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The impact of public funding on the adoption of robotic radical prostatectomies in Poland

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Authors' Contribution:

A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Dictionary

Robotic-assisted surgery – a surgical approach that utilizes robotic systems managed by skilled surgeons to enhance precision, minimize invasiveness, and improve patient outcomes [13].

RARP – a minimally invasive surgical technique for prostate cancer that uses robotic technology to assist in prostate removal [24].

Abstract:

Background and Study Aim: In Poland, robotic technology was first used in the public healthcare financing system in 2010. However, it was not until 2022 that the public payer began to finance robotic surgeries in urology. This study aimed to evaluate is knowledge about the impact of integrating a stable funding source into the development and utilization of robotic surgery.

Material and Methods: Using data from the National Health Fund, we conducted a retrospective analysis of these procedures, focusing on radical prostatectomies from the beginning of the funding period to November 2023.

Results: The study We showed that in the first year of public funding (2022), 2,149 radical prostatectomies were performed using robotic systems, and this number almost doubled to 4,331 by October 2023. Patients aged ≥60 years accounted for >80% of those who underwent robotic surgery. The implementation of public funding for RARP (a minimally invasive surgical technique for prostate cancer that uses robotic technology to assist in prostate removal) in Poland was critical to expanding access to advanced surgical technologies, as evidenced by a doubling of the number of procedures in the second year after implementation. The role of stable public funding in enabling the rap-id adoption of robotic surgery reflects a broader trend toward precise, minimally invasive procedures that are designed to improve patient outcomes, particularly among older adults most affected by prostate cancer, who accounted for over 80% of those treated.

Conclusions: Future research to optimize resource allocation and reduce operating costs will be essential to ensure that further expansion of robotic surgery remains cost-effective and widely available, meeting the evolving needs of healthcare systems in Po-land and beyond.

Keywords: prostate cancer, public payer, RARP, robotic surgery

1. Introduction

The growing number of robotic system services indicates the progressive development of robotics in medicine and surgery [1-5]. Robotic surgery has revolutionized urology, particularly in the treatment of prostate cancer, since the early 2000s [6-9, 2, 10, 11]. Robotic systems offer improved visualization, high-resolution imaging, reduced tremor, enhanced dexterity, and improved clinical outcomes, including decreased postoperative pain, faster recovery, and lower complication rates than traditional surgery [12,13]. However, despite these benefits, adoption has been slow in regions such as Poland, mainly because of high costs and limited public funding. Robotic surgery was first introduced in Poland in 2010, and public financing began in 2022 for radical prostatectomy, an essential treatment for prostate cancer [14]. Public funding has improved access to this advanced technology, which may lead to improved outcomes in a larger patient population. Although new tools can enhance patient safety, they pose challenges that require further research and analysis.

Robotic technology in surgery

The use of robotics in urological procedures has significantly improved surgical precision, patient outcomes, and operative efficiency. Robotic systems facilitate the performance of tasks independently or under human guidance by using advanced effectors and receptors [12, 2, 13, 4, 15]. Robot-assisted surgery in urology has significantly improved the treatment of prostate cancer, offering three-dimensional visualization, increased precision, and reduced tremors [12,13]. In Poland, robotic technology was first used in 2010 at the Specialist Hospital in Wrocław to perform colorectal surgery on a 71-year-old man, and the procedures were financed by the hospital or external sources [14]. In April 2022, the Polish public health care system began financing robot-assisted radical prostatectomy under the reimbursement code "L31R – radical prostatectomy with the use of a robotic system." This funding has expanded access to robotic surgery, particularly in urology, and offers clinical benefits, such as increased precision, reduced blood loss, faster recovery, and improved patient outcomes [16]. For example, the da Vinci platform provides high-resolution 3D visualization and tremor-filtered control, enabling precise dissection and suturing, which is particularly critical in restricted pelvic anatomy during prostate surgery [12,13]. The decision to fund robotic surgery aligns with global trends in which robotics is becoming increasingly the standard of care. This change is expected to significantly improve the quality of surgical care in Poland, particularly for patients with prostate cancer, and may pave the way for broader application in other surgical specialties.

The surgical techniques of robot-assisted radical prostatectomy (RARP) exhibit variations influenced by regional preferences for robotic systems, training protocols, and surgical approaches. Predominantly, Western countries [17] and Russia [18] utilize the da Vinci system most frequently, while emerging markets like China adopt alternative platforms such as the KangDuo [17]. Individual countries may prefer different robotic platforms [19] due to availability, cost, and regulatory approval, but the basic surgical techniques remain similar. A multicenter study in Japan [20] indicated that Japanese surgeons may make specific technical modifications to suit their patient population and healthcare infrastructure. Practices in some regions may focus more on minimizing operative time [6, 17, 21], reducing healthcare costs[22, 23, 8, 6], improving final patient outcomes [22, 24, 6, 23, 8, 21, 11], and shortening the length of hospital stay [8, 17, 21, 9, 11]. Limited articles in the literature directly

