneous tissue	2.3% _a (±0.22%)	1.7% _b (±0.16%)	2.2% (±0.17%)
Diseases of the musculoskeletal system and connective tissue	3.9% _a (±0.12%)	3.6% _b (±0.17%)	3.9% (±0.13%)
Diseases of the genitourinary system	2.4% _a (±0.14%)	1.6% _b (±0.14%)	2.3% (±0.14%)
Pregnancy, childbirth and the postpartum period	0.4% _a (±0.08%)	0.2% _b (±0.06%)	0.4% (±0.06%)
Selected conditions starting in the perinatal period	0.0% _a (±0.01%)	0.0% _a (±0.02%)	0.0% (±0.01%)
Congenital malformations, distortions, and chromosomal aberrations	0.0% _a (±0.01%)	0.0% _b (±0.01%)	0.0% (±0.01%)
Symptoms, signs, and abnormal results of clinical and laboratory tests; not elsewhere classified	3.4% _a (±0.18%)	2.9% _b (±0.16%)	3.4% (±0.16%)
Injury, poisoning, and other specific effects of external factors	2.2% _a (±0.03%)	2.1% _b (±0.02%)	2.2% (±0.03%)
External causes of illness and death	0.2% _a (±0.01%)	0.1% _b (±0.02%)	0.2% (±0.01%)
Factors influencing health condition and contact with health services	46.2% _a (±0.45%)	50.5% _b (±0.41%)	46.8% (±0.42%)
Total	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

Additionally, after dividing cardiovascular diseases into groups, we observed that in the case of ischemic heart disease a higher percentage of cases was found in people who declared smoking; however, for arterial hypertension, the opposite relationship was obtained. The exact results are shown in the Table 5 below.

Table 5. Relationship between cigarette smoking and the incidence of individual ICD-10 groups (cardiovascular diseases)—percentages (with 95% CI) for the smoking category ¹.

	Smoking		Total
	No	Yes	
Acute rheumatic disease	0.0% _a (±0.1%)	n/a	0.0% (±0.1%)
Chronic rheumatic heart disease	0.0% _a (±0.1%)	0.0% _a (±0.1%)	0.0% (±0.1%)
Hypertension	87.0% _a (±0.3%)	86.3% _b (±0.3%)	86.9% (±0.3%)
Ischemic heart disease	7.1% _a (±0.2%)	8.8% _b (±0.1%)	7.4% (±0.2%)
Cardiopulmonary syndrome and pulmonary circulation diseases	0.0% _a (±0.1%)	0.0% _a (±0.1%)	0.0% (±0.1%)
Other heart conditions	1.8% _a (±0.1%)	1.8% _a (±0.1%)	1.8% (±0.1%)
Cerebral vessel diseases	0.2% _a (±0.1%)	0.3% _a (±0.1%)	0.2% (±0.1%)
Diseases of arteries, arterioles, and capillaries	0.4% _a (±0.1%)	0.4% _a (±0.1%)	0.4% (±0.1%)
Diseases of the veins, lymph vessels, and lymph nodes, not elsewhere classified	3.3% _a (±0.3%)	2.3% _b (±0.2%)	3.1% (±0.2%)
Other and unspecified disorders of the circulatory system	0.1% _a (±0.1%)	0.1% _a (±0.1%)	0.1% (±0.1%)
Total	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

Analyzing the relationship between selected diseases and declared smoking, it turned out that in the group of smokers a higher percentage of people with hypertension and type 2 diabetes was observed; in the case of lipid disorders, the opposite correlation was obtained (see Table 6).

Table 6. Relationship between cigarette smoking and the occurrence of selected diseases—percentages (with 95% CI) of the smoking category ¹.

	Smoking		Total
	No	Yes	
Hypertension	44.5% _a (±0.1%)	48.7% _b (±0.1%)	45.1% (±0.1%)
Type 2 diabetes	8.2% _a (±0.2%)	8.9% _b (±0.2%)	8.3% (±0.2%)
Lipid disorders	43.6% _a (±0.4%)	37.5% _b (±0.3%)	42.8% (±0.3%)
Coronary artery disease	3.6% _a (±0.1%)	5.0% _b (±0.1%)	3.8% (±0.1%)
Total	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the year category whose column proportions do not differ significantly at the level of 5%.

3.3. Cigarette Smoking and Comorbidities

The figure below shows the occurrence of particular comorbidities in the group of people who declared smoking. The most common diseases in this group were: arterial hypertension (39%), lipid disorders (26.7%), and hypertension and lipid disorders (16.5%). The remaining diseases occurred in less than 5% of the patients (see Figure 2).

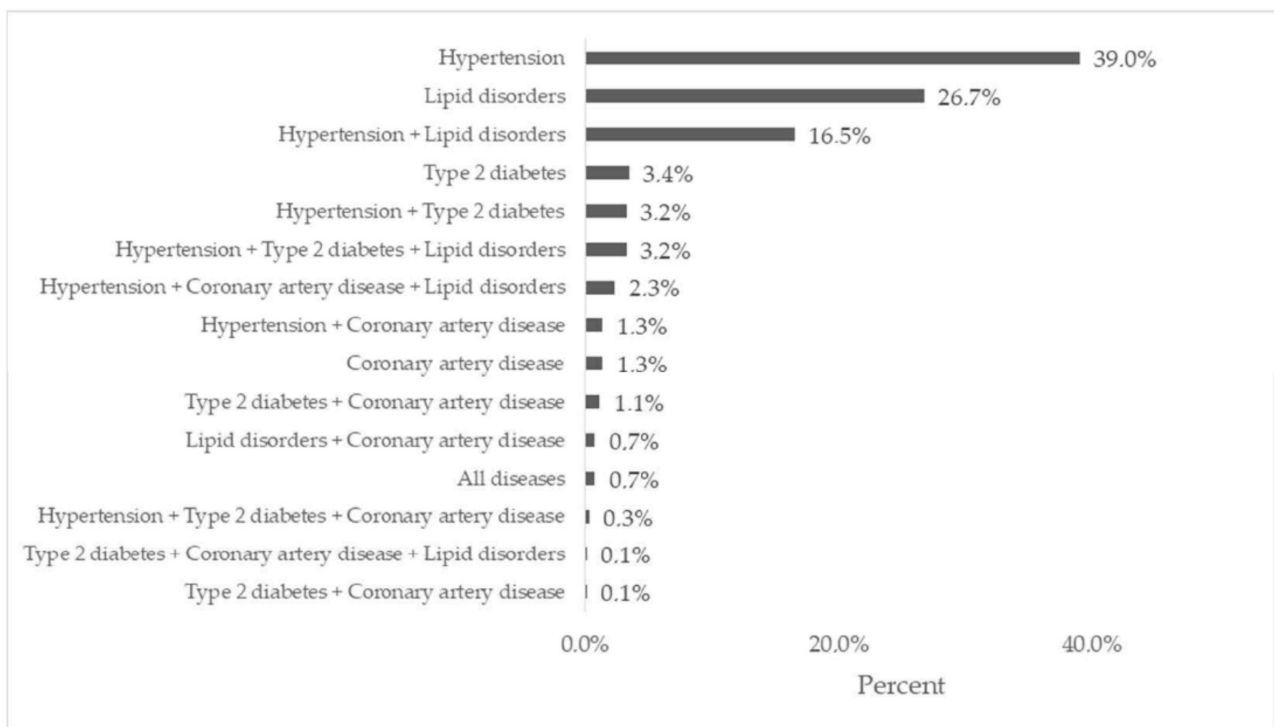


Figure 2. Occurrence of comorbidities in the group of people who declared smoking (95% CI: hypertension: ±0.1%, lipid disorders: ±0.3%; others: ±0.1%).

Moreover, we confirmed that people who declared smoking cigarettes have significantly more diagnosed diseases as compared to people who do not smoke ($p < 0.001$). The obtained results are presented graphically in the Figure 3 below.

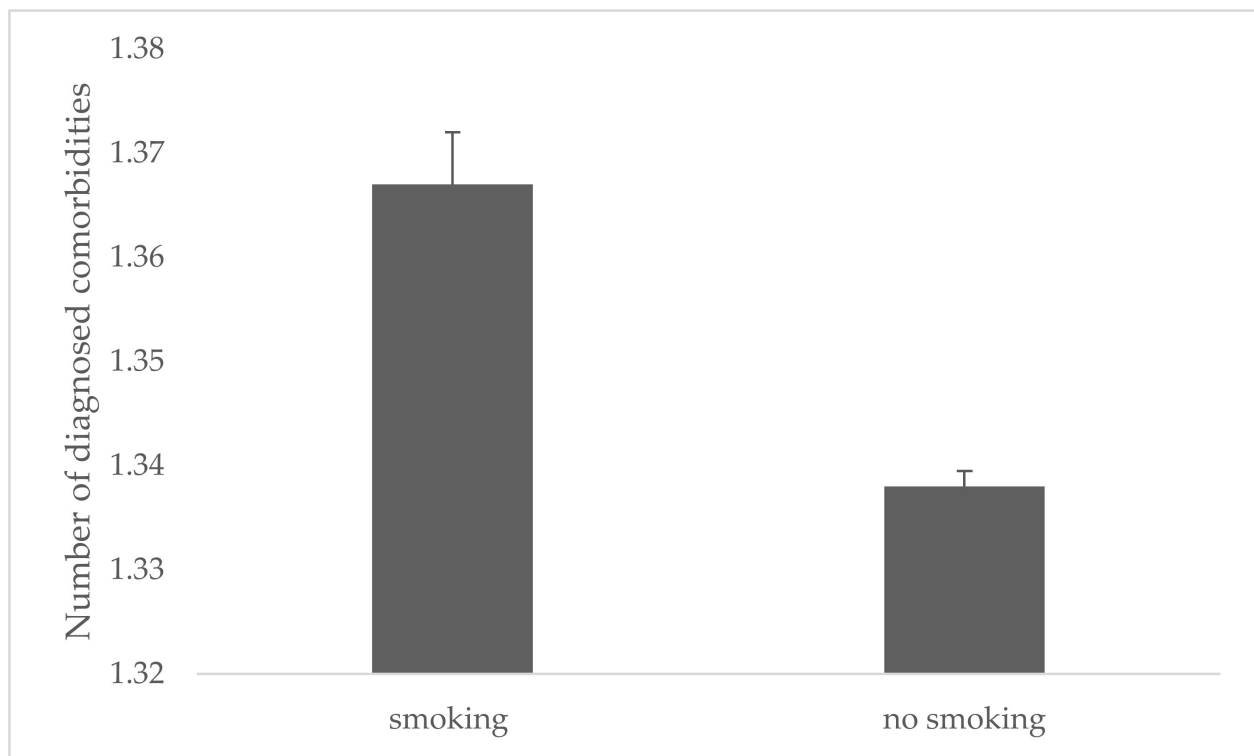


Figure 3. Number of diagnosed comorbidities in the group of people declaring or not smoking (with SD).

4. Discussion

In this study, we examined in detail the rates of smoking in Poland using data from 2016–2020. In general, irrespective of the year of measurement, 11.6% of women and 17.1% of men declared smoking. After sorting by year of measurement, we found that the percentage of female smokers was decreasing, while that of males remained relatively consistent. Clearly, the proportion of cigarette smokers in Poland remains high, it is lower than in other European countries [1,2]. In addition, we are very pleased with the delicate downward trend, which, in our opinion, requires intensive legislative changes to strengthen it, i.e., significantly lowering the percentage of active smokers in the group of professionally active Poles [33].

The relationship between smoking and obesity is not clear and published studies have produced conflicting results. Some studies showed no relationship between smoking and obesity, and some give quite different data based on the metabolic effects of nicotine (restricted absorption, reduced calorific intake, increased metabolic rate, and thermogenesis). The Mendelian randomization analysis of UK Biobank data indicated that each standard deviation increment in body mass index (4.6) increased the risk of being a smoker (odds ratio 1.18 (95% confidence interval 1.13 to 1.23), $p < 0.001$) [34–36].

In our study, it was clearly found that among tobacco smokers the percentage of people with normal body weight decreases with successive years of measurement, while the percentage of overweight and level I obesity increases. In our opinion, along with the increase in the number of obese patients, it is another factor contributing to the development of comorbidities in this group of patients [34,35].

The relationship between cigarette smoking and the occurrence of individual ICD-10 categories is obviously marked in the group of patients with cardiovascular diseases [37–40]. It is due to mechanisms, which we present in Figure 4.

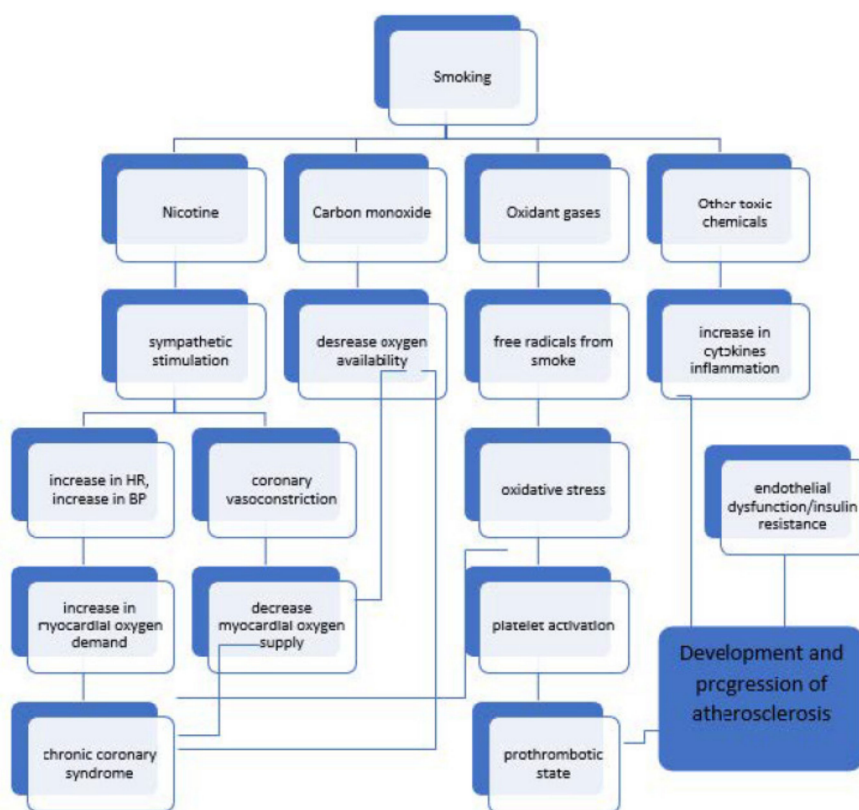


Figure 4. Pathophysiologic mechanisms of tobacco smoke in cardiovascular disease.

Moreover, it turned out that in the group of smokers a higher percentage of people with hypertension, ischemic heart disease, and type 2 diabetes was observed. therefore, in the largest Polish epidemiological study in the field of cigarette smoking, we are consistent with the results of international studies on cardiovascular risk [37–40]. Moreover, we confirmed that people who declared smoking cigarettes have significantly more diagnosed diseases as compared to people who do not smoke ($p < 0.001$)

5. Conclusions

Active preventive actions are necessary to reduce the number of smokers and the negative impact of smoking on the occurrence of comorbid diseases.

Author Contributions: Conceptualization, A.R., P.P. and J.D.-K.; Data curation, A.R. and I.P.; Formal analysis, I.P.; Investigation, A.R.; Methodology, I.P. and J.D.-K.; Project administration, I.P.; Supervision, J.D.-K.; Writing—original draft, I.P., W.L. and J.D.-K.; Writing—review & editing, J.D.-K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Conflicts of Interest: There is no conflict of interest (all Cases) Anna Rulkiewicz, Iwona Pilchowska and Justyna Domienik-Karłowicz are Lux med employees.

Appendix A. Additional Analyzes

The study included 1,450,455 visits to occupational medicine (collected from 931,985 unique Patients) from 2016–2020. The exact number of collected results depending on the year of measurement is presented below.

