







Risk factors for prostate cancer: A review

Czynniki ryzyka wystąpienia raka gruczołu krokowego – praca przeglądowa

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ABSTRACT

Prostate cancer is one of the most frequently diagnosed malignancies in men worldwide. Geographic variations in incidence and mortality suggest a significant role of both genetic and environmental factors. A literature review was conducted, covering 220 scientific articles published in the last 10 years, among the databases PubMed, Embase, and Cochrane Central. The analysis focused on risk factors for prostate cancer, including age, genetic predisposition, lifestyle, diet, comorbidities, and pharmacotherapy. The non-modifiable risk factors were age over 50, positive family history, and genetic predispositions (e.g., *BRCA2* or *HOXB13* mutations). Among the modifiable factors, obesity and diets rich in saturated fats, red and processed meat, and dairy products were associated with increased risk. Conversely, the consumption of tomatoes, soy products, coffee, and tea was linked to reduced risk. Associations with physical activity, alcohol consumption, smoking, and the use of metabolic drugs remain inconclusive. Identifying prostate cancer risk factors is crucial for the development of preventive strategies. Promoting healthy lifestyle habits, maintaining proper body weight, and adopting a balanced diet may significantly reduce risk. Although many factors are non-modifiable, their recognition enables more personalized prevention and diagnostic approaches.

KEYWORDS

risk factors, prostate cancer, prevention

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STRESZCZENIE

Rak gruczołu krokowego jest jednym z najczęściej diagnozowanych nowotworów złośliwych u mężczyzn na świecie. Zróżnicowanie geograficzne zachorowalności i umieralności sugeruje istotną rolę zarówno czynników genetycznych, jak i środowiskowych. Przeprowadzono przegląd literatury obejmujący 220 artykułów naukowych z baz PubMed, Embase i Cochrane Central, opublikowanych w ciągu ostatnich 10 lat. Analizowano czynniki ryzyka raka prostaty, w tym wiek, predyspozycje genetyczne, styl życia, sposób odżywiania, obecność chorób współistniejących oraz stosowaną farmakoterapię. Do niemodyfikowalnych czynników ryzyka zalicza się wiek powyżej 50 lat, dodatni wywiad rodzinny i predyspozycje genetyczne (m.in. mutacje *BRCA2*, *HOXB13*). Wśród czynników modyfikowalnych otyłość, dieta bogata w tłuszcze nasycone, czerwone i przetworzone mięso oraz nabiał wiązały się ze zwiększonym ryzykiem wystąpienia raka. Z kolei spożycie pomidorów, produktów sojowych, kawy i herbaty wiązało się ze zmniejszeniem ryzyka. Zależności dotyczące aktywności fizycznej, spożycia alkoholu, palenia tytoniu i stosowania leków metabolicznych pozostają niejednoznaczne. Rozpoznanie czynników ryzyka raka prostaty ma istotne znaczenie dla opracowania strategii profilaktycznych. Kluczowe jest promowanie zdrowego stylu życia, utrzymanie prawidłowej masy ciała oraz odpowiedniej diety. Choć wiele czynników jest niemodyfikowalnych, ich rozpoznanie umożliwia bardziej spersonalizowane podejście w profilaktyce i diagnostyce.

SŁOWA KLUCZOWE

czynniki ryzyka, rak prostaty, profilaktyka

Introduction

Prostate cancer is one of the most commonly diagnosed malignant neoplastic diseases in men worldwide. According to data from 2020, it accounted for 14.1% of all cancer cases overall [1]. In 2020, there were 1,414,249 cases of this cancer worldwide and 375,000 deaths from it, making it the fifth leading cause of cancer deaths globally. Global Cancer Observatory epidemiological data from 2020 showed that prostate cancer was the most common cancer in 112 out of 185 countries worldwide, accounting for over 60% [2,3]. The highest number of new cases is observed in Western and Northern European countries, while the highest mortality rates are recorded in the Caribbean and Central Africa. The lowest rates of both incidence and mortality from prostate cancer were recorded in Asian countries. The variation in the incidence and mortality rates between different regions of the world may be partly due to ethnicity [1,2,3].