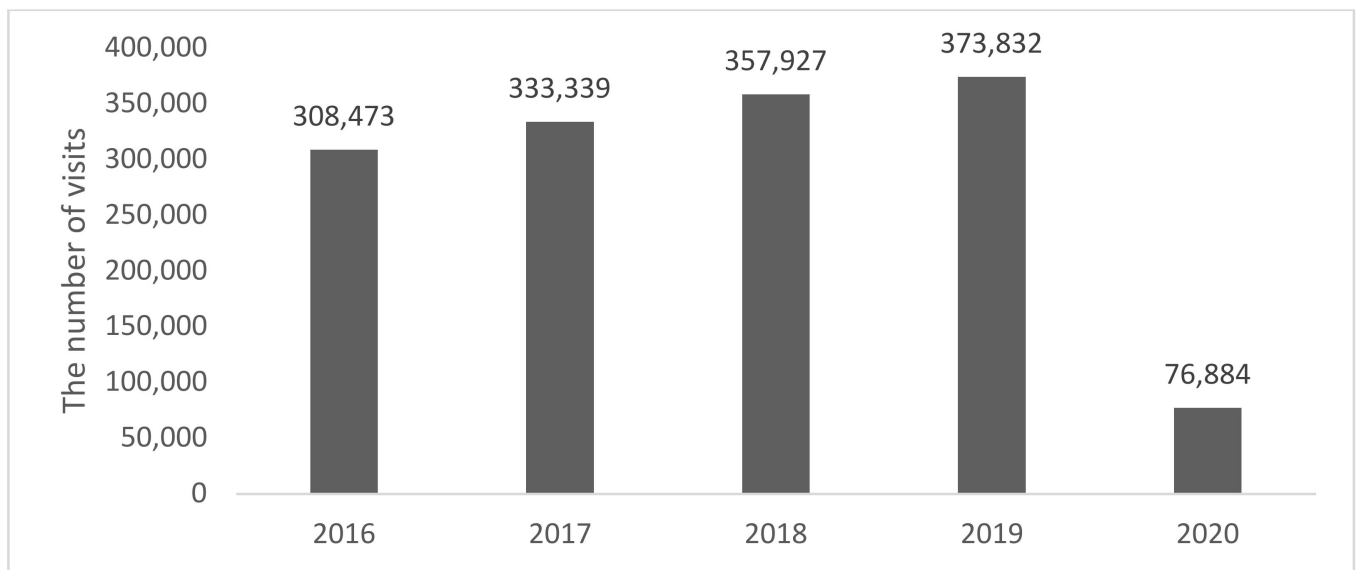


Figure A1. The number of visits analyzed versus the year of measurement.

In terms of sex, the results of men accounted for a slightly higher percentage (51.6%). Along with the successive stages of the study, the percentage of surveyed men slightly increased (see Figure A2).

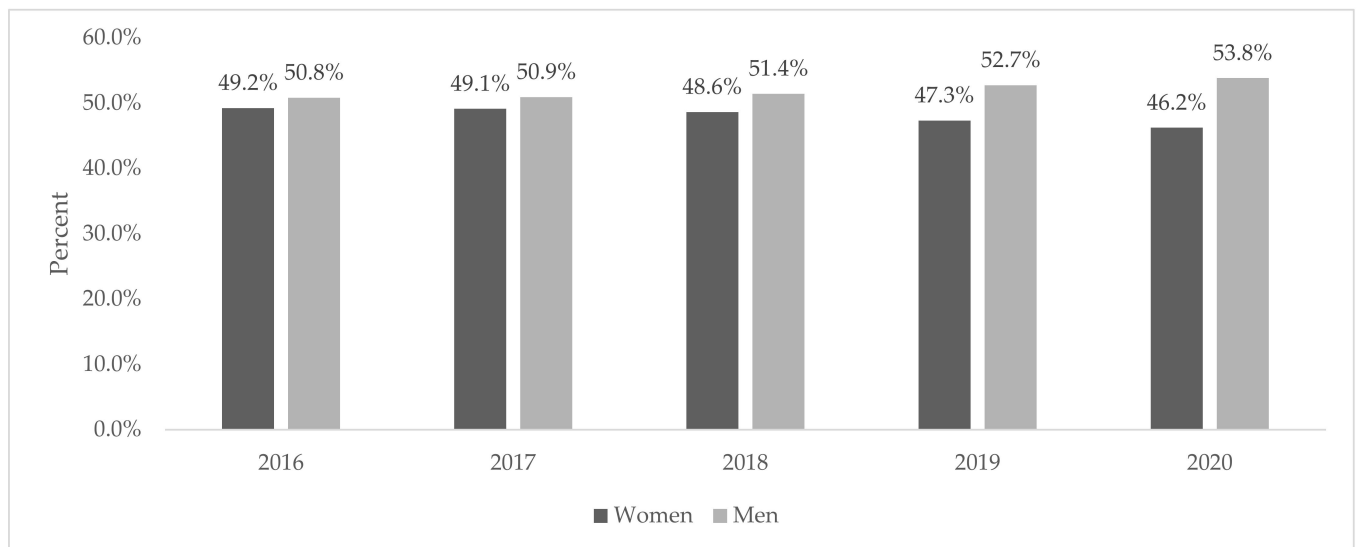


Figure A2. Sex distribution depending on the year of measurement (95% CI: $\pm 0.2\%$).

The age of the respondents ranged between 14 and 90 years ($M = 36.59$; $SD = 11.56$). A slight trend was observed indicating the mean age of the examined patients slightly increased with each year of measurement (see Figure A3). Clarification: patients can change age categories if their change in age necessitates this; this is not to be misinterpreted as a tautological restatement of the patients aging with time.

The exact distribution of age groups depending on the year of measurement is presented in the table below. It was found that with successive years of measurement, a decreased percentage of people aged 18–35 and an increased percentage in the age group 35–54 were observed; in the case of the remaining age groups, the trends were not as clear as in the case of these two age categories.

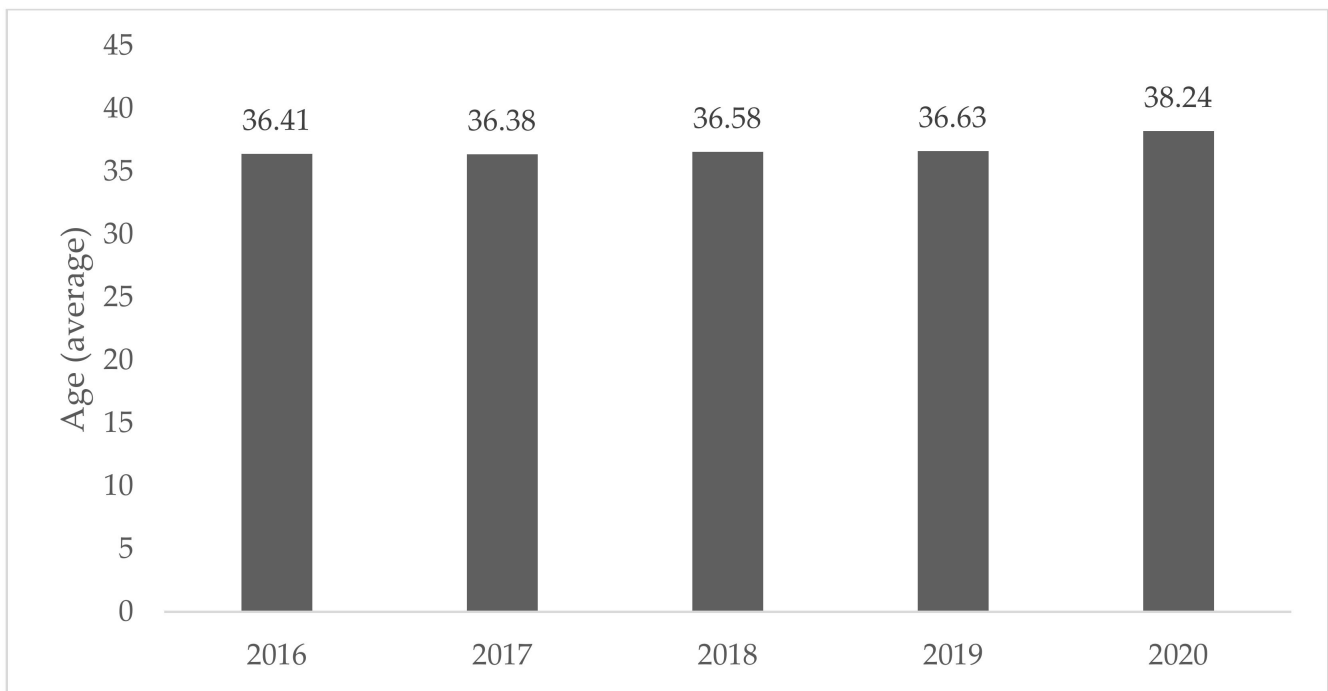


Figure A3. Patient age distribution versus the year of measurement.

Table A1. Distribution of age groups versus the year of measurement (with 95% CI).

	2016	2017	2018	2019	2020	Total
<18	0.0% (±0.1%)	0.0% (±0.1%)	0.1% (±0.1%)	0.1% (±0.1%)	0.0% (±0.2%)	0.1% (±0.2%)
18–35	54.5% (±0.2%)	54.3% (±0.3%)	53.3% (±0.2%)	52.5% (±0.2%)	46.8% (±0.2%)	53.2% (±0.2%)
35–54	35.7% (±0.2%)	35.8% (±0.2%)	36.7% (±0.2%)	37.6% (±0.2%)	41.9% (±0.3%)	36.8% (±0.2%)
55–69	9.6% (±0.1%)	9.7% (±0.1%)	9.8% (±0.1%)	9.7% (±0.1%)	11.1% (±0.1%)	9.8% (±0.1%)
>69	0.1% (±0.1%)	0.1% (±0.1%)	0.2% (±0.1%)	0.2% (±0.1%)	0.3% (±0.1%)	0.2% (±0.1%)
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

There were also no significant differences in terms of the distribution of the respondents by year of measurement and the voivodeship of residence (see Table A2).

Table A2. Distribution of voivodships depending on the year of measurement (with 95% CI).

	2016	2017	2018	2019	2020	Total
Lower Silesia	12.6% (±0.2%)	13.1% (±0.2%)	12.7% (±0.1%)	13.0% (±0.1%)	13.6% (±0.2%)	12.9% (±0.2%)
Kuyavian-Pomeranian	3.9% (±0.1%)	4.1% (±0.1%)	4.1% (±0.1%)	3.8% (±0.1%)	3.7% (±0.1%)	4.0% (±0.1%)
Lublin	0.9% (±0.1%)	0.9% (±0.1%)	0.9% (±0.1%)	0.8% (±0.1%)	0.7% (±0.1%)	0.8% (±0.1%)
Lubusz	1.4% (±0.1%)	1.4% (±0.1%)	1.5% (±0.1%)	1.6% (±0.1%)	1.9% (±0.1%)	1.5% (±0.1%)
Lodz	7.2% (±0.1%)	7.1% (±0.1%)	6.6% (±0.1%)	6.7% (±0.2%)	6.3% (±0.1%)	6.9% (±0.1%)

Table A2. Cont.

	2016	2017	2018	2019	2020	Total
Lesser	10.9% (±0.1%)	11.2% (±0.2%)	11.8% (±0.2%)	11.3% (±0.2%)	11.6% (±0.2%)	11.3% (±0.2%)
Mazowieckie	33.6% (±0.2%)	32.0% (±0.3%)	30.8% (±0.3%)	28.6% (±0.2%)	29.0% (±0.2%)	31.0% (±0.2%)
Opole	1.1% (±0.1%)	1.1% (±0.1%)	1.1% (±0.1%)	1.2% (±0.1%)	1.2% (±0.1%)	1.1% (±0.1%)
Subcarpathian	2.0% (±0.1%)	2.4% (±0.1%)	3.4% (±0.1%)	3.1% (±0.1%)	2.8% (±0.1%)	2.8% (±0.1%)
Podlasie	1.8% (±0.1%)	1.9% (±0.1%)	1.7% (±0.1%)	1.6% (±0.1%)	1.5% (±0.1%)	1.7% (±0.1%)
Pomeranian	6.2% (±0.1%)	6.3% (±0.1%)	6.8% (±0.2%)	7.3% (±0.1%)	6.5% (±0.1%)	6.7% (±0.1%)
Silesian	6.1% (±0.1%)	6.2% (±0.1%)	6.2% (±0.1%)	8.2% (±0.1%)	8.3% (±0.1%)	6.8% (±0.1%)
Świętokrzyskie	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)
Warmia-Masurian	2.1% (±0.1%)	1.9% (±0.1%)	2.0% (±0.1%)	2.1% (±0.1%)	2.1% (±0.1%)	2.0% (±0.1%)
Greater	7.0% (±0.2%)	6.8% (±0.2%)	6.7% (±0.3%)	6.4% (±0.2%)	6.7% (±0.2%)	6.7% (±0.2%)
West Pomeranian	2.6% (±0.1%)	3.0% (±0.1%)	3.0% (±0.1%)	3.5% (±0.1%)	3.5% (±0.1%)	3.1% (±0.1%)
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

References

- World Health Organization. Tobacco Control Country Profiles. 2014. Available online: http://www.who.int/tobacco/surveillance/policy/country_profile/en/ (accessed on 1 February 2022).
- Marcon, A.; Pesce, G.; Calciano, L.; Bellisario, V.; Dharmage, S.C.; Garcia-Aymerich, J.; Gislason, T.; Heinrich, J.; Holm, M.; Janson, C.; et al. Trends in smoking initiation in Europe over 40 years: A retrospective cohort study. *PLoS ONE* **2018**, *13*, e0201881. [CrossRef] [PubMed]
- GBD 2015 SDG Collaborators. Measuring the health-related Sustainable Development Goals in 188 countries: A baseline analysis from the Global Burden of Disease Study 2015. *Lancet* **2016**, *388*, 1813–1850. [CrossRef]
- Hoffman, S.J.; Tan, C. Overview of systematic reviews on the health-related effects of government tobacco control policies. *BMC Public Health* **2015**, *15*, 744. [CrossRef] [PubMed]
- World Health Organization (WHO). *WHO Report on the Global Tobacco Epidemic, 2017: Monitoring Tobacco Use and Prevention Policies*; World Health Organization: Geneva, Switzerland, 2017.
- Eurobarometer, Special Report 429 (EB82.4): Attitudes of Europeans towards Tobacco and Electronic Cigarettes*; European Commission: Brussels, Belgium, 2021. Available online: <https://europa.eu/eurobarometer/surveys/detail/2240> (accessed on 1 February 2022).
- World Health Organization. Tobacco. 2015. Available online: <http://www.who.int/me-diacentre/factsheets/fs339/en/> (accessed on 22 July 2020).
- Mlinaric, A.; Popovic Grle, S.; Nadalin, S.; Skurla, B.; Munivrana, H.; Milosevic, M. Passive smoking and respiratory allergies in adolescents. *Eur. Rev. Med. Pharmacol. Sci.* **2011**, *15*, 973–977. [PubMed]
- Svanes, C.; Koplun, J.; Skulstad, S.M.; Johannessen, A.; Bertelsen, R.J.; Benediktsdottir, B.; Bråbäck, L.; Elie Carsin, A.; Dharmage, S.; Dratva, J.; et al. Father's environment before conception and asthma risk in his children: A multi-generation analysis of the Respiratory Health In Northern Europe study. *Int. J. Epidemiol.* **2017**, *46*, 235–245. [CrossRef]
- Northstone, K.; Golding, J.; Davey Smith, G.; Miller, L.L.; Pembrey, M. Prepubertal start of father's smoking and increased body fat in his sons: Further characterisation of paternal transgenerational responses. *Eur. J. Hum. Genet.* **2014**, *22*, 1382–1386. [CrossRef]
- Accordini, S.; Calciano, L.; Johannessen, A.; Portas, L.; Benediktsdóttir, B.; Bertelsen, R.J.; Bråbäck, L.; Carsin, A.E.; Dharmage, S.C.; Dratva, J.; et al. A three-generation study on the association of tobacco smoking with asthma. *Int. J. Epidemiol.* **2018**, *47*, 1106–1117. [CrossRef]

12. Centers for Disease Control and Prevention (US); National Center for Chronic Disease Prevention and Health Promotion (US); Office on Smoking and Health (US). *How Tobacco Smoke Causes Disease: The Biology and Behavioral Basis for Smoking-Attributable Disease: A Report of the Surgeon General*; Publications and Reports of the Surgeon General; Centers for Disease Control and Prevention (US): Atlanta, GA, USA, 2010.
13. Warner, K.E.; Burns, D.M. Hardening and the hard-coresmoker: Concepts, evidence, and implications. *Nicotine Tob. Res.* **2003**, *5*, 37–48. [[CrossRef](#)]
14. Hughes, J.R. The hardening hypothesis: Is the ability to quit decreasing due to increasing nicotine dependence? A review and commentary. *Drug Alcohol Depend.* **2011**, *117*, 111–117. [[CrossRef](#)]
15. Baker, C.L.; Flores, N.M.; Zou, K.H.; Bruno, M.; Harrison, V.J. Benefits of quitting smoking on work productivity and activity impairment in the United States, the European Union and China. *Int. J. Clin. Pract.* **2017**, *71*, e12900. [[CrossRef](#)]
16. Halpern, M.T.; Shikar, R.; Rentz, A.M.; Khan, Z.M. Impact of smoking status on workplace absenteeism and productivity. *Tob. Control* **2001**, *10*, 233–238. [[CrossRef](#)] [[PubMed](#)]
17. Berman, M.; Crane, R.; Seiber, E.; Munur, M. Estimating the cost of a smoking employee. *Tob. Control* **2014**, *23*, 428–433. [[CrossRef](#)]
18. Bunn, W.B., 3rd; Stave, G.M.; Downs, K.E.; Alvir, J.M.; Dirani, R. Effect of smoking status on productivity loss. *J. Occup. Environ. Med.* **2006**, *48*, 1099–1108. [[CrossRef](#)] [[PubMed](#)]
19. Robroek, S.J.; van den Berg, T.I.; Plat, J.F.; Burdorf, A. The role of obesity and lifestyle behaviours in a productive workforce. *Occup. Environ. Med.* **2011**, *68*, 134–139. [[CrossRef](#)] [[PubMed](#)]
20. Wegner, C.; Gutsch, A.; Hessel, F.; Wasem, J. Smoking-attributable productivity loss in Germany—A partial sickness cost study based on the human capital potential method. *Gesundheitswesen* **2004**, *66*, 423–432. [[CrossRef](#)]
21. Yu, J.; Wang, S.; Yu, X. Health risk factors associated with presenteeism in a Chinese enterprise. *Occup. Med.* **2015**, *65*, 732–738. [[CrossRef](#)]
22. US Department of Health and Human Services (USDHHS). The health consequences of smoking—50 years of progress. In *A Report of the Surgeon General*; US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health: Atlanta, GA, USA, 2014. Available online: <http://www.surgeongeneral.gov/library/reports/50-years-of-progress/> (accessed on 1 February 2022).
23. Connolly, M.J. Smoking cessation in old age: Closing the stable door? *Age Ageing* **2000**, *29*, 193–195. [[CrossRef](#)]
24. La Croix, A.Z.; Lang, J.; Scherr, P.; Wallace, R.B.; Cornoni-Huntley, J.; Berkman, L.; Curb, J.D.; Evans, D.; Hennekens, C.H. Smoking and mortality among older men and women in three communities. *N. Engl. J. Med.* **1991**, *324*, 1619–1625. [[CrossRef](#)]
25. Friedman, R.J.; Sengupta, N.; Lees, M. Economic impact of venous thromboembolism after hip and knee arthroplasty: Potential impact of rivaroxaban. *Expert Rev. Pharmacoecon. Outcomes Res.* **2011**, *11*, 299–306. [[CrossRef](#)]
26. Rasmussen, S.R.; Prescott, E.; Sorensen, T.I.; Sogaard, J. The total life-time health cost savings of smoking cessation to society. *Eur. J. Public Health* **2005**, *15*, 601–606. [[CrossRef](#)]
27. Hill, S.; Amos, A.; Clifford, D.; Platt, S. Impact of tobacco control interventions on socioeconomic inequalities in smoking: Review of the evidence. *Tob. Control* **2014**, *23*, e89–e97. [[CrossRef](#)] [[PubMed](#)]
28. Kostova, D.; Ross, H.; Blecher, E.; Markowitz, S. Is youth smoking responsive to cigarette prices? Evidence from low- and middle-income countries. *Tob. Control* **2011**, *20*, 419–424. [[CrossRef](#)] [[PubMed](#)]
29. Hanewinkel, R.; Isensee, B.; Sargent, J.D.; Morgenstern, M. Cigarette advertising and teen smoking initiation. *Pediatrics* **2011**, *127*, e271–8. [[CrossRef](#)] [[PubMed](#)]
30. Serrano-Alarcón, M.; Kunst, A.E.; Bosdriesz, J.R.; Perelman, J. Tobacco control policies and smoking among older adults: A longitudinal analysis of 10 European countries. *Addiction* **2019**, *114*, 1076–1085. [[CrossRef](#)]
31. Fitch, K.; Iwasaki, K.; Pyenson, B. Covering Smoking Cessation as a Health Benefit: A Case for Employers. 2006. Available online: <http://www.dfwbgh.org/events07/9-27-2007.pdf> (accessed on 1 February 2022).
32. Jackson, K.C., 2nd; Nahoopii, R.; Said, Q.; Dirani, R.; Brixner, D. An employer-based cost-benefit analysis of a novel pharmacotherapy agent for smoking cessation. *J. Occup. Environ. Med.* **2007**, *49*, 453–460. [[CrossRef](#)] [[PubMed](#)]
33. Bala, M.M.; Strzeszynski, L.; Topor-Madry, R. Mass media interventions for smoking cessation in adults. *Cochrane Database Syst. Rev.* **2017**, *11*, CD004704. [[CrossRef](#)]
34. Carreras-Torres, R.; Johansson, M.; Haycock, P.C.; Relton, C.L.; Davey Smith, G.; Brennan, P.; Martin, R.M. Role of obesity in smoking behaviour: Mendelian randomisation study in UK Biobank. *BMJ* **2018**, *361*, k1767. [[CrossRef](#)] [[PubMed](#)]
35. Dare, S.; Mackay, D.F.; Pell, J.P. Relationship between smoking and obesity: A cross-sectional study of 499,504 middle-aged adults in the UK general population. *PLoS ONE* **2015**, *10*, e0123579. [[CrossRef](#)]
36. Chiolero, A.; Faeh, D.; Paccaud, F.; Cornuz, J. Consequences of smoking for body weight, body fat distribution, and insulin resistance. *Am. J. Clin. Nutr. United States* **2008**, *87*, 801–809. [[CrossRef](#)]
37. GBD 2016 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: A systematic analysis for the Global Burden of Disease Study 2016. *Lancet* **2017**, *390*, 1151–1210. [[CrossRef](#)]
38. GBD 2016 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. *Lancet* **2017**, *390*, 1345–1422. [[CrossRef](#)]

39. Doll, R.; Peto, R.; Boreham, J.; Sutherland, I. Mortality in relation to smoking: 50 years' observations on male British doctors. *BMJ* **2004**, *328*, 1519. [[CrossRef](#)] [[PubMed](#)]
40. Thun, M.J.; Carter, B.D.; Feskanich, D.; Freedman, N.D.; Prentice, R.; Lopez, A.D.; Hartge, P.; Gapstur, S.M. 50-year trends in smoking-related mortality in the United States. *N. Engl. J. Med.* **2013**, *368*, 351–364. [[CrossRef](#)] [[PubMed](#)]

This is a provisional PDF only. Copyedited and fully formatted version will be made available soon.



CARDIOLOGY
JOURNAL

ISSN: 1897-5593
e-ISSN: 1898-018X

Beyond ChatGPT: What does GPT-4 add to healthcare? The dawn of a new era

Authors: Simona Wójcik, Anna Rulkiewicz, Piotr Pruszczyk, Wojciech Lisik, Marcin Poboży, Justyna Domienik-Karłowicz

DOI: 10.5603/cj.97515

Article type: Invited Review Article

Submitted: 2023-09-20

Accepted: 2023-10-03

Published online: 2023-10-12

This article has been peer reviewed and published immediately upon acceptance. It is an open access article, which means that it can be downloaded, printed, and distributed freely, provided the work is properly cited. Articles in "Cardiology Journal" are listed in PubMed.

Beyond ChatGPT: What does GPT-4 add to healthcare? The dawn of a new era

Simona Wójcik et al., Artificial intelligence in healthcare

Simona Wójcik^{1*}, Anna Rulkiewicz^{1*}, Piotr Pruszczyk², Wojciech Lisik³, Marcin Poboży⁴,
Justyna Domienik-Karłowicz^{1,2}

¹LUX MED Llc, Warsaw, Poland

²Department of Internal Medicine and Cardiology with The Center for Diagnosis and Treatment of Thromboembolism, Medical University of Warsaw, Poland

³Department of General and Transplantation Surgery, Medical University of Warsaw, Poland

⁴Cichowski Pobozy Healthcare Facility, Maciejowice, Poland

Address for correspondence: Justyna Domienik-Karłowicz, MD, Lindley'a 4, 00-005
Warszawa, Poland, tel: +48 22 502 11 44, fax: +48 22 502 13 63, e-mail: jdomienik@tlen.pl

**Equal contribution*

Abstract

Over the past few years, artificial intelligence (AI) has significantly improved healthcare. Once the stuff of science fiction, AI is now widely used, even in our daily lives — often without us thinking about it. All healthcare professionals — especially executives and medical doctors — need to understand the capabilities of advanced AI tools and other breakthrough innovations. This understanding will allow them to recognize opportunities and threats emerging technologies can bring to their organizations. We hope to contribute to a meaningful public discussion about the role of this new type of AI and how our approach to healthcare and medicine can best evolve with the rapid development of this technology.

Since medicine learns by example, only a few possible uses of AI in medicine are provided, which merely outline the system's capabilities.

Among the examples, it is worth highlighting the roles of AI in medical notes, education, preventive programs, consultation, triage and intervention.

It is believed by the authors that large language models such as chat generative pre-trained transformer (ChatGPT) are reaching a level of maturity that will soon impact clinical medicine as a whole and improve the delivery of individualized, compassionate, and scalable healthcare. It is unlikely that AI will replace physicians in the near future. The human aspects of care, including empathy, compassion, critical thinking, and complex decision-making, are invaluable in providing holistic patient care beyond diagnosis and treatment decisions. The GPT-4 has many limitations and cannot replace direct contact between an experienced physician and a patient for even the most seemingly simple consultations, not to mention the ethical and legal aspects of responsibility for diagnosis.

Keywords: ChatGPT, innovations, artificial intelligence, AI in medicine, health IT

Introduction

Over the past few years, artificial intelligence (AI) has significantly improved healthcare. What was once a concept relegated to the realms of science fiction is now a common feature in our everyday existence, seamlessly integrating without our conscious acknowledgment. However, it was only a short while ago that AI could not understand the content. AI could read and write, but it lacked the next level of intelligence that comes from understanding. With chat generative pre-trained transformer (ChatGPT), that next level has been truly unlocked. Major technology companies are in a competitive race to integrate technology, especially LLMs, into their products and services. One of the most well-known AI-driven tools is ChatGPT, a natural language processing model crafted by OpenAI. OpenAI, with support from Microsoft, is developing some increasingly powerful AI systems, GPT-4 the most sophisticated among them, has been openly available since March 2023.

ChatGPT uses a neural transformer network to process and generate text independently. In this way, it can answer users' questions and interact with them via chat, using natural language and trying to provide coherent and relevant answers to their questions. LLMs have demonstrated remarkable capabilities in natural language understanding and generation across various fields, including medicine. We anticipate that GPT-4 might soon be eclipsed by more potent and adept AI entities, marking the ascendancy of a new echelon of

machines characterized by enhanced power and intelligence [3]. Given its potential, the tool immediately underwent extensive testing. The prompt can be presented as a question and as an instruction for a specific task, e.g., “Please read and summarize this article on medical research” or “Please read and summarize the last European Society of Cardiology guidelines on Arterial Hypertension”. Furthermore, prompts are not limited to English sentences; they can be written in various human languages and include inputs such as spreadsheets, technical outlines, academic journals, and complex mathematical formulations [1].

The potential applications of LLM in education, research, and healthcare can be promising if the essential issues involved are proactively explored and addressed. Few industries are as data-rich and text-heavy and have as high a critical need for automation as healthcare. In addition to these characteristics, an acute information asymmetry exists for both patients and clinicians alike; patients want to be better informed about their condition, and clinical teams crave more up-to-date, easily accessible insights about their patients and populations to better inform them about the healthcare they deliver. In this context, AI can provide comprehensive and accurate medical advice and information from multiple independent sources to better inform and educate patients about their conditions or symptoms.

All healthcare professionals — especially executives and medical doctors, should grasp the potential of advanced AI tools and other breakthrough innovations. Hence, they know what opportunities and threats emerging technologies can bring to their organizations. We hope to contribute to a meaningful public discussion about this new form of AI and discuss how healthcare and medicine can adapt to keep pace with the swift advancements in this technology. The key values are presented in the Central Illustration.

How can AI bring greater value to the broader healthcare system and support clinical practice?

The goal in this study is to highlight AI’s potential applications and limitations in healthcare and cardiology, used efficiently in two main streams: IT and robots. The first stream allows for improved control of service management systems health such as electronic medical records and is also used in software used to analyze medical images such as angiography, echocardiography, computer tomography, magnetic resonance imaging of the heart, endovascular ultrasonography, and technologies such as machine learning, deep learning, and natural language processing such as in automated support systems’ clinical

decisions. The second stream (robotic) is used in interventional cardiology to perform percutaneous coronary artery procedures. An interventional cardiologist can control the device from a separate room, eliminating the need to wear heavy protective clothing and reducing risks of radiation exposure and orthopedic injuries [1].

Since the field of medicine often advances through real-world examples, only a few examples of possible uses of AI in medicine are provided, which merely outlines the system's capabilities.

Example 1: Medical notes

ChatGPT can help medical professionals in composing and documenting medical records, including clinical notes and discharge reports, by offering real-time suggestions and adjustments [2]. In March 2023, Nuance Communications, a part of Microsoft, unveiled its latest speech-enabled medical writing application integrated with GPT-4. The new application aims to leverage Nuance's ability to capture, analyze, and distill the content of physician visits with patients to reduce physician workload, particularly administrative tasks and paperwork. A study by the American Medical Association found that for every hour physicians spend on patient visits, they spend nearly 2 hours on electronic medical records and desk work during work hours. In the proposed implementation of this feature, once the patient gives consent, GPT-4 captures the transcript and processes the conversation between the doctor and patient in a manner similar to today's "smart speakers".

After the session, the software creates a note at the provider's request. GPT-4 can make notes in several formats and automatically insert the appropriate billing codes. In addition to notes, GPT-4 can also answer questions about the consultation, extract information about prior authorizations, create lab orders and prescriptions, or write post-visit summaries and provide critical feedback to the physician and patient [2]. In a proposed use of this feature, after the patient gives consent, GPT-4 would obtain the transcript by listening to the doctor-patient encounter like today's "smart speakers" do. After the meeting, the software would generate the transcript at the doctor's request. GPT-4 can create notes in familiar formats, such as SOAP (subjective, objective, assessment, and plan), and automatically insert appropriate billing codes. Beyond the findings, GPT-4 can answer questions about the exam, extract pre-authorization information, generate lab and prescription orders that meet Health

Level Seven Fast Healthcare Interoperability Resources standards, generate post-exam summaries, and provide critical feedback to the physician and patient.

Example 2: Education

Moreover, ChatGPT-4 has the potential to improve medical education. The system could provide medical professionals and students with instant access to the medical information and resources they need for their development.

ChatGPT demonstrated its proficiency when tasked with answering a series of questions typically found on the standardized tests that United States universities administer for medical licensure. A collective of researchers from multiple American universities conducted an experiment tasked with answering a series of questions on the standard tests that United States universities use to grant or deny licensure to practice medicine, ChatGPT proved more than capable of passing the exam. A collective of researchers from multiple American universities conducted an experiment where ChatGPT was subjected to the United States Medical Licensing Examination (USMLE) without any specific preparation tutoring. The exam consists of three sections with questions covering most medical subjects, from biochemistry to diagnostic reasoning to bioethics. Before the test, the researchers reviewed the questions and deleted those related to interpreting radiological and other images (which requires specialized training), leaving 350 out of 376 questions. As detailed in PLoS Digital Health, ChatGPT's performance was commendable, securing between 52.4% and 75% accurate responses.