Due to epidemiology, in order to prevent prostate cancer, it is important to implement appropriate preventive measures, which include lifestyle changes and screening and diagnostic tests, which enable early detection and identification of risk factors [4,5]. A common element of prostate cancer prevention is screening, which includes testing for prostate-specific antigen (PSA), a protein produced by the prostate gland that serves as a marker. It is assumed that if the cancer is confined to the prostate and has not metastasized, it is potentially curable [6]. Currently, the diagnosis of prostate cancer is based mainly on free and total PSA concentrations, as well as prostate tissue biopsy, magnetic resonance imaging or ultrasound imaging, and assessment of prostate health index [2,7].

The aim of the narrative review was to determine the impact of selected factors – age, nutritional status, lifestyle (physical activity and diet), the presence of comorbidities, and pharmacotherapy – on the risk of prostate cancer in men.

Methods

For the purposes of this study, a detailed literature review was conducted, covering medical and scientific articles published within the last 10 years in reputable scientific journals and appearing in the databases PubMed, Embase, and Cochrane Central. A total of 220 articles containing information on risk factors for prostate cancer and the lifestyle of prostate cancer patients were analyzed. Figure 1 shows the search process.

Risk factors for prostate cancer

Among the risk factors for cancer in general, genetic, epigenetic, immunological, hormonal, environmental, and lifestyle factors are distinguished [5,8]. The factors determining the occurrence of cancer, including prostate cancer, are endogenous (internal) and exogenous (external) in nature and constitute a very complex group of determinants [4]. These factors are also divided into modifiable and non-modifiable factors. The former includes factors such as physical activity, diet, and lifestyle, i.e., factors that patients can influence. Non-modifiable factors include genetic predisposition and age [6]. The literature describes many potential factors that may be associated with the risk of prostate cancer. Among them, the best studied are factors related to the course and treatment of metabolic syndromes, the administration of hormonal drugs, nutritional factors, and the level of physical activity [5,9].

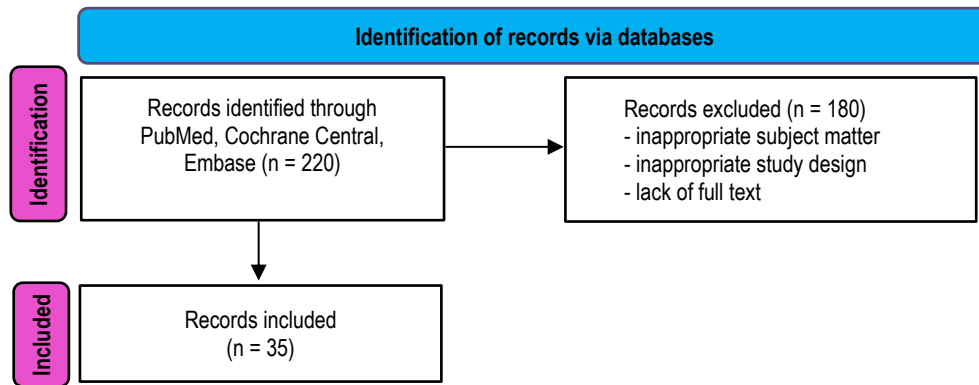


Fig. 1. Flowchart of the record search

Non-modifiable risk factors for prostate cancer

Non-modifiable factors include age, height, family history, and genetic predisposition [2]. Epidemiological studies conducted by Siegel et al. [10] indicate that age is one of the main risk factors for prostate cancer. The incidence of this cancer increases with age, and it is most commonly diagnosed in men over 65 years of age. The incidence of prostate cancer is lowest in men under 50 years of age and more common in older age groups. Among men under 30, the risk of developing the disease is 5% on average, increasing 1.7-fold every 10 years. In the over-79 age group, it reaches 59%.

Height is another non-modifiable risk factor. Research conducted by Lophatananon et al. [11] showed that height may be associated with an increased risk of prostate cancer. This study, conducted in a population of 2,480 men, showed that men taller than 180 cm are 22% more at risk than men shorter than 173 cm (OR = 1.22, 95% CI = 1.01–1.48). The potential mechanism underlying this association may be related to insulin-like growth factor levels during puberty, but further research is needed.