With an average passing rate hovering around 60%, the chances of success for the AI system would be very high. In addition, ChatGPT had an unusually high percentage of coherent responses — 94.6%. No answers contradicted each other, and in 88.9% of its solutions, it offered explanations that were not trivial or obvious, revealing some intuition [4]. It is worth noting that a similar system developed by the world's largest database of scientific publications, PubMed (PubMedGPT), could only answer up to 50% of the answers correctly in the same USMLE exam, far behind ChatGPT. ChatGPT also allows for summarizing the published scientific data to keep clinicians informed.

Inspired by the remarkable performance of ChatGPT on the USMLE, a similar experiment was conducted on the equivalent exam in Poland, the LEK (note: prompts were given in Polish). According to Polish law, to obtain full qualifications allowing access to

practice the profession of a physician/dentist in Poland, the holder of the *Lekarz* (MD) or *Lekarz Dentysta* (DMD) degree diploma has to pass the Medical/Dental Final Examination — LEK/LDEK, which is organized and carried out by the Medical Examination Center in Lodz. A typical LEK problem (question statistics: 66.7% correct answers), along with the ChatGPT-4 response (shown in Figure 1), where ChatGPT-4 explains its reasoning, refers to known medical facts, highlights causal correlations, references and literature, excludes other proposed responses and furnishes persuasive reasoning to support its selected response. For the more difficult questions on the LEK exam, illustrated in Figure 2, GPT-4 also showed a high success rate, with only 41.6% of students marking the correct answer, which confirms ChatGPT-4's ability to assist the human learning process of its target audience.

ChatGPT must be continuously fed with the most current publications for maximum effectiveness. This practical application of the tool would benefit the clinician and the healthcare system while avoiding the risk of AI making the final clinical decisions, as trust in this area is intangible. This medical knowledge makes GPT-4 potentially valuable for the clinical setting and academic research. GPT-4 can digest medical research and discuss its contents, offering summaries, analyzing data, referencing past studies, assessing findings, and suggesting areas for future research [6].

This artificial intelligence system has also shown that it has excellent potential to help students train and prepare so that they can use it to study for exams and enhance their knowledge. The authors of the present study employed ChatGPT to refine the initial draft of the article, ensuring logical coherence and clarifying ambiguous sections.

Example 3: Medical consultation

For typical initial medical consultations, including information about a patient's presentation or summaries of laboratory test results, GPT-4 provides valuable answers that can help the physician who makes a request to resolve an issue. Because of the interactive nature of the system, the user can clarify the solutions by asking for more specifics or by requesting more concise answers to get "to the point" more quickly [3]. ChatGPT can also provide instantaneous translation services to bridge the communication gap between patients and healthcare professionals. Thanks to its advanced language processing skills, ChatGPT is adept at swiftly and precisely translating complex medical terminology, technical phrases, and everyday language. This ensures patients are well-informed about their diagnoses, available treatment alternatives, and directions for medication. ChatGPT is already being used in some

United States hospitals to transcribe more complex reports so patients can better understand the results of an exam, diagnosis, or treatment.

Limited literacy skills are among the strongest predictors of poor patient health outcomes. As communication barriers may go undetected in healthcare settings and can have severe effects on the health and safety of patients, ChatGPT-4 abilities in this area were tested. Figure 3 presents an example of how ChatGPT-4 can simplify and visually explain medical jargon to patients.

GPT-4's wealth of medical knowledge is beneficial not just in patient care but also for research purposes. It can delve into medical studies, offer informed perspectives, summarize key points, perform technical analyses, reference related works, evaluate the findings, and suggest areas for additional research.

Example 4: Patient triage

ChatGPT can be employed for patient triage, where it queries patients about their symptoms and medical history, helping to assess the severity and urgency of their condition. AI will likely support medical practice by helping physicians use technology to improve clinical care. Technology will not replace human intelligence but will complement it [9].

Example 5: Virtual assistants

ChatGPT has the potential to create a virtual assistant to help patients make appointments, receive treatment, and manage their health records. With the rise in telemedicine popularity, an increasing number of patients are opting for treatments within the comfort of their home.. A virtual assistant powered by ChatGPT can offer the necessary guidance and assistance for patients to effectively oversee their health from a distance. The virtual assistant can provide accurate and precise answers without being burdened by human emotions or adverse reactions to stressful situations [9].

Example 6. Clinical use

Back to the topic of robotic AI, the significance of R-One can hardly be overstated. This robotic percutaneous coronary intervention (PCI) system is engineered to diminish

radiation exposure to the operator, enhance ergonomics, and ensure precise navigation and delivery of guidewires/devices during PCI procedures [10]. The European multicentre R-EVOLUTION study, which was prospective in nature, involved patients experiencing de novo coronary artery stenosis (with a length of < 38 mm and reference diameter between 2.5–4.0 mm) who were undergoing the process of stent implantation. Researchers made a distinction between clinical and technical achievement. The former referred to the lack of significant complications during the procedure, while the latter related to the successful maneuvering and removal of all PCI tools (like guidewires, balloons, and stents) without fully manual adjustments. The R-EVOLUTION research encompassed 62 ongoing patients (with B2/C lesions making up 25.0% or 16 out of 64) who underwent robotic PCI. The primary method of access was radial, utilized in 96.8% or 60 out of the 62 operations. The average duration for the robotic procedure was approximately 19.9 ± 9.6 minutes, and the average time for fluoroscopy was around 10.3 ± 5.4 minutes. It is worth noticing that clinical success was 100%, and technical success was 95.2% (59/62). Exposure to radiation for the operator decreased by 84.5% beneath and 77.1% above the lead apron when contrasted with doses noted on the patient table. The R-Evolution research deems the robotic PCI with R-One to be a reliable and efficient instrument, significantly minimizing radiation contact for the user [10].

ChatGPT could assist in the global obesity pandemic by offering personalized dietary and exercise advice based on individual user inputs and current scientific guidelines. By analyzing vast amounts of research data, ChatGPT can provide up-to-date information on effective obesity prevention and treatment strategies to both healthcare professionals and the public. Through interactive sessions, ChatGPT can motivate and educate individuals about the importance of lifestyle changes, helping to track progress and set realistic goals. For healthcare professionals, ChatGPT can serve as a tool to quickly access the latest research on obesity-related diseases, ensuring that patients receive evidence-based care. ChatGPT could be integrated into telemedicine platforms, allowing patients struggling with obesity to have consistent access to guidance and support, regardless of their geographical location.

Chat GPT is designated as an innovative tool in the field of education and raising awareness about the dangers of smoking. Its ability to provide accurate information in real-time can serve as a platform for educating people about the health effects associated with smoking. Through interactive sessions, ChatGPT has the potential to motivate smokers to quit the habit. In the digital age, such technologies can become a key component of public health strategies aimed at reducing smoking.

Discussion

The most critical point is that GPT-4 is not an end but opens the door to new opportunities and threats. GPT-4 and similar AI systems have enormous potential in medicine, but their use should be approached with caution and consideration of the limitations and risks involved.

Thus, while this new multimodal model is impressive, much room exists for improvement. Like every other pre-trained model before it, GPT-4 is limited by its training data, and the question of what constitutes acceptable overall AI performance still needs to be answered. How should the general intelligence of a tool like GPT-4 be evaluated? To what extent can users 'trust' GPT-4, or must they take the time to verify its accuracy? Despite its enormous potential, critical ethical issues cannot be ignored when discussing ChatGPT. The emergence of ChatGPT and similar advanced AI technologies marks a pivotal moment in the evolution of AI. It becomes crucial to deliberate on the ethical and safe deployment of these progressively intelligent and potent tools. Other ethical issues must be considered when implementing AI tools in the medical community. The most important cases for healthcare involve privacy and security. When using ChatGPT, users give it data; that data is often confidential patient information in healthcare. This has massive privacy implications, as systems must be in place to ensure the confidentiality of patient data before ChatGPT can be widely used in healthcare. In addition, there is a risk that patients will unknowingly trust that the system is 100% accurate at all times due to the incredible capabilities of ChatGPT. ChatGPT is better suited as a supportive tool rather than a complete solution, and all work and information it provides must be verified. In the event of an error, the AI-generated information provided by ChatGPT could affect a person's health; therefore, extreme caution should be exercised [2]. In clinical medicine and medical ethics, the patient-physician relationship is crucially based on a solid ethical and legal framework. Physicians take the Hippocratic Oath at the beginning of their careers, on the first day of medical school, which commits them to patient welfare and confidentiality. These two crucial dogmas of the medical code are most affected by AI when it comes to protecting patient data and misdiagnosis. Introducing artificial intelligence leads to a complex relationship between physician and patient and AI. It is difficult to determine whether the third actor in this extended relationship is the human behind the code or the AI itself, triggering a profound debate about liability [3].

Addressing ethical, regulatory, and policy issues is crucial when designing, implementing, and incorporating AI applications and system components. Due to usability and safety concerns, new applications must meet the same standards as other medical technologies. This requires a similar level of rigor in testing as in other areas of medicine [6].

In essence, ChatGPT holds the promise to refine and enhance healthcare delivery significantly. It is poised for broad acceptance, and is expected to instigate transformative changes akin to the impact the internet has made on the industry. Nonetheless, the deployment of such technology should be judicious, with healthcare decisions firmly rooted in the expertise of qualified healthcare professionals.

Conclusions

It is believed herein, that LLMs such as ChatGPT are reaching a level of maturity that will soon impact clinical medicine as a whole and improve the delivery of individualized, compassionate, and scalable healthcare. It is unlikely that AI will replace physicians in the near future. The human aspects of care, including empathy, compassion, critical thinking, and complex decision-making, are invaluable in providing holistic patient care beyond diagnosis and treatment decisions. ChatGPT-4 has many limitations and cannot replace direct contact between an experienced physician and a patient for even the most seemingly simple consultations, not to mention the ethical and legal aspects of responsibility for diagnosis. In conclusion, half-jokingly, half seriously, chatbots, algorithms, and AI will not replace the doctor but will remain a great tool in his hands as long as the laws of robotics cannot be effectively extended to the Hippocratic Oath.

Conflict of interest: None declared

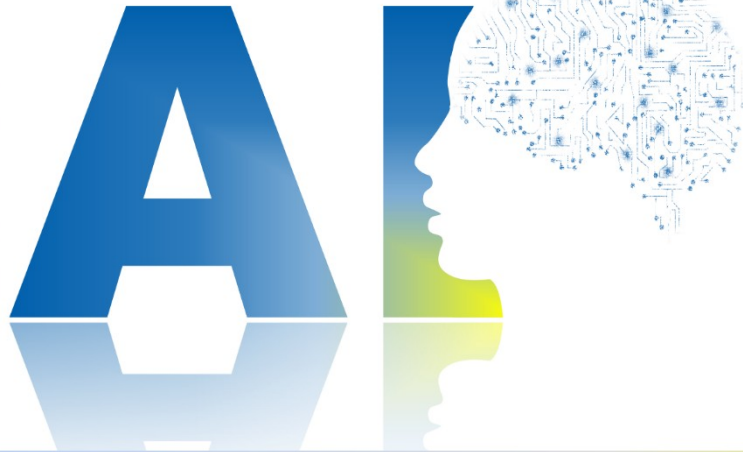
References

1. Johnson KW, Torres Soto J, Glicksberg BS, et al. Artificial Intelligence in Cardiology. *J Am Coll Cardiol.* 2018; 71(23): 2668–2679, doi: [10.1016/j.jacc.2018.03.521](https://doi.org/10.1016/j.jacc.2018.03.521), indexed in Pubmed: [29880128](https://pubmed.ncbi.nlm.nih.gov/29880128/).

2. Lee P, Bubeck S, Petro J. Benefits, limits, and risks of GPT-4 as an AI chatbot for medicine. *N Engl J Med*. 2023; 388(13): 1233–1239, doi: [10.1056/NEJMsr2214184](https://doi.org/10.1056/NEJMsr2214184), indexed in Pubmed: [36988602](https://pubmed.ncbi.nlm.nih.gov/36988602/).
3. Waisberg E, Ong J, Paladugu P, et al. Challenges of artificial intelligence in space medicine. *Space: Sci Technol*. 2022; 2022, doi: [10.34133/2022/9852872](https://doi.org/10.34133/2022/9852872).
4. Haug CJ, Drazen JM. Artificial intelligence and machine learning in clinical medicine, 2023. *N Engl J Med*. 2023; 388(13): 1201–1208, doi: [10.1056/NEJMra2302038](https://doi.org/10.1056/NEJMra2302038), indexed in Pubmed: [36988595](https://pubmed.ncbi.nlm.nih.gov/36988595/).
5. Kung TH, Cheatham M, Medenilla A, et al. Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models. *PLOS Digit Health*. 2023; 2(2): e0000198, doi: [10.1371/journal.pdig.0000198](https://doi.org/10.1371/journal.pdig.0000198), indexed in Pubmed: [36812645](https://pubmed.ncbi.nlm.nih.gov/36812645/).
6. Beam AL, Drazen JM, Kohane IS, et al. Artificial Intelligence in Medicine. *N Engl J Med*. 2023; 388(13): 1220–1221, doi: [10.1056/NEJMe2206291](https://doi.org/10.1056/NEJMe2206291), indexed in Pubmed: [36988598](https://pubmed.ncbi.nlm.nih.gov/36988598/).
7. <https://www.ibsafoundation.org/en/blog/chatgpt-passes-medical-licensing-examination> (Accessed April 2023).
8. <https://www.news-medical.net/health/What-does-ChatGPT-mean-for-Healthcare.aspx> (Accessed April 2023).
9. Bernard Marr (2023). Revolutionizing Healthcare: The Top 14 Uses Of ChatGPT In Medicine And Wellness [online]. Forbes. <https://www.forbes.com/sites/bernardmarr/2023/03/02/revolutionizing-healthcare-the-top-14-uses-of-chatgpt-in-medicine-and-wellness/> (Accessed April 2023).
10. Durand E, Sabatier R, Smits PC, et al. Evaluation of the R-One robotic system for percutaneous coronary intervention: the R-EVOLUTION study. *EuroIntervention*. 2023; 18(16): e1339–e1347, doi: [10.4244/EIJ-D-22-00642](https://doi.org/10.4244/EIJ-D-22-00642), indexed in Pubmed: [36602883](https://pubmed.ncbi.nlm.nih.gov/36602883/).
11. Emily Henderson, B.Sc. (2023) What does ChatGPT mean for Healthcare? <https://www.news-medical.net/health/What-does-ChatGPT-mean-for-Healthcare.aspx> (Accessed April 2023).

Central illustration. What does GPT-4 add to healthcare? The dawn of a new era.

What Does GPT-4 Add To Healthcare? The Dawn of a New Era



Education- ChatGPT could provide medical professionals and students with instant access to the medical information and resources they need to develop and has ability to assist the human learning process of its target audience.



Medical consultation- ChatGPT has the potential to create a virtual assistant to help patients make appointments, receive treatment, and manage their health records



Medical notes- ChatGPT can help medical professionals write and document medical reports, such as clinical notes and discharge reports, by providing real-time suggestions and adjustments



Virtual assistants- ChatGPT can also provide real-time translation services to facilitate communication between patients and healthcare providers.



Patient triage- ChatGPT can be used to triage patients by asking them questions about their symptoms and medical history to determine the urgency and severity of their condition

Prompt: Indicate the true statement concerning corrected congenital transposition of the great arteries:

- A. It is characterized by high mortality in the infantile period**
- B. Regurgitation of the anatomical tricuspid valve leads to peripheral edema**
- C. The isolated form is asymptomatic for many years**
- D. Often coexists with atrial arrhythmias**
- E. May be an indication for anatomic correction (Jatene operation)**

GPT-4: Corrected congenital truncus arteriosus translocation (ccTGA), also known as D-transposition, is a condition in which both the atria and ventricles have swapped places. As a result, despite the abnormal anatomy, blood flows in the correct direction, allowing for long-term survival, often asymptomatic for many years.

Hence, the true statement is:

C. The isolated form is asymptomatic for many years.

Patients with ccTGA may experience cardiac problems later in life, such as tricuspid regurgitation (anatomical mitral valve), which can lead to right ventricular failure, arrhythmias and other problems. Treatment may include various interventions, including tricuspid valve surgery or other cardiac procedures. However, ccTGA by itself is not usually an indication for anatomical correction (modo Jatene surgery), which is used for uncorrected transposition of the great vessels (dTGA).

Prompt: That is a good answer. I still don't understand why. Explain to me by referring to the literature why.

GPT-4: Congenital transposition of the truncus arteriosus (TGA) is a serious heart defect in which the pulmonary and systemic circulatory pathways are separated because the pulmonary artery and aorta have swapped places. In corrected congenital transposition of the great vessels (ccTGA), also known as atrial septal dependent transposition, the atria have also swapped places, allowing normal blood flow despite an abnormal anatomy.

In ccTGA, blood flows from the right atrium to the right ventricle and then to the pulmonary arteries (which are normally supplied by the left ventricle). Blood returns from the lungs to the left atrium, from which it flows to the left ventricle and then to the aorta (which is normally supplied by the right ventricle). This pathway of blood flow is called the 'loop' circulation.

For a period of time, people with ccTGA may not have any symptoms because blood flow is maintained more or less correctly, despite the heart structures being in swapped places. However, over the years, the anatomical tricuspid valve, which is normally the mitral valve, but in ccTGA, it serves as the aortic valve and may become regurgitated. This valve is not built to withstand the pressure that the left ventricle generates when pumping blood throughout the body, thus, regurgitation can occur.

Quoting "Congenitally corrected transposition of the great arteries" from the Orphanet Journal of Rare Diseases (2017): "Clinically, ccTGA varies widely, from asymptomatic newborns to patients with severe heart failure. Many people with ccTGA are first diagnosed as adults, suggesting that some people with ccTGA may survive into adulthood without any problems."

Also, in "Congenitally corrected transposition of the great arteries (ccTGA)" from the Circulation Journal (2019): "The incidence of ccTGA is approximately 1% of all congenital heart defects and 0.05 per 1,000 live births. In the isolated form of ccTGA, patients may survive into late adulthood without surgical intervention, and the first symptom may be heart failure associated with systemic tricuspid regurgitation." The Jatene operation, also known as arterial truncus transposition surgery, is a technique primarily used to treat uncorrected transposition of the great vessels (dTGA) rather than ccTGA. It is a procedure in which the pulmonary artery and the aorta are swapped back into their correct places. This is significantly different from the situation in ccTGA, where blood flow is more or less normal, despite the heart structures being in swapped places. In ccTGA, other interventions are often needed, such as tricuspid valve repair or Mustard or Senning surgery, which redirect blood flow at the level of the atria of the heart. However, these procedures are usually performed based on an individual patient's assessment and the extent of their symptoms, rather than as routine treatment for all patients with ccTGA. Given the above, for a patient with ccTGA, the correct statement is: "Isolated"

Figure 1. ChatGPT-4 explains its reasoning, refers to known medical facts, notes causal relationships, and literature, excludes other proposed responses and provides convincing justification for its 'decision'.

Prompt: Indicate the true statement concerning corrected congenital transposition of the great arteries:

- A. It is characterized by high mortality in the infantile period**
- B. Regurgitation of the anatomical tricuspid valve leads to peripheral edema**
- C. The isolated form is asymptomatic for many years**
- D. Often coexists with atrial arrhythmias**
- E. May be an indication for anatomic correction (Jatene operation)**

GPT-4: Answer: The correct answer is: C. Further observation, follow-up in 6–12 months. Explanation: This patient has moderate to severe mitral regurgitation (ERO 0.38 cm² suggests severe regurgitation) but is symptomless. The size of the left ventricle, ejection fraction (EF), and left atrium volume are within normal range, and the systolic pressure in the right ventricle is only slightly elevated. According to the 2021 ESC guidelines for the management of valvular heart diseases, it's recommended that patients with severe but symptomless mitral regurgitation should be clinically monitored every 6–12 months.

Rejected answers:

- A. Exercise testing might be used if the patient was experiencing symptoms, but is symptomless
- B. NT-proBNP concentration testing is more useful in managing heart failure, not specifically mitral regurgitation
- D. Initiating ACE inhibitor therapy might be helpful in treating heart failure or hypertension, but it doesn't directly impact mitral regurgitation
- E. Holter ECG could be used to detect atrial fibrillation attacks, but it doesn't directly impact the management of mitral regurgitation in this case

Figure 2. ChatGPT-4 explains its reasoning, refers to known medical facts, notes causal relationships, and literature, excludes other proposed responses and provides convincing justification for its 'decision' in more difficult cases; ESC — European Society of Cardiology; NT-proBNP — N terminal pro-B-type natriuretic peptide; ACE — angiotensin converting enzyme; ECG — electrocardiogram.

Prompt: I would like you to explain to me as a patient in a pictorial and understandable way what it means for me to have mitral regurgitation

GPT-4: Think of the heart as a house with four rooms. The two rooms at the top (the atria) are where the blood begins its journey, and the two rooms at the bottom (the ventricles) are where the blood pumps out to the rest of the body.

Your mitral valve is like a door between one of the rooms at the top — the left atrium — and one of the rooms at the bottom — the left ventricle. When your heart beats, the mitral valve opens to allow blood to pass from the left atrium to the left ventricle, and then closes to prevent blood from returning back to the atrium.

Now, mitral valve regurgitation means that this door does not close as well as it should — it's slightly ajar. So, when the blood is pumped out of the ventricle, a little bit goes back into the atrium instead of flowing forward into the rest of the body.

It's a bit like when you have an incompletely closed door and the wind causes some of the air to enter back into the room, instead of flowing outside. But instead of wind and air, we are talking about the heart and the pumping of blood. So, the heart has to work harder to pump that 'escaping' blood, just as a fan would have to work harder to pump air out through a door which is ajar. But for the time being, as you have no symptoms, it looks like your heart is coping well with this extra effort.

Figure 3. How ChatGPT-4 can easily and pictorially explain medical jargon to a patient.



Article

An Alarming High Number of Candidates for Bariatric Procedures among Professionally Active Poles and Its Strong Relationship with Cardiovascular Co-Morbidities—POL-O-CARIA 2022 Study

Anna Rulkiewicz, Iwona Pilchowska, Wojciech Lisik, Piotr Pruszczyk, Simona Wójcik, Marcin Poboży and Justyna Domienik-Karłowicz

Topic Collection

Obesity: From Diagnosis to Treatment

Edited by

Dr. Tigran Poghosyan





Article

An Alarming High Number of Candidates for Bariatric Procedures among Professionally Active Poles and Its Strong Relationship with Cardiovascular Co-Morbidities—POL-O-CARIA 2022 Study

Anna Rulkiewicz¹, Iwona Pilchowska^{1,2}, Wojciech Lisik³ , Piotr Pruszczyk⁴ , Simona Wójcik¹, Marcin Poboży⁵ and Justyna Domienik-Karłowicz^{1,4,*}

- ¹ LUX MED, Postępu 21C, 02-676 Warsaw, Poland; simona.wojcik@luxmed.pl (S.W.)
² Department of Psychology, SWPS University of Social Sciences and Humanities, 03-815 Warsaw, Poland
³ Department of General and Transplantation Surgery, Medical University of Warsaw, 02-005 Warsaw, Poland; wojciech.lisik@wum.edu.pl
⁴ Department of Internal Medicine and Cardiology, Medical University of Warsaw, 02-097 Warsaw, Poland; piotr.pruszczyk@wum.edu.pl
⁵ HealthCare Facility Cichowski-Poboży, 08-480 Maciejowice, Poland; marcinpobozy1@gmail.com
* Correspondence: jdomienik@tlen.pl; Tel.: +48-(22)-502-11-44

Abstract: Over recent years, the global healthcare system has experienced a notable increase in the prevalence of obesity and its associated health complications such as hypertension, type 2 diabetes, lipid disorders, etc. What is more, one of the significant phenomena is the increasing demand for bariatric procedures among individuals of working age due to the high prevalence of type III obesity and type II obesity with co-morbidities. This trend is pronounced in Poland, due to the increasing number of patients meeting the qualifying criteria for surgery among professionally active and inactive patients. The aim of this study is to characterize the alarmingly high number of candidates for bariatric procedures among professionally active Poles. In total, the results of 2,056,861 initial, control, and periodic visits as part of the occupational medicine certificate were analyzed—collected from 1,342,749 unique patients (51.7% men; mean age of whole group: 36.81, SD = 10.91). Statistical calculations were performed, qualitative data were assessed using percentage and occurrence counts, while qualitative data were described using mean (M), standard deviation (SD), median, skewness, kurtosis, and range values. Results with $p < 0.05$ were deemed significant. Chi-square analysis and one-way ANOVA (with Scheffe's post hoc test) were employed. Charts were created in the R program. It was noticed that there was a consistent rise in the proportion of individuals classified as candidates for bariatric procedures (an increase of 0.3%) alongside a notable decrease in the percentage of individuals maintaining a healthy body weight. Moreover, it is imperative to conduct yearly evaluations of the prevalence of obesity and its associated health conditions. It should be noted that hypertension occurred in 42.2% of patients, type 2 diabetes in 6.2% of patients, and lipid disorders in 8.4% of patients with third-degree obesity. This proactive approach is essential in order to adequately equip the healthcare system to address the increasing population of obese individuals, especially candidates for bariatric procedures.

Keywords: BMI (kg/m^2); professionally active adult population; cardiovascular diseases; obesity; bariatric procedures



Citation: Rulkiewicz, A.; Pilchowska, I.; Lisik, W.; Pruszczyk, P.; Wójcik, S.; Poboży, M.; Domienik-Karłowicz, J. An Alarming High Number of Candidates for Bariatric Procedures among Professionally Active Poles and Its Strong Relationship with Cardiovascular Co-Morbidities—POL-O-CARIA 2022 Study. *J. Clin. Med.* **2023**, *12*, 6431. <https://doi.org/10.3390/jcm12206431>

Academic Editor: Tigran Poghosyan

Received: 22 August 2023

Revised: 3 October 2023

Accepted: 8 October 2023

Published: 10 October 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

In recent years, the global healthcare system has observed a notable increase in the prevalence of obesity and its associated health complications [1,2]. Furthermore, a rising demand for bariatric procedures among working-age individuals has emerged as a noteworthy phenomenon [3]. This trend is especially pronounced in Poland, due to the

growing number of professionally active patients meeting the surgical qualifying criteria. This study examines the concerning increase in professionally active Poles seeking bariatric interventions and explores the strong correlation between this trend and cardiovascular co-morbidities.

It is worth noting that the escalating prevalence of obesity has raised alarms not just regarding individual health, but also concerning the strain on healthcare systems and global economies [4]. Bariatric procedures have emerged as crucial interventions in addressing severe obesity and its related health risks, offering the potential for improved quality of life and long-term health outcomes [5–7]. However, the specific implications of this surge, particularly among those in professional roles, warrant further investigation. The POL-O-CARIA 2022 study focuses on the rising inclination among professionally active Poles towards bariatric procedures. By examining the main factor driving this trend and the cardiovascular co-morbidities commonly associated with it, the study aims to contribute valuable insights to both medical practitioners and policymakers. Recognizing the intricate association between the surging demand for bariatric surgeries and cardiovascular health can guide specialized interventions, public health initiatives, and policy strategies to alleviate the health and economic repercussions of obesity-linked diseases [8].

Through a comprehensive analysis of data and trends, the POL-O-CARIA 2022 study seeks to provide a comprehensive understanding of the complex interplay between bariatric procedures, cardiovascular co-morbidities, and the professional lives of individuals in Poland. This research has the potential to drive informed decision-making in healthcare, facilitating proactive strategies that address the multifaceted challenges posed by the increasing prevalence of obesity and its associated health consequences among the working-age population.

1.1. Obesity and Co-Morbidities

Beyond its evident impact on physical appearance, obesity is closely associated with a spectrum of accompanying health conditions that significantly compromise individual well-being. Numerous research studies documented in existing literature underscore the strong link connecting excess weight and obesity to the onset of a diverse range of medical conditions [9]. A comprehensive meta-analysis conducted in 2015 yielded illuminating insights, revealing that even a moderate 5 kg increase in weight substantially increases the risk of certain cancers. The analysis specifically showed an 11% heightened risk for post-menopausal breast cancer, a 39% surge in the risk of endometrial cancer, a 13% rise in the risk of ovarian cancer, and a 9% growth in the risk of colon cancer for men [10]. Further explorations through cohort investigations, undertaken as part of the Me-Can 2.0 program across several European nations such as Austria, Norway, and Sweden, corroborated these findings. These investigations illuminated that individuals classified as overweight up until the age of 40 exhibit a significant rise in the probability of developing various malignancies. Notably, these encompassed increased risks for endometrial cancer, renal-cell cancer and colon cancer in men [11]. Beyond its immediate impacts, obesity assumes the status of a chronic metabolic disorder that profoundly influences the prevalence of cardiovascular diseases. Excessive fat accumulation impacts cardiac function directly by influencing the myocardium and blood vessels, and indirectly through associated health issues. The building up of too much fat tissue causes circulatory changes, such as increased blood volume and heart activity along with decreased overall blood vessel resistance. This weight gain is also tied to increased blood pressure, triggered by the renin–angiotensin–aldosterone and sympathetic nervous systems. Furthermore, obesity directly harms the heart muscle through fat buildup leading to subsequent scarring, potentially resulting in LVDD and HF with a preserved ejection fraction (HFpEF) [12]. Comprehensive profiling of HFpEF patients, both with and without obesity, in contrast to normal individuals, revealed that obese individuals with HFpEF exhibited pronounced LV adjustments, enlargement of the right ventricle, and associated dysfunction. Scientific research leaves little room for doubt regarding the complex connections between obesity and conditions such as hypertension,

coronary artery disease, atrial fibrillation, obstructive sleep apnea, non-alcoholic fatty liver disease, and diabetes [2,9,12–14]. The body of evidence not only underscores the complexities of obesity's impacts on health but also emphasizes the urgency of comprehensive approaches to address its wide-ranging consequences [2]. First of all, we should underline who is eligible for bariatric surgery. Above all, this should include individuals who have not achieved weight loss through diet, physical activity, and pharmacotherapy, with a body mass index (BMI) of 40 or more kg/m^2 , indicating severe obesity. Moreover, those with a BMI ranging from 35 to 39.9 kg/m^2 (considered obese), along with a significant weight-related medical issue like type 2 diabetes, hypertension, or severe sleep apnea should also be included.

1.2. Obesity and Professional Activity

The impact of work on overweightness and obesity has been acknowledged. Employers take steps to encourage healthy eating habits and boost physical activity among their staff. Providing complimentary fruits and vegetables at workplaces is becoming more common. Factors within the work environment that can contribute to overweightness and obesity encompass sedentary job roles, stress, and sleep issues [15]. Engaging in office work and sedentary tasks escalates the susceptibility to obesity among employees. A study by Shields and Tremblay in 2008 affirmed a positive correlation between obesity and prolonged sitting during leisure time, such as when using a computer [15]. Conversely, there are various studies that refute the link between sedentary work or leisure pursuits and the prevalence of overweightness and obesity. Stress encountered in the workplace is also a significant factor associated with overweightness and obesity.

2. Aim of the Study

The aim of this study is to characterize the alarmingly increasing number of candidates for bariatric procedures among professionally active Poles who underwent occupational medicine examinations in Poland in 2016–2022 and its strong relationship with cardiovascular co-morbidities (POL-O-CARIA 2022 study). Because the study aims to explore rather than confirm specific research hypotheses, the article does not propose any research hypotheses. Instead, we formulated research inquiries that delineated the primary focus of the investigations: examining how the severity of obesity evolves over time and its interactions with other medical conditions.