The risk of prostate cancer may be linked to genetic predisposition. Hereditary predisposition to cancer can significantly increase the risk of developing cancer, especially when there have been cases of the disease in close relatives [12,13]. The risk of prostate cancer depends on the number of affected relatives and the closeness of the relative (i.e., first degree vs. second degree). Brothers and sons of men with prostate cancer have an approximately 2.5-fold higher risk of being diagnosed with prostate cancer. A meta-analysis conducted by Ren and Zhu [13] showed that having a first-degree relative with breast cancer is associated with a 1.2-fold higher risk of prostate cancer. Given these findings, the patient's family history of cancer should be taken into account when estimating the risk of prostate cancer. Research in the field of prostate cancer diagnosis indicates that it may be associated with genetic predisposition. The two most common alleles that may increase the incidence of this type of cancer are mutations in the *HOXB13* and *BRCA2* genes, mutations that may occur in several genes

responsible for DNA repair pathways, such as *BRCA1*, *ATM*, *CHEK2*, or *NBS1*, and the genes involved in Lynch syndrome (*MLH1*, *MSH2*, *MSH6*, and *PMS2*) [12]. Genetic testing indicates that men who carry certain genetic mutations have a higher-than-average risk of developing prostate cancer. The risk also depends on the family history of prostate cancer and age. This information can be used to provide a more personalized assessment of prostate cancer risk in men and to tailor screening [11,12]. The genetic links to prostate cancer incidence and disease aggressiveness are variable and require further study.

Modifiable risk factors for prostate cancer

Nutritional status

Epidemiological studies on cancer have shown that nutritional status, diet, and consumption of certain foods may be associated with the occurrence of prostate cancer. The European Association of Urology (EAU) has indicated that obese patients have a lower chance of developing low-grade prostate cancer, but a higher risk of developing high-grade cancer. Research conducted by Vallières et al. [14] has shown that among men with a body mass index (BMI) equal to or greater than 30 kg/m², the risk of prostate cancer is lower, regardless of its stage. Body circumference measurements are also used to assess overweight and obesity: if the waist circumference is equal to or greater than 102 cm and the waist-to-height ratio is equal to or greater than 0.6, the risk of developing highly malignant prostate cancer increases by 33% [14,15].

Diet and intake of selected nutrients

Quantitative analyses of the diet of patients with prostate cancer did not show a correlation between the consumption of macronutrients (fats, proteins, and carbohydrates) and the risk of prostate cancer. A meta-analysis conducted by Alzahrani et al. [15] showed a higher risk of prostate cancer from milk protein (for men, consuming ≥ 30 g/day). This risk was dose-dependent, increasing with each 20 g/day of milk protein intake. This study did not find an increased risk for other animal proteins in meat or eggs, nor for plant proteins. Studies evaluating the impact of fat consumption indicate that a diet rich in saturated fatty acids



and monounsaturated fatty acids increases the risk of prostate cancer by 19% and 14%, respectively. Cirne et al. [4] showed that in the population of poorly and moderately developed countries, an increase in fat consumption is associated with a higher risk of prostate cancer.

Although high consumption of fruit, vegetables, and fiber – especially from whole grains – is recommended for the prevention of many cancers, no effect of vegetable, fruit, or fiber consumption has been observed on the occurrence of prostate cancer [16,17,18]. A meta-analysis conducted by Li and Mao [16] in a group of 281,034 men diagnosed with prostate cancer showed a correlation with high dairy consumption. In studies by Li and Mao [16] on the frequency of dairy product consumption, a lower risk of prostate cancer was observed compared to the reference group. The consumption of cow's milk was associated with a higher risk of prostate cancer incidence and mortality. Several studies indicate that high meat consumption, particularly processed meat and red meat such as beef and pork, may also contribute to a higher risk [2,8]. A study conducted by Watling et al. [18], which analyzed the medical data and medical histories of over 450,000 patients over 11 years of observation, showed that pescatarians and vegetarians who consumed meat products less than five times a week were less likely to develop any type of cancer than people who consumed meat products more than five times a week. The analysis also showed that the risk of prostate cancer was lower among pescatarians and vegetarians. Studies have shown that high consumption of beverages such as coffee and tea has a beneficial effect on reducing the risk of prostate cancer. A meta-analysis conducted by Chen et al. [19] and based on the results of 16 cohort studies showed that higher coffee consumption reduced the risk of prostate cancer. Similarly to coffee, higher tea consumption was associated with lower PSA levels and other indicators of prostate cancer [4].