3. Materials and Methods

This paper examines the findings of the POL-O-CARIA 2016–2022 study, focusing on professionally active adults seen from January 2016 to September 2022 for occupational health purposes. The LUX MED Group supplied the data. In all, 2,056,861 initial, control, and periodic occupational health check-ups were reviewed. They were collected from 1,342,749 unique patients (51.7% men; mean age of whole group: 36.81, SD = 10.91). Throughout the research, factors such as gender, age, residency province, medical certification period, and medical history elements like self-assessed health and smoking habits were monitored. Over the years, there has been a steady rise in the percentage of individuals categorized as overweight or obese. This makes it crucial to regularly monitor obesity prevalence in different societal groups. Studying the health of working Polish adults is important for multiple reasons, including monitoring overall health and anticipating the onset of certain lifestyle-related diseases in specific groups. The existence of conditions like obesity, hypertension, type 2 diabetes, sleep apnea, and non-alcoholic steatohepatitis often results in fewer medical approvals for job roles.

Obesity is generally classified based on body mass index (BMI), which is a numerical value derived from an individual's weight and height. While the exact thresholds can vary slightly depending on the source or country, the World Health Organization (WHO) and many other health institutions use the following classifications for adult obesity:

1. Class 1 Obesity: A BMI of 30.0 to 34.9.

2. Class 2 Obesity: A BMI of 35.0 to 39.9.
3. Class 3 Obesity: A BMI of 40.0 and above.

The European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) provide guidelines on the management of arterial hypertension. According to the ESH/ESC, arterial hypertension is usually defined as a systolic blood pressure (SBP) of 140 mmHg or higher, and/or a diastolic blood pressure (DBP) of 90 mmHg or higher. For the diagnosis of type 2 diabetes, we use the general criteria, which typically include:

1. Fasting Plasma Glucose: ≥ 7.0 mmol/L (or ≥ 126 mg/dL).
2. 2 h Plasma Glucose during an Oral Glucose Tolerance Test (OGTT) with 75 g of glucose: ≥ 11.1 mmol/L (or ≥ 200 mg/dL).
3. HbA1c (Glycated Hemoglobin): $\geq 6.5\%$.
4. Random Plasma Glucose: ≥ 11.1 mmol/L (or ≥ 200 mg/dL) in the presence of diabetes symptoms.

Statistical Analysis

Statistical analyses were conducted utilizing IBM SPSS Statistics 25. For the examination of qualitative data, we utilized percentages and frequency counts. To describe qualitative data, we relied on metrics such as mean (M), standard deviation (SD), median, skewness, kurtosis, as well as the smallest and largest values. Results were deemed statistically significant if the likelihood of a type I error was below 5% ($p < 0.05$). For our statistical evaluations, we employed chi-square tests in contingency tables (with Bonferroni correction applied for assessing column ratios) and a one-way ANOVA (utilizing Scheffe’s post hoc test for contrasting means). Graphical representations were crafted using the R software 4.2.3.

4. Results

4.1. Information on BMI (kg/m^2)

It was noticed that, over successive years of observation, there was a consistent rise in the proportion of individuals classified as overweight or obese (regardless of the level of severity), alongside a notable decrease in the percentage of individuals maintaining a healthy body weight. Detailed results are presented in Table 1.

Table 1. BMI (kg/m^2) distribution depending on the year of measurement.

	2016	2017	2018	2019	2020	2021	2022	Total
Underweight	3.4%	3.4%	3.4%	3.2%	3.1%	3.0%	2.8%	3.0%
Normal body weight	51.6%	51.1%	50.1%	49.3%	48.2%	48.1%	47.6%	49.3%
Overweight	31.4%	31.5%	32.0%	32.2%	32.1%	32.4%	32.7%	32.4%
I degree of obesity	10.4%	10.7%	11.0%	11.5%	12.1%	12.3%	12.4%	12.4%
II degree of obesity	2.5%	2.6%	2.7%	2.9%	3.7%	4.1%	4.4%	2.6%
III degree of obesity	0.7%	0.7%	0.8%	0.8%	0.8%	0.1%	0.1%	0.3%
Total	100.0%	100.0%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%

In relation to body mass index (BMI), it was discovered that individuals with a normal body weight, who were actively engaged in their professions, obtained the longest medical certificates. These certificates lasted for approximately 34 months. For those categorized as overweight or dealing with obesity, a clear correlation emerged between the severity of obesity and the duration of medical certification (refer to Table 2). Based on medical decisions, individuals with overweight conditions were granted work-related medical certificates, averaging around 31 months. The capacity to remain occupationally active notably declined as the obesity level escalated: 1st degree obesity led to an average certificate duration of about 28 months, 2nd degree obesity was associated with roughly 27 months, and 3rd degree obesity resulted in nearly 26 months of certification—we present these details in Table 2.

Table 2. Descriptive statistics on the average number of months of the issued medical certificates depending on BMI (kg/m²).

	Underweight	Normal Body Weight	Overweight without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity
M	36.01	34.21	31.12	27.89	26.77	26.01
Me	36.00	36.00	36.00	23.00	23.00	23.00
SD	11.67	12.83	13.78	15.23	14.29	13.71
Skewness	−0.54	−0.62	−0.34	−0.14	0.23	0.21
Kurtosis	−0.12	−0.53	−0.66	−0.76	−0.58	−0.63
Min	0.00	0.00	0.00	0.00	0.00	0.00
Max	156.00	156.00	178.00	155.00	156.00	70.00

4.2. Patient Characteristics Depending on BMI (kg/m²) Level

Chi-square analysis showed that similar trends were observed for both women and men regarding the dynamics of occurrence of individual BMI (kg/m²) categories. In both groups, a noteworthy decline was identified on an annual basis among individuals with a normal body weight. Additionally, the inclination towards an increase in individuals categorized with 1st and 3rd degree obesity was more pronounced among men. Here, we observed a concerning rise in potential candidates for bariatric surgery (see Table 3).

Table 3. Relationship between BMI (kg/m²) and measurement time as well as patients’ sex—data percentage to the year of measurement.

		2016	2017	2018	2019	2020	2021	2022	Total
Women	Underweight	6.1%	6.2%	6.0%	5.8%	5.6%	5.6%	5.4%	5.9%
	Normal body weight	64.4%	63.7%	62.7%	62.0%	61.9%	61.5%	61.3%	62.4%
	Overweight without obesity	19.6%	19.9%	20.7%	20.9%	21.4%	21.6%	22.1%	20.6%
	I degree of obesity	7.1%	7.3%	7.5%	8.0%	8.1%	8.2%	8.1%	7.9%
	II degree of obesity	2.1%	2.2%	2.2%	2.4%	2.1%	2.3%	2.5%	2.4%
	III degree of obesity	0.7%	0.8%	0.8%	0.8%	0.9%	0.8%	0.6%	0.8%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Men	Underweight	0.8%	0.8%	0.9%	0.9%	0.8%	0.8%	0.9%	0.8%
	Normal body weight	39.3%	38.9%	38.3%	37.9%	37.1%	37.1%	36.9%	38.1%
	Overweight without obesity	42.7%	42.8%	42.7%	42.4%	42.3%	42.6%	42.6%	42.6%
	I degree of obesity	13.6%	14.0%	14.3%	14.7%	15.3%	15.6%	15.7%	14.6%
	II degree of obesity	2.9%	2.9%	3.2%	3.3%	3.4%	3.2%	3.1%	3.1%
	III degree of obesity	0.6%	0.7%	0.8%	0.8%	1.1%	0.7%	0.8%	0.8%
	Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notable disparities were observed in a one-way variance analysis for age and the duration for which measurement were taken, irrespective of the measurement year (in both instances, the variation between groups was significant at $p < 0.001$). More detailed results are elaborated on below. Regarding the age of the patients, a post-hoc examination using Scheffe’s adjustment indicated that only between individuals with II and III obesity degrees were there no age differences. In other comparisons, the significance of variations between specific groups stood at $p < 0.001$. The oldest average age was noted among those with obesity, whereas the youngest was among individuals with underweight or standard weight (see Figure 1).

Individuals with a standard weight were predominantly found in the under 35 age group. Conversely, the proportion of those with obesity, particularly of the 1st degree, rose notably across all age groups (refer to Table 4).

Table 5 displays the data by adjusting the percentages based on BMI categories. The findings indicate that as BMI increases, the proportion of individuals under 35 years of age diminishes in every group. For those aged between 35 and 69, it was observed that they were more frequently categorized into the overweight or obesity groups compared to those with standard weight.

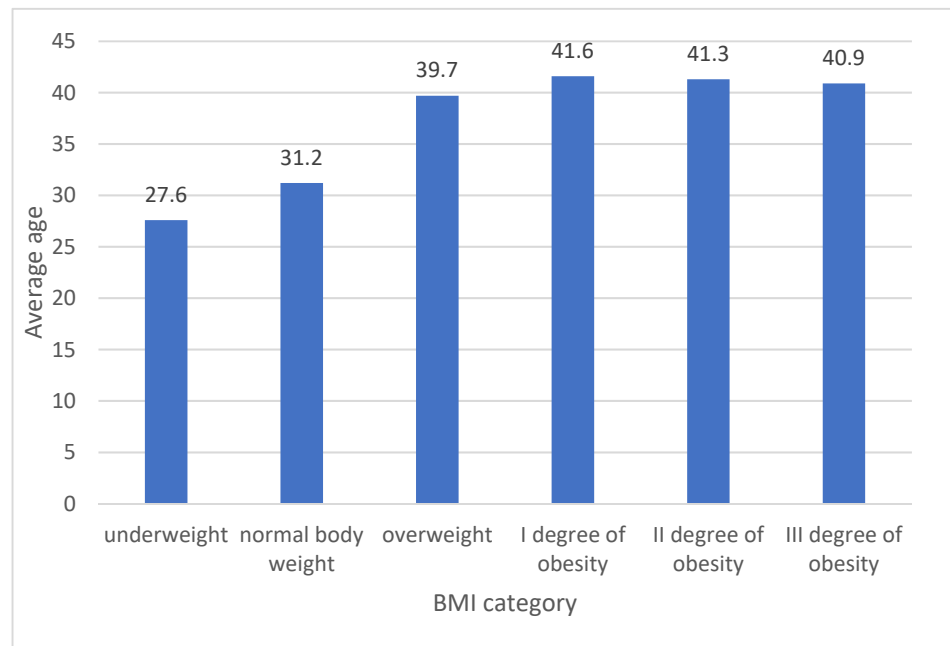


Figure 1. The average age varies based on BMI category (kg/m²). In the graph, all group differences are statistically significant at a $p < 0.001$ threshold. Due to the multitude of groups being compared, specific differences are not displayed in the figure.

Table 4. Association between BMI (kg/m²) and age of patients—percentage distribution across age categories.

	<18	18–35	35–54	55–69	>69	Total
Underweight	13.9%	4.9%	1.2%	0.4%	0.4%	3.0%
Normal body weight	61.3%	59.3%	39.9%	26.5%	26.8%	49.3%
Overweight	18.1%	26.0%	40.3%	42.4%	52.1%	32.4%
I degree of obesity	4.2%	7.4%	14.4%	24.4%	18.4%	12.4%
II degree of obesity	2.0%	1.8%	3.3%	6.2%	2.1%	2.6%
III degree of obesity	0.5%	0.6%	0.9%	0.1%	0.2%	0.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5. Relationship between BMI (kg/m²) and age of patients—data percentage to the BMI category.

	Underweight	Normal Body Weight	Overweight without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity	Total
<18	0.10%	0.20%	0.10%	0.10%	0.00%	0.00%	0.00%
18–35	83.70%	63.80%	44.30%	33.20%	31.60%	33.80%	54.20%
35–54	14.10%	29.50%	42.10%	49.00%	51.20%	51.60%	38.60%
55–69	2.10%	6.40%	13.40%	17.50%	17.10%	14.50%	7.10%
>69	0.00%	0.10%	0.10%	0.20%	0.10%	0.10%	0.10%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

In the examination of the durations for medical certificate issuance, notable variations among the groups were identified. A linear trend was evident, demonstrating that as the BMI level rises, the average duration of the issued certification shortens- what we present on Figure 2. Furthermore, a post-hoc evaluation using Scheffe’s adjustment highlighted significant disparities across all BMI categories. More comprehensive outcomes are delineated in the subsequent sections.

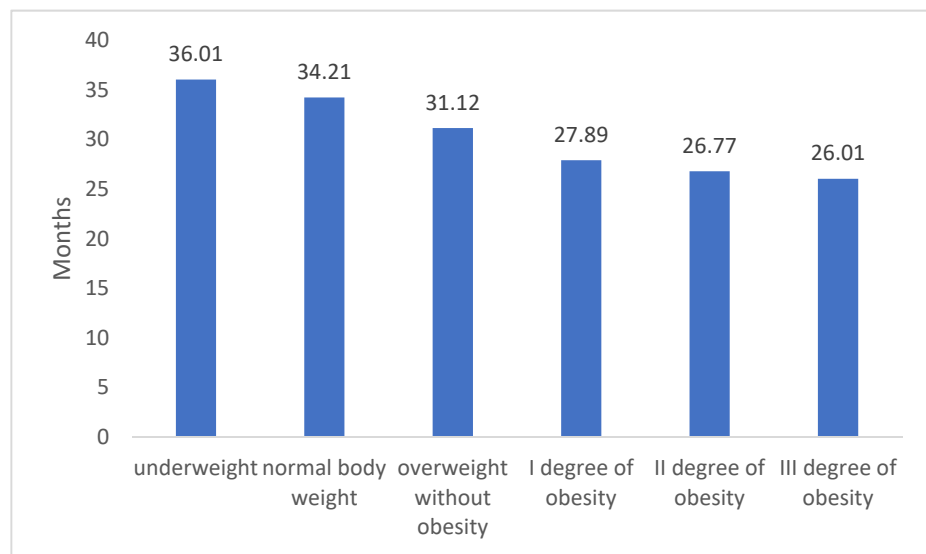


Figure 2. The mean duration in months of the provided medical certificate varies based on BMI category. In the chart, every group showcases notable statistical differences at a $p < 0.05$ threshold. Owing to the extensive group comparisons, specific distinctions are not illustrated in the figure.

Individuals with standard or underweight showed a lower tendency to smoke compared to those who were overweight or obese. This distinction is statistically significant at a minimum threshold of $p < 0.05$. Such a pattern was consistent across all measurement years, as depicted in Figure 3.

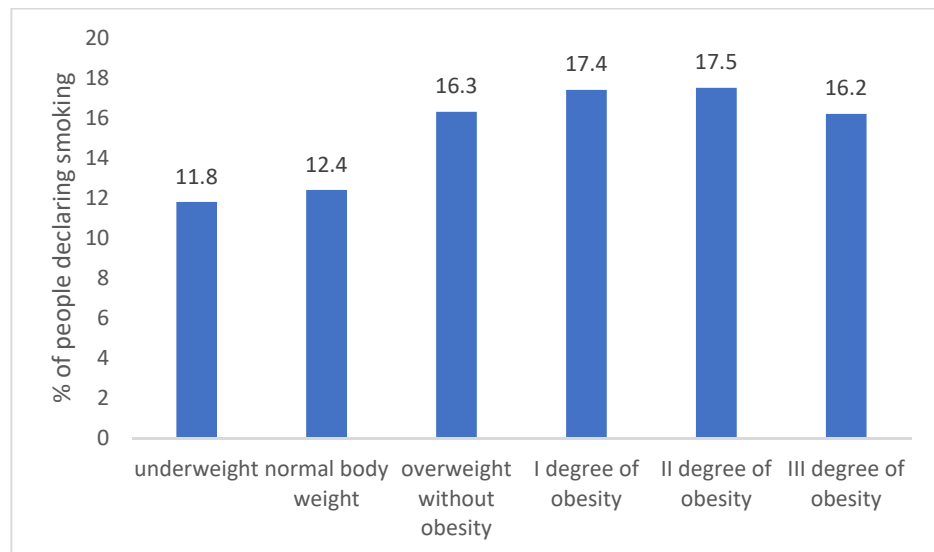


Figure 3. Percentage of people declaring smoking depending on BMI category (due to the number of groups compared, results for differences are not shown in the figure).

An exploration was conducted into the association between BMI classifications and individuals’ self-evaluation of health. It was observed that those who rated their health as “good” were less frequently categorized as having normal weight compared to those who rated their health as “very good”. The opposite trend was evident for individuals who were overweight or obese. More in-depth findings are elaborated on in the following sections and in Table 6.

Table 6. Association between BMI (kg/m²) and personal health evaluation—percentage data for health ratings.

	Subjective Health Assessment		Total
	Good	Very Good	
Underweight	3.10%	3.20%	3.10%
Normal body weight	48.10%	58.30%	52.30%
Overweight without obesity	32.10%	31.50%	31.90%
I degree of obesity	14.10%	5.60%	10.30%
II degree of obesity	2.10%	1.10%	1.90%
III degree of obesity	0.50%	0.30%	0.50%
Total	100.00%	100.00%	100.00%

Table 7 illustrates the connection between chosen ailments and BMI classifications. A notable association between these variables was determined ($p < 0.001$). The most distinct variations were seen in hypertension (as BMI increased, the proportion of individuals with this condition rose) and in lipid imbalances and type 2 diabetes.

Table 7. Association between BMI and the prevalence of specific illnesses—percentage representation for each BMI group.

	Underweight	Normal Body Weight	Overweight without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity	Total
Hypertension	29.8%	38.9%	45.7%	50.6%	52.5%	56.1%	45.3%
Type 2 diabetes	8.7%	6.1%	7.1%	10.1%	16.1%	17.1%	8.2%
Lipid disorders	58.7%	52.1%	43.1%	35.5%	28.1%	24.1%	43.5%
Coronary disease	2.8%	2.9%	4.1%	3.8%	3.3%	2.7%	3.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

4.3. BMI and Observed Co-Morbidities

A notable correlation was found between BMI (kg/m²) classifications and the presence of co-morbidities ($\chi^2(70) = 16138; p < 0.001$). In-depth findings indicated that among patients diagnosed with hypertension or lipid imbalances, there were significant variations across all groups. Specifically, as BMI escalated, the likelihood of each condition’s presence also grew. It should be noted that hypertension occurred in 56.1% of patients, type 2 diabetes in 17.1% of patients, and lipid disorders in 24.1% of patients with third-degree obesity. A Table 8, further down provides a comparative overview of all co-morbidities based on BMI levels.

It should be noted that hypertension occurred in 42.2% of patients, type 2 diabetes in 6.2% of patients, and lipid disorders in 8.4% of patients with third-degree obesity. The cross-tabulation chi-square analysis performed confirmed that there was an association between age and co-morbidities ($\chi^2(56) = 27809.28; p < 0.001$). In the case of hypertension, it was obtained that the prevalence of hypertension was more common in those aged 18–54 compared to other age groups. In addition, the prevalence of lipid disorders was significantly different in each of the age groups—a trend was observed showing that the diagnosis of this disease decreased with age. A detailed comparison of the age groups for the other diseases is shown below, in Table 9.

Table 8. Association between BMI (kg/m²) and co-existing conditions—percentage data relative to BMI.

	Underweight	Normal Body Weight	Overweight without Obesity	I Degree of Obesity	II Degree of Obesity	III Degree of Obesity	Total
Hypertension	26.4%	31.2%	34.5%	39.4%	42.2%	46.5%	35.1%
Type 2 diabetes	6.8%	3.0%	2.6%	3.4%	4.7%	6.2%	3.6%
Lipid disorders	58.4%	48.1%	32.7%	18.9%	12.3%	8.4%	33.1%
Coronary disease	2.1%	0.8%	1.2%	1.2%	0.8%	0.3%	1.0%
Hypertension + type 2 diabetes	0.8%	0.7%	2.6%	4.4%	8.1%	10.3%	2.7%
Hypertension + lipid disorders	4.3%	12.4%	18.4%	22.3%	18.9%	15.9%	17.6%
Hypertension + coronary disease	0.2%	0.8%	0.5%	1.5%	1.1%	0.9%	0.4%
Type 2 diabetes + lipid disorders	0.3%	0.4%	1.3%	0.9%	1.4%	1.2%	0.8%
Type 2 diabetes + coronary disease	0.1%	0.0%	0.2%	0.1%	0.4%	0.1%	0.1%
Lipid disorders + coronary disease	0.2%	0.8%	0.6%	0.4%	0.4%	0.1%	0.5%
Hypertension + type 2 diabetes + lipid disorders	0.1%	1.2%	2.9%	4.2%	7.6%	7.6%	2.6%
Hypertension + type 2 diabetes + coronary disease	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%
Hypertension + lipid disorders + coronary disease	0.1%	0.4%	1.6%	1.9%	0.7%	1.1%	1.6%
Type 2 diabetes + lipid disorders + coronary disease	0.1%	0.0%	0.1%	0.1%	0.1%	0.2%	0.1%
All		0.1%	0.7%	1.2%	1.1%	1.2%	0.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 9. Relationship between age and co-morbidities—data percentage to age¹.

	Age					Total
	<18	18–35	35–54	55–69	>69	
Hypertension	50.0%	37.50%	34.60%	32.10%	30.50%	34.60%
Type 2 diabetes	50.0%	6.80%	3.30%	2.50%	2.10%	3.40%
Lipid disorders		44.70%	35.10%	18.10%	7.50%	33.20%
Coronary disease		0.40%	0.70%	2.40%	1.70%	0.80%
Hypertension + type 2 diabetes		0.80%	2.20%	4.40%	6.80%	2.40%
Hypertension + lipid disorders		8.50%	18.50%	21.70%	19.40%	17.60%
Hypertension + coronary disease		0.20%	0.30%	2.40%	4.10%	0.70%
Type 2 diabetes + lipid disorders		0.50%	0.80%	1.30%	1.20%	1.20%
Type 2 diabetes + coronary disease		0.00%	0.10%	0.30%	0.70%	0.10%
Lipid disorders + coronary disease		0.20%	0.40%	1.40%	1.40%	0.70%
Hypertension + type 2 diabetes + lipid disorders		0.30%	2.40%	6.30%	7.50%	3.10%
Hypertension + type 2 diabetes + coronary disease		0.00%	0.20%	0.50%	2.10%	0.10%
Hypertension + Lipid disorders + coronary disease		0.10%	1.20%	4.60%	9.50%	1.50%
Type 2 diabetes + lipid disorders + coronary disease		0.00%	0.00%	0.10%	0.60%	0.10%
All		0.00%	0.20%	1.90%	4.90%	0.50%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

¹ Each letter in subscript represents a subset of the age category for which the column proportions do not differ significantly at the level of 5%.

5. Discussion

In this research study, we utilized data obtained from a substantial cohort of 1,450,455 distinct adult patients. Employing a comprehensive analytical approach, we derived estimations regarding the trends in body mass index (BMI); while previous analyses have explored the prevalence of obesity in Poland in preceding years, none have focused on the present time frame nor have they encompassed such an extensive patient pool [16].

A distinctive aspect of our analysis lies in its incorporation of correlations between BMI and critical factors, including the average duration of medical certificates issued and the concurrent presence of severe illnesses primarily associated with the cardiovascular system. Notably concerning is the revelation that as BMI escalates, individuals' capacity to remain productive within the workforce diminishes. Importantly, our study does not

encompass individuals who, due to obesity and its related co-morbidities, are unable to engage in work altogether.

It is paramount to emphasize that, within this vast patient cohort, we have established the coexistence of ailments that significantly affect patients' overall quality of life [7]. The extent of such co-morbidities distinctly corresponds to the degree of obesity. Our data unequivocally demonstrated that approximately one third of active female professionals and nearly two thirds of their male counterparts fall within the overweight or obese categories. This finding is deeply disconcerting.

Morbid obesity is increasingly recognized as a pivotal factor in the development and progression of several co-morbid conditions, notably hypertension, type 2 diabetes, and dyslipidemia. Numerous studies have elucidated the intricate pathways through which excessive adipose tissue can drive the onset of high blood pressure. Mechanisms such as increased renal sodium retention and heightened sympathetic nervous system activity have been identified as mediators of this relationship. Furthermore, the secretion of adipokines from visceral fat, abundant in morbidly obese individuals, can lead to systemic inflammation and impaired insulin signaling, setting the stage for the onset of type 2 diabetes mellitus. The elevated risk of developing this form of diabetes is particularly pronounced in those with extreme levels of obesity. Concurrently, the perturbed lipid metabolism in these individuals gives rise to dyslipidemia, characterized by imbalances in LDL cholesterol, triglycerides, and HDL cholesterol levels. The simultaneous presence of these conditions in morbidly obese individuals amplifies their risk of cardiovascular diseases. It is noteworthy that weight loss interventions, especially bariatric surgery, have shown remarkable efficacy in resolving or significantly improving these co-morbidities. Additionally, the economic ramifications of these interconnected conditions emphasize the importance of early and holistic interventions. Contemporary research advocates for a collaborative approach to patient care, drawing on the expertise of cardiologists, endocrinologists, and obesity specialists. Addressing the root cause, morbid obesity, can have cascading benefits, potentially reversing the associated co-morbidities and enhancing the overall quality of life for affected individuals. The interplay of these conditions underscores the multifaceted challenges posed by morbid obesity and necessitates comprehensive, evidence-based strategies for effective management.

Furthermore, our study illuminates an alarming temporal trend that indicates a surge in this phenomenon over time. This development raises apprehensions regarding both access to medical services and the economic burden on the healthcare system. The data underscore the non-uniform distribution of this issue across various regions of the country. Appendix A provide unique insights delineating how obesity diversifies based on geographic regions.

Whereas grade II and grade III obesity were once exceptional occurrences, our findings indicate that they may soon dominate the spectrum of BMI categories within patient populations. Given the existing limitations in physicians' capacity to effectively manage obese patients, the persistent progression of this trend is poised to become a formidable challenge for the entirety of the healthcare sector.

Bariatric surgery in particular has emerged as a game-changing intervention for patients with morbid obesity and those with grade II obesity accompanied by co-morbid conditions. The transformative potential of such procedures extends beyond mere weight reduction. Studies have consistently demonstrated the ability of bariatric interventions, like gastric bypass or sleeve gastrectomy, to induce remission of type 2 diabetes, often independent of significant weight loss. This remarkable effect is believed to be mediated through hormonal changes, improvements in insulin sensitivity, and alterations in gut microbiota.

Moreover, bariatric surgery has been found to induce significant and sustained reductions in blood pressure, thereby directly addressing hypertension in this patient population. Patients post-surgery often experience a favorable shift in their lipid profile, with decreases in LDL cholesterol and triglycerides and an elevation in protective HDL cholesterol. This

reconfiguration of the lipid landscape contributes to the reduction in cardiovascular risks associated with morbid obesity.

The long-term benefits of bariatric surgery also include a reduction in the mortality rates from cardiovascular events and certain cancers. Economic evaluations reveal that, while the upfront costs of bariatric procedures are significant, the resultant savings from reduced medication requirements, fewer hospitalizations, and diminished need for interventions related to co-morbidities, make it cost-effective in the long run.

However, as transformative as bariatric surgery can be, it is vital to recognize its role as part of a comprehensive care package. Nutritional guidance, psychological support, and regular medical follow-ups are essential components that ensure the success and sustainability of surgical interventions. An individualized, patient-centric approach, where surgery is complemented by lifestyle and behavioral modifications, offers the best chance of restoring health and vitality to those grappling with the multifarious challenges of type II and III obesity.

6. Conclusions

In addition to the above, is imperative to conduct yearly evaluations of the prevalence of obesity and its associated health conditions. This proactive approach is essential in order to adequately equip the healthcare system for addressing the increasing population of obese individuals—candidates for bariatric procedures, who are actively engaged in their professions. By doing so, we can strategically implement the most efficient interventions to counteract this trend and ensure optimal health outcomes.

Author Contributions: Conceptualization, A.R. and I.P.; Formal analysis, M.P.; Data curation, A.R. and I.P.; Writing—original draft, A.R., I.P., W.L., S.W., M.P. and J.D.-K.; Writing—review & editing, P.P. and J.D.-K.; Supervision, P.P. and J.D.-K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Ethical review and approval were waived for this study due to REASON: retrospective anonymized analysis.

Informed Consent Statement: Not applicable.

Data Availability Statement: On demand from corresponding author.

Conflicts of Interest: There is no conflict of interest (all cases). Anna Rulkiewicz, Iwona Pilchowska, Simona Wójcik, and Justyna Domienik-Karłowicz are Lux med employees. Lux med is a medical company which provides ambulatory medical services and hospitals in Poland.

Appendix A. Additional Analyses

This study included 2,056,861 visits to occupational medicine (collected from 1,342,749 unique patients) from 2016–2022. The exact number of collected results depending on the year of measurement is presented below.

Regarding gender, men made up a marginally larger portion at 51.7%. As the study progressed, the proportion of male participants saw a modest rise (refer to Figure A2).

The age span of the participants was from 18 to 90 years, with an average (M) of 36.81 and a standard deviation (SD) of 10.91. There was a subtle pattern indicating that the average age of the subjects studied rose slightly year by year (refer to Figure A3). It is essential to note that as patients age, they naturally move into different age categories. This observation is not just a redundant statement that people age over time.

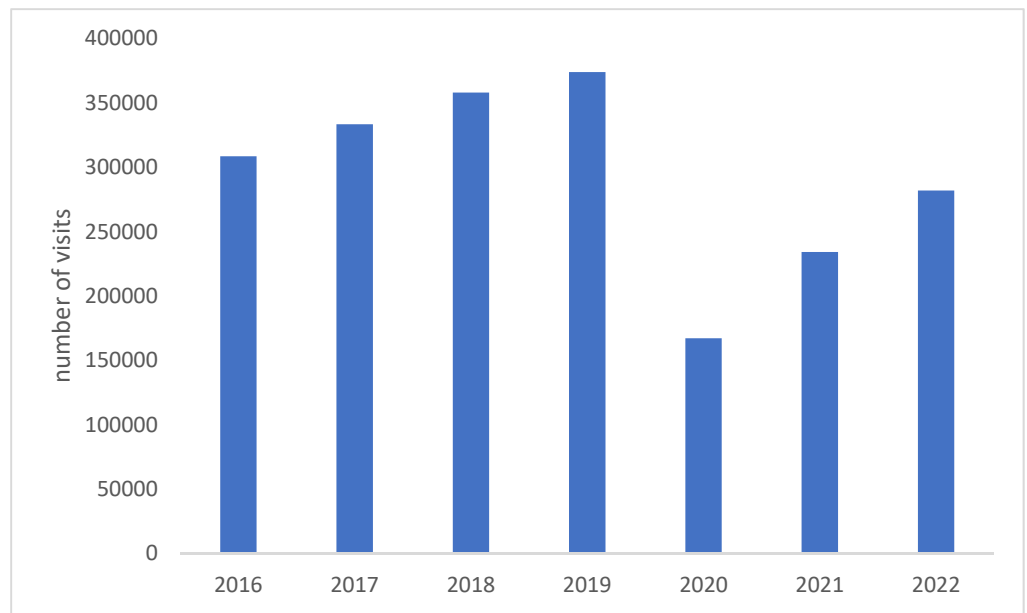


Figure A1. The number of visits analyzed versus the year of measurement.

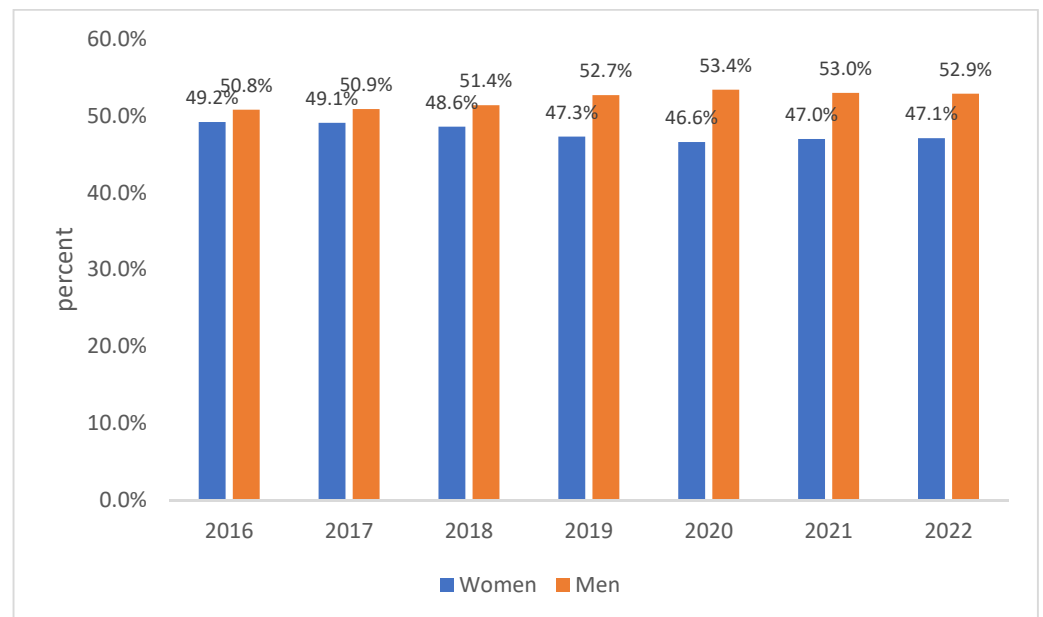


Figure A2. Sex distribution depending on the year of measurement (95% CI: $\pm 0.2\%$).