Nutritional factors that may influence the development of cancer also include the supply of vitamins and minerals. The literature contains studies evaluating the relationship between the risk of prostate cancer and the intake of selected vitamins, particularly vitamins D and E. The EAU indicates that both deficiency and excessive intake may increase the risk of prostate cancer [5]. For example, a meta-analysis conducted by Gao et al. [20] showed a link between higher vitamin D levels and an increased risk of prostate cancer, although cohort studies conducted by Stroomberg et al. [21] in a group of 4,000 patients and randomized studies by Jiang et al. [22] (a group of 79,148 patients with prostate cancer) do not confirm this. Similarly, studies have not shown any significant correlation between vitamin E levels and the risk of prostate cancer. The results of nearly 30 years of research by Lawrence et al. [23] showed that serum vitamin E levels are not associated with a reduced or increased risk of prostate cancer.

Nutrition studies also cover the frequency of consumption of selected foods in relation to the risk of prostate cancer. For example, a study conducted by Cirne et al. [4], which assessed the impact of soy products on the risk of prostate cancer, showed that high consumption of these products may have a beneficial effect on reducing the risk of this cancer. Similar results were obtained in an assessment of the impact of plant product consumption, which showed that high tomato consumption may reduce the risk of prostate cancer. The results of a study conducted by Fraser et al. [24] showed that eating tomatoes more than 4 times a week is associated with a lower risk of prostate cancer. These studies compared the consumption of 64 g of tomatoes per day with 0 g of tomatoes in the diet. The effect on reducing the risk of prostate cancer may be due to the antioxidant effect of lycopene. For this reason, the EAU points out that eating tomatoes may be a factor in reducing the risk of prostate cancer, although caution is advised due to the lack of recommendations on the use of antioxidants [8].

Smoking and alcohol consumption

Research on cancer risk factors indicates that smoking and alcohol consumption are factors that increase the risk of developing various cancers due to their impact on aging processes and damage to cells and the structure of DNA [24,25,26]. Studies on the impact of alcohol and smoking on prostate cancer risk provide inconsistent results. In the case of alcohol consumption, most studies have found no effect on the risk of prostate cancer, regardless of the amount or frequency of consumption. A meta-analysis of cohort studies by Hong et al. [26] showed that alcohol consumption, regardless of type, does not affect the risk of adenocarcinoma, either its aggressive or benign forms. The results of studies on the relationship between alcohol consumption and prostate cancer are inconclusive. Despite this, the EAU indicates that high alcohol consumption increases the risk of prostate cancer by nearly 1.5 times, citing a systematic review of the literature with a meta-analysis, which shows that both low (<25 g/day) and high (>65 g/day) alcohol consumption may increase the risk of prostate cancer by 8% and 18%, respectively, compared to non-drinkers [5,26].

The EAU has a similar position on smoking, pointing out that smoking statistically significantly increases the risk of death from prostate cancer. Smoking is a modifiable environmental risk factor leading to high mortality among cancer patients [5,8]. In a meta-analysis conducted by Al-Fayez and El-Metwally [27] including a total of 17 cohort studies, 15 studies showed that smoking has an inverse correlation with prostate cancer incidence, with a relative risk of 0.84 (95% CI = 0.78–0.91). Five cohort studies in this study assessed the association between current male smokers and the risk of death from prostate cancer and showed that current smokers



had a 42% higher risk of death from prostate cancer compared to non-smokers, with a relative risk of 1.42.

Physical activity

The relationship between physical activity levels and the risk of developing prostate cancer remains unclear. Research conducted by Murray et al. [28] showed that high levels of physical activity are associated with a 13% higher risk of prostate cancer. However, the authors pointed out that men who regularly participate in sports have higher health awareness and are more likely to attend screening and periodic examinations, which may be one explanation for this phenomenon. There is little research available on the impact of physical activity on the risk of prostate cancer. In addition, these studies use heterogeneous methods, which leads to conflicting results. Due to the lack of sufficient research, it is currently not possible to draw definitive conclusions about the role that physical activity may play in the risk of prostate cancer progression [28,29]. Studies conducted by Brassetti et al. [29] showed that there is currently no answer to the question of whether high or low levels of physical activity affect the risk of prostate cancer. They indicate that future studies should take into account the clinical complexity of prostate cancer and aim to define the optimal level of physical activity in patients.

Impact of metabolic disorders on prostate cancer

Lipid disorders

Among the factors contributing to the development of cancer, including prostate cancer, the occurrence of so-called metabolic syndrome stands out, which consists of elements such as abdominal obesity, elevated blood pressure, and metabolic disorders of glucose and lipid metabolism [8,30]. Lipid profile disorders include high triglyceride, cholesterol and low-density lipoprotein (LDL) concentrations and low high-density lipoprotein (HDL) levels. In a study by Suh et al. [30] involving 1,740 people, 720 men (41.4%) were diagnosed with prostate cancer. In a multivariate logistic regression analysis, age, prostate-specific antigen (PSA), and triglyceride levels were found to significantly increase the risk of prostate cancer, while total cholesterol levels significantly reduced the risk of prostate cancer. Increased serum triglyceride levels increased the risk of both locally advanced prostate cancer and metastatic cancer. In addition, these studies showed that serum triglyceride levels increase the risk of locally advanced disease rather than organ-confined disease. Similar conclusions were reached in a meta-analysis conducted by Gacci et al. [8], who demonstrated a slight association between metabolic syndrome and a higher incidence of cancer (OR = 1.17, 95% CI = 1.00–1.36, $p = 0.04$). The relationship between triglyceride concentration and the risk of prostate cancer was also observed in a study conducted by Garrido et al. [31], which assessed the impact of total cholesterol, HDL,

LDL, and serum triglyceride levels in 237 patients undergoing prostate biopsy who had PSA levels between 2 and 10 ng/ml. The results indicate that total cholesterol levels were lower in patients with cancer, with the difference being statistically significant for LDL ($p = 0.010$) and borderline for total cholesterol ($p = 0.050$). Lipid disorders may be genetically determined. The results obtained in studies indicate that genetically determined elevated levels of lipoprotein A (modified LDL) are associated with a higher risk of prostate cancer before the age of 55 [30,31].

Diabetes and glycemic disorders

In a study conducted by Cui et al. [32], the incidence of prostate cancer was assessed in a total of over 57,000 men with and without diabetes. The results from 2012–2015 indicate that the incidence of prostate cancer was lower among men with diabetes than among men without diabetes (OR = 0.53, 95% CI = 0.33–0.83, $p = 0.006$).

Use of medications

It is assumed that in people with type II diabetes, some medications (e.g., metformin or thiazolidinedione) may reduce the risk of prostate cancer through mechanisms such as inhibiting cancer cell proliferation, inhibiting cell colony development, or preventing cancer cell invasion. This topic requires further research. A meta-analysis conducted by Cui et al. [32] based on observational studies and randomized controlled trials shows that there is no statistically significant association between the use of antidiabetic drugs and a reduced risk of prostate cancer. However, this meta-analysis indicated that the use of thiazolidinediones and glucagon-like peptide-1 (GLP-1) receptor agonists may reduce the risk of prostate cancer by affecting BMI and reducing body weight [30]. Studies on the use of GLP analogues provide conflicting results, and therefore the 2023 EAU guidelines indicate that metformin use is not associated with a reduced or increased incidence of prostate cancer. A meta-analysis conducted by Feng et al. [33], based on 18 cohort and case-control studies involving a total of 52,328 cases, showed that metformin use was not significantly associated with the risk of prostate cancer. Contrary results were provided by studies conducted by Mottet et al. [5] in people taking only metformin as an oral hypoglycemic drug, where an approximately 16% lower risk of prostate cancer was observed. Studies conducted by Drewa et al. [34] yielded similar conclusions. However, the researchers emphasize that the effect of GLP analogues may depend on their impact on periprostatic adipose tissue, metabolic syndrome, and obesity, as well as the impact of these factors on the development and progression of prostate cancer. They indicate that, due to the action of GLP-1, this group of drugs effectively reduces the symptoms of high glucose concentration and, when used long-term, may reduce the risk of developing overweight and/or obesity [34,35,36,37,38,39]. Further research is needed to determine the impact of GLP-1



analogues on the risk of prostate cancer, as it is currently unclear whether diabetes and the use of antidiabetic drugs are associated with an increased risk of prostate cancer [33,34,40]. However, studies indicate that GLP-1 receptor agonists may be a treatment option that could also bring therapeutic benefits to patients with prostate cancer [5,33,35,40].