The detailed breakdown of age groups based on the year of assessment is shown in the following table. It was observed that as the years of measurement progressed, there was a decline in the percentage of individuals aged 18–35, and a rise in the 35–54 age bracket. For other age groups, the trends were not as distinctly noticeable compared to these two age ranges.

There were also no significant differences in terms of the distribution of the respondents by year of measurement and the voivodeship of residence (see Table A2).

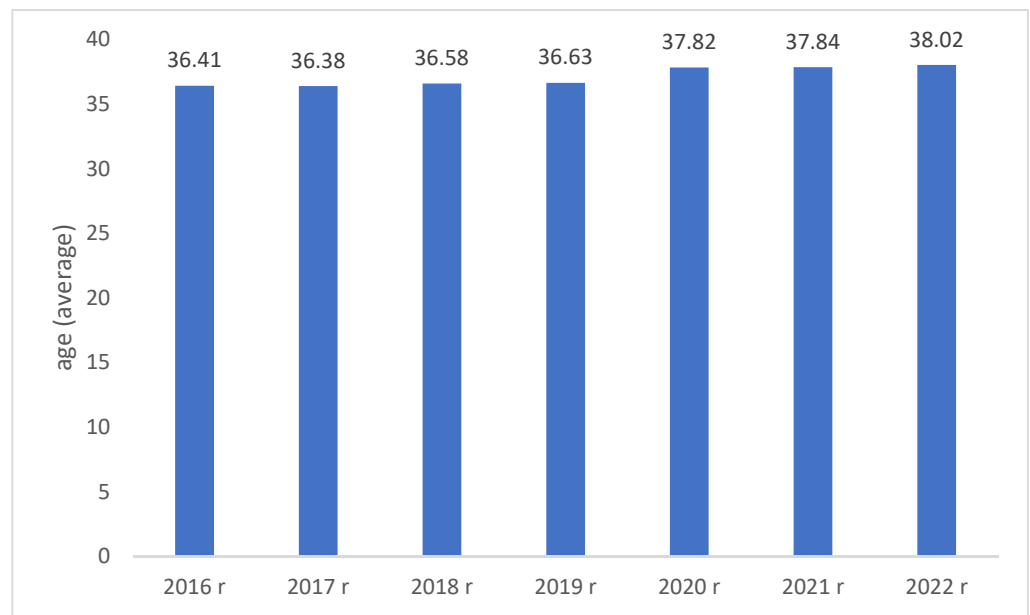


Figure A3. Patient age distribution versus the year of measurement.

Table A1. Distribution of age groups versus the year of measurement (with 95% CI).

	2016	2017	2018	2019	2020	2021	2022	Total
<18	0.0% (±0.1%)	0.0% (±0.1%)	0.1% (±0.1%)	0.1% (±0.1%)	0.0% (±0.2%)	0.1% (±0.1%)	0.0% (±0.1%)	0.1% (±0.2%)
18–35	54.5% (±0.2%)	54.3% (±0.3%)	53.3% (±0.2%)	52.5% (±0.2%)	46.6% (±0.2%)	52.1% (±0.2%)	52.3% (±0.2%)	53.3% (±0.2%)
35–54	35.7% (±0.2%)	35.8% (±0.2%)	36.7% (±0.2%)	37.6% (±0.2%)	42.0% (±0.3%)	36.9% (±0.2%)	36.4% (±0.2%)	36.5% (±0.2%)
55–69	9.6% (±0.1%)	9.7% (±0.1%)	9.8% (±0.1%)	9.7% (±0.1%)	11.2% (±0.1%)	10.7% (±0.1%)	10.4% (±0.1%)	9.1% (±0.1%)
>69	0.1% (±0.1%)	0.1% (±0.1%)	0.2% (±0.1%)	0.2% (±0.1%)	0.3% (±0.1%)	0.3% (±0.1%)	0.9% (±0.1%)	0.2% (±0.1%)
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	0.1% (±0.1%)	100.0%

Table A2. Distribution of voivodships depending on the year of measurement (with 95% CI).

	2016	2017	2018	2019	2020	2021	2022	Total
Lower Silesia	12.6% (±0.2%)	13.1% (±0.2%)	12.7% (±0.1%)	13.0% (±0.1%)	13.6% (±0.2%)	12.6% (±0.2%)	11.7 (±0.2%)	12.8% (±0.2%)
Kuyavian-Pomeranian	3.9% (±0.1%)	4.1% (±0.1%)	4.1% (±0.1%)	3.8% (±0.1%)	3.7% (±0.1%)	4.2% (±0.1%)	3.9% (±0.1%)	4.0% (±0.1%)
Lublin	0.9% (±0.1%)	0.9% (±0.1%)	0.9% (±0.1%)	0.8% (±0.1%)	0.7% (±0.1%)	0.9% (±0.1%)	1.1% (±0.1%)	0.8% (±0.1%)
Lubusz	1.4% (±0.1%)	1.4% (±0.1%)	1.5% (±0.1%)	1.6% (±0.1%)	1.9% (±0.1%)	1.4% (±0.1%)	1.5% (±0.1%)	1.4% (±0.1%)
Lodz	7.2% (±0.1%)	7.1% (±0.1%)	6.6% (±0.1%)	6.7% (±0.2%)	6.3% (±0.1%)	7.2% (±0.1%)	7.4% (±0.1%)	7.0% (±0.1%)
Lesser Mazowieckie	10.9% (±0.1%)	11.2% (±0.2%)	11.8% (±0.2%)	11.3% (±0.2%)	11.6% (±0.2%)	11.4% (±0.2%)	10.5% (±0.2%)	11.3% (±0.2%)
Opole	33.6% (±0.2%)	32.0% (±0.3%)	30.8% (±0.3%)	28.6% (±0.2%)	29.0% (±0.2%)	32.0% (±0.3%)	31.6% (±0.3%)	31.1% (±0.2%)
Subcarpathian	1.1% (±0.1%)	1.1% (±0.1%)	1.1% (±0.1%)	1.2% (±0.1%)	1.2% (±0.1%)	1.2% (±0.1%)	1.2% (±0.1%)	1.1% (±0.1%)
Podlasie	2.0% (±0.1%)	2.4% (±0.1%)	3.4% (±0.1%)	3.1% (±0.1%)	2.8% (±0.1%)	2.4% (±0.1%)	1.8% (±0.1%)	2.8% (±0.1%)
Pomeranian	1.8% (±0.1%)	1.9% (±0.1%)	1.7% (±0.1%)	1.6% (±0.1%)	1.5% (±0.1%)	1.9% (±0.1%)	1.4% (±0.1%)	1.7% (±0.1%)
Silesian	6.2% (±0.1%)	6.3% (±0.1%)	6.8% (±0.2%)	7.3% (±0.1%)	6.5% (±0.1%)	6.3% (±0.1%)	6.5% (±0.1%)	6.7% (±0.1%)
Świętokrzyskie	6.1% (±0.1%)	6.2% (±0.1%)	6.2% (±0.1%)	8.2% (±0.1%)	8.3% (±0.1%)	6.2% (±0.1%)	5.6% (±0.1%)	6.8% (±0.1%)
Warmia-Masurian	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)	0.7% (±0.1%)	0.8% (±0.1%)	0.7% (±0.1%)
Greater West Pomeranian	2.1% (±0.1%)	1.9% (±0.1%)	2.0% (±0.1%)	2.1% (±0.1%)	2.1% (±0.1%)	1.9% (±0.1%)	2.2% (±0.1%)	2.0% (±0.1%)
West Pomeranian	7.0% (±0.2%)	6.8% (±0.2%)	6.7% (±0.3%)	6.4% (±0.2%)	6.7% (±0.2%)	6.8% (±0.2%)	7.5% (±0.2%)	6.7% (±0.2%)
Total	2.6% (±0.1%)	3.0% (±0.1%)	3.0% (±0.1%)	3.5% (±0.1%)	3.5% (±0.1%)	3.0% (±0.1%)	5.3% (±0.1%)	3.1% (±0.1%)
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

References

- Rulkiewicz, A.; Pilchowska, I.; Lisik, W.; Pruszczyk, P.; Ciurzyński, M.; Domienik-Karłowicz, J. Prevalence of Obesity and Severe Obesity among Professionally Active Adult Population in Poland and Its Strong Relationship with Cardiovascular Co-Morbidities-POL-O-CARIA 2016–2020 Study. *J. Clin. Med.* **2022**, *11*, 3720. [CrossRef] [PubMed]
- Powell-Wiley, T.M.; Poirier, P.; Burke, L.E.; Després, J.P.; Gordon-Larsen, P.; Lavie, C.J.; Lear, S.A.; Ndumele, C.E.; Neeland, I.J.; Sanders, P.; et al. Obesity and Cardiovascular Disease: A Scientific Statement From the American Heart Association. *Circulation* **2021**, *143*, e984–e1010. [CrossRef]
- Wysocki, M.; Łabul, M.; Małczak, P.; Proczko-Stepaniak, M.; Szymański, M.; Hady, H.R.; Głuszyńska, P.; Myśliwiec, P.; Walędziak, M.; Zarzycki, P.; et al. Analysis of the risk factors for perioperative morbidity after laparoscopic revisional bariatric procedures: Results from the multicenter Polish Revision Obesity Surgery Study. *Surg. Obes. Relat. Dis. Off. J. Am. Soc. Bariatric Surg.* **2023**, *19*, 68–75. [CrossRef]

4. NCD Risk Factor Collaboration. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: A pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. *Lancet* **2017**, *390*, 2627–2642. [[CrossRef](#)] [[PubMed](#)]
5. Riedel, O.; Braitmaier, M.; Dankhoff, M.; Hornschuch, M.; Klein, M.; Zachariassen, W.; Hoyer, J. Quality of life in bariatric patients up to twelve years after surgery—Results from a nationwide retrospective cohort study. *Obes. Res. Clin. Pract.* **2023**, *17*, 353–360. [[CrossRef](#)] [[PubMed](#)]
6. Domienik-Karłowicz, J.; Dzikowska-Diduch, O.; Lisik, W.; Chmura, A.; Pruszczyk, P. Short-term cardiometabolic risk reduction after bariatric surgery. *Hell. J. Cardiol.* **2015**, *56*, 61–65.
7. Soroceanu, R.P.; Timofte, D.V.; Danila, R.; Timofeiov, S.; Livadariu, R.; Miler, A.A.; Ciuntu, B.M.; Drugus, D.; Checherita, L.E.; Drochioiu, I.C.; et al. The Impact of Bariatric Surgery on Quality of Life in Patients with Obesity. *J. Clin. Med.* **2023**, *12*, 4225. [[CrossRef](#)] [[PubMed](#)]
8. Reilly, J.J.; El-Hamdouchi, A.; Diouf, A.; Monyeki, A.; Somda, S.A. Determining the worldwide prevalence of obesity. *Lancet* **2018**, *391*, 1773–1774. [[CrossRef](#)] [[PubMed](#)]
9. Badimon, L.; Bugiardini, R.; Cenko, E.; Cubedo, J.; Dorobantu, M.; Duncker, D.J.; Estruch, R.; Milicic, D.; Tousoulis, D.; Vasiljevic, Z.; et al. Position paper of the European Society of Cardiology—working group of coronary pathophysiology and microcirculation: Obesity and heart disease. *Eur. Heart J.* **2017**, *38*, 1951–1958. [[CrossRef](#)] [[PubMed](#)]
10. Keum, N.; Greenwood, D.C.; Lee, D.H.; Kim, R.; Aune, D.; Ju, W.; Hu, F.B. Adult weight gain and adiposity-related cancers: A dose-response meta-analysis of prospective observational studies. *J. Natl. Cancer Inst.* **2015**, *107*, djv088. [[CrossRef](#)] [[PubMed](#)]
11. Bjørge, T.; Häggström, C.; Ghaderi, S.; Nagel, G.; Manjer, J.; Tretli, S.; Ulmer, H.; Harlid, S.; Rosendahl, A.H.; Lang, A.; et al. BMI and weight changes and risk of obesity-related cancers: A pooled European cohort study. *Int. J. Epidemiol.* **2019**, *48*, 1872–1885. [[CrossRef](#)] [[PubMed](#)]
12. Gutiérrez-Cuevas, J.; Sandoval-Rodríguez, A.; Meza-Rios, A.; Monroy-Ramírez, H.C.; Galicia-Moreno, M.; García-Bañuelos, J.; García-Bañuelos, J.; Santos, A.; Armendariz-Borunda, J. Molecular Mechanisms of Obesity-Linked Cardiac Dysfunction: An Up-Date on Current Knowledge. *Cells* **2021**, *10*, 629. [[CrossRef](#)] [[PubMed](#)]
13. Hall, M.E.; Cohen, J.B.; Ard, J.D.; Egan, B.M.; Hall, J.E.; Lavie, C.J.; Ma, J.; Ndumele, C.E.; Schauer, P.R.; Shimbo, D.; et al. Weight-Loss Strategies for Prevention and Treatment of Hypertension: A Scientific Statement From the American Heart Association. *Hypertension* **2021**, *78*, e38–e50. [[CrossRef](#)] [[PubMed](#)]
14. Gutiérrez-Cuevas, J.; Santos, A.; Armendariz-Borunda, J. Pathophysiological Molecular Mechanisms of Obesity: A Link between MAFLD and NASH with Cardiovascular Diseases. *Int. J. Mol. Sci.* **2021**, *22*, 11629. [[CrossRef](#)] [[PubMed](#)]
15. Shields, M.; Tremblay, M.S. Sedentary behaviour and obesity. *Health Rep.* **2008**, *19*, 19–30. [[PubMed](#)]
16. Zawadzka, K.; Więckowski, K.; Stefura, T.; Major, P.; Szopa, M. Current Knowledge and Perceptions of Bariatric Surgery among Diabetologists and Internists in Poland. *J. Clin. Med.* **2022**, *11*, 2028. [[CrossRef](#)] [[PubMed](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.



Komisja Bioetyczna przy Warszawskim Uniwersytecie Medycznym

Tel.: 022/ 57 - 20 -303
Fax: 022/ 57 - 20 -165

ul. Żwirki i Wigury nr 61
02-091 Warszawa

e-mail: komisja.bioetyczna@wum.edu.pl
www.komisja-bioetyczna.wum.edu.pl

Warszawa, dnia 09.10 2023

AKBE/ 276/ 2023

Dr hab .n.med. Justyna Domienik-Karłowicz
Klinika Chorób Wewnętrznych i Kardiologii
Z Centrum Diagnostyki i Leczenia Żylnej
Choroby Zakrzepowo-Zatorowej,
ul. Lindley'a 4
02-005 Warszawa

OŚWIADCZENIE

Niniejszym oświadczam, że Komisja Bioetyczna przy Warszawskim Uniwersytecie Medycznym w dniu 09 października 2023 r. przyjęła do wiadomości informację na temat badania pt. " Czynniki ryzyka sercowo-naczyniowego w populacji aktywnych zawodowo Polaków." Przedstawione badanie nie stanowi eksperymentu medycznego w rozumieniu art. 21ust.1 ustawy z dnia 5 grudnia 1996 r. o zawodach lekarza i lekarza dentystry (Dz.U. z 2018 r poz. 617) i nie wymaga uzyskania opinii Komisji Bioetycznej przy Warszawskim Uniwersytecie Medycznym, o której mowa w art. 29 ust.1 ww. ustawy.

Przewodnicząca Komisji Bioetycznej

Prof. dr hab. n. med. Magdalena Kuźma –Kozakiewicz