Hormone therapy

Hormones, particularly androgens such as testosterone, also influence the risk of prostate cancer. Hormones can stimulate the growth of prostate cancer cells by binding to the androgen receptor, which is primarily responsible for mediating the physiological effects of androgens. Some hormone therapies can block androgen production or androgen receptor signaling and are therefore a primary treatment strategy for advanced prostate cancer. However, prostate cancer can also develop in patients receiving hormone therapy. Lopez et al. [36] conducted a study on testosterone replacement therapy used alone or in combination with statins in a group of over 86,000 men. The introduction of hormone replacement therapy reduced the risk of prostate cancer by 26% and by 47% in combination with statins. Nevertheless, the EAU points out that in men with hypogonadism who are treated with testosterone, no increase in the risk of prostate cancer has been observed. Additionally, in a study conducted by Watts et al. [37] based on an analysis of 20 different studies, men diagnosed with low free testosterone levels have a lower risk of developing this cancer than men whose levels are within norms. So-called 5- α -reductase inhibitors are used in the treatment of some forms of prostate cancer [37]. These drugs inhibit the enzyme 5- α -reductase, which converts testosterone into the more potent dihydrotestosterone, which, among other things, slows down prostate growth [5,37]. The EAU's position indicates that the use of 5- α -reductase inhibitors may reduce the risk of disease for International Society of Urological Pathology grade 1, but may slightly increase the risk of highly advanced prostate cancer [8]. For this reason, none of the currently available 5- α -reductase inhibitor drugs have been approved by the European Medicines Agency as a chemopreventive drug.

Comorbidities

The literature also discusses the relationship between the incidence of prostate cancer and male pattern baldness. None of the studies conducted to date have shown a link between general male pattern baldness and the risk of prostate cancer, but research by Khan

et al. [38] conducted over 22 years of observation of a group of over 36,000 men showed a link between vertex alopecia and an increased risk of prostate cancer in men under the age of 60.

Summary

Based on a review of the literature, it has been established that the main risk factors for prostate cancer are age over 50, height over 183 cm, ethnicity, genetic predisposition, and a positive family history of the disease [1,2,3,4,5,6,7,8,39]. Modifiable risk factors include BMI and waist-hip ratio (obesity and overweight), a diet rich in saturated fats, high consumption of red and processed meat [2,4,8] or dairy products, and low daily intake of legumes and certain vegetables (tomatoes) [12,16]. In addition, high consumption of coffee and tea had a beneficial effect on reducing the risk of this cancer [4,19]. The frequency of consumption of alcohol does not increase the risk of prostate cancer [5,24,26]. Studies on cigarette smoking provide inconsistent results. Nevertheless, the EAU indicates that smoking and alcohol consumption are factors that may significantly increase the risk of death from prostate cancer, although further research is needed on this topic [5,8,27]. The impact of physical activity is similar. Currently, there are not enough studies to observe the effect of physical activity on reducing the risk of prostate cancer [28,29].

Research on the relationship between comorbidities and their treatment indicates that a disturbed lipid profile (total cholesterol concentration), elevated LDL lipoprotein concentration, and genetically determined elevated lipoprotein A (modified LDL) levels are associated with a higher risk of prostate cancer [30,31]. In the case of glucose metabolism disorders, it is currently not possible to conclusively determine whether the presence of diabetes and the use of antidiabetic drugs are associated with a higher risk of prostate cancer, although some studies on GLP-1 analogues show their potential to reduce the risk of prostate cancer [32,34,40]. Due to inconsistent results, this topic requires further research.

Conclusions

Based on a review of the literature, it was concluded that modifiable factors, such as maintaining a healthy body weight and diet, may be an important preventive factor in reducing the risk of prostate cancer. Although many risk factors for this cancer are non-modifiable, the identification of overall risk factors is crucial for the prevention and treatment of this cancer.

Authors' contribution

Study design – T. Jurys, M. Grajek, E. Nowara

Data collection – T. Jurys, A. Gdańska, E. Działach

Manuscript preparation – T. Jurys, A. Gdańska, E. Nowara

Literature research – E. Nowara, E. Działach, M. Grajek

Final approval of the version to be published – T. Jurys, A. Gdańska, E. Nowara, E. Działach, M. Grajek



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