address the use of RARP in individual countries. Most studies focus on comparing different robotic systems or assessing surgical outcomes without delving into how national healthcare policies, surgical training standards, and cultural factors shape the adoption and adaptation of RARP techniques. Economic factors play a crucial role in shaping surgical techniques in different countries. Laviana et al. [24] highlighted that while RARP offers improved functional outcomes, the high cost of robotic systems remains a barrier in many regions. As such, countries with limited healthcare budgets may adopt standardized, cost-effective surgical approaches, potentially leading to differences in technique performance and postoperative protocols [16] despite the literature demonstrating lower complication rates, increased safety, and improved precision of RARP. The variation in RARP techniques by country is multifaceted, encompassing differences in robotic system utilization, surgical training, perioperative practices, and economic considerations. Increased funding levels significantly increase the adoption rate of RARP in healthcare facilities, making it easier to acquire advanced robotic systems and offsetting initial and maintenance costs [22, 23, 25].

This study aimed to evaluate is knowledge about the impact of integrating a stable funding source into the development and utilization of robotic surgery.

2. Materials and Methods

This retrospective analysis was conducted using data from the National Health Fund (NFZ) database, focusing on robotic radical prostatectomy procedures in Poland. This study covers the period from April 2022, when public funding for these procedures began, to November 2023, the last month for which complete data were reported.

Data collection and sources

Data were collected from the National Health Fund (NFZ), which manages and maintains detailed records of publicly funded healthcare services in Poland. The National Health Fund collects information from healthcare providers that are reimbursed for services in the public healthcare system. Data included patient demographics, types of procedures performed, healthcare facilities, and related costs [26]. The analysis focused on medical services coded as L31R, which means 'radical prostatectomy using a robotic system'. These codes, as part of the 'Homogeneous Patient Group' (HPG) or Homogeneous Patient Groups, provide precise categorization and tracking of medical services, allowing the study to focus specifically on procedures related to robot-assisted radical prostatectomy [27]. Healthcare providers reported the number of procedures performed for the NHF and detailed patient in-formation, including age, diagnosis, and clinical information. Data were aggregated, anonymized, and made available to researchers who could access them for epidemiological research and healthcare analysis. This dataset enables researchers to analyse trends in healthcare services, such as the number of radical prostatectomies per-formed, patient outcomes, and the financial costs of such procedures over time. Data collected by the National Health Fund are helpful in retrospective analyses of medical procedures, such as the increase in the number of robot-assisted radical prostatectomies in Poland after the introduction of public financing in 2022. By comparing annual procedure volumes, patient demographics, and outcomes, researchers can assess the impact of new financing models on the availability and efficiency of healthcare services [28]. The structured and detailed data collection process of the National Health Fund provides

a solid basis for healthcare analysis, supporting clinical research, and policy decisions to improve patient care in Poland..

Inclusion and exclusion criteria

The analysis included all patients who underwent robot-assisted radical prostatectomy financed by the public health care system (NFZ) between April 2022 and November 2023. Exclusion criteria included procedures not funded by the public payer or surgeries unrelated to prostate cancer treatment.

Data standardization and financial adjustments

Financial data were adjusted using the 2018 purchasing power parity (PPP) exchange rate to allow for international comparisons, which was calculated as 1 USD = 1787 PLN. This adjustment allows for comparisons between countries by eliminating differences in price levels [16]. Final cost data were presented in Polish zloty (PLN) and U.S. dollars (USDPPP) to standardize the financial analysis and facilitate the inter-national context.

Analysis methodology

The analysis assessed vital factors, such as procedure volume, patient demographics, and healthcare costs.

The total number of robot-assisted radical prostatectomies performed during the study period was calculated. The age distribution of patients undergoing the procedure was determined and aggregated into appropriate age groups. The financial burden of robotic prostatectomies in the Polish healthcare system during the study period was analysed. The number of procedures and trends in financial expenditure were tracked and compared across age groups.

Statistical analysis

All data were analysed using descriptive statistics. Continuous variables, such as the number of procedures and associated costs, are expressed as means with standard deviations. Categorical variables such as patient age were reported as percentages. The association between the number of procedures and healthcare expenditures was also assessed to determine whether the increased use of robotic surgery had a proportional effect on healthcare costs. The correlation between the number of procedures and total healthcare expenditure was analysed to identify significant trends.

Ethical considerations

All data used in this study were obtained from publicly available NHF datasets, which ensured compliance with ethical standards regarding patient confidentiality and data protection. The NHF anonymized all patient data before making them available for analysis, thus ensuring that no personal or confidential information was available to the researchers.

3. Results

In Poland, despite the use of robotic systems since 2010 (over 13 years), it was only in mid-2022 that these procedures began to be financed by the public payer [9]. In the early period of financing radical prostatectomy procedures (the year when public funding began, 2022), the public payer financed these procedures for 2,149 patients

the following year (partial data until October 2023), almost doubling the number of patients treated using this technology to 4,331 (Figure 1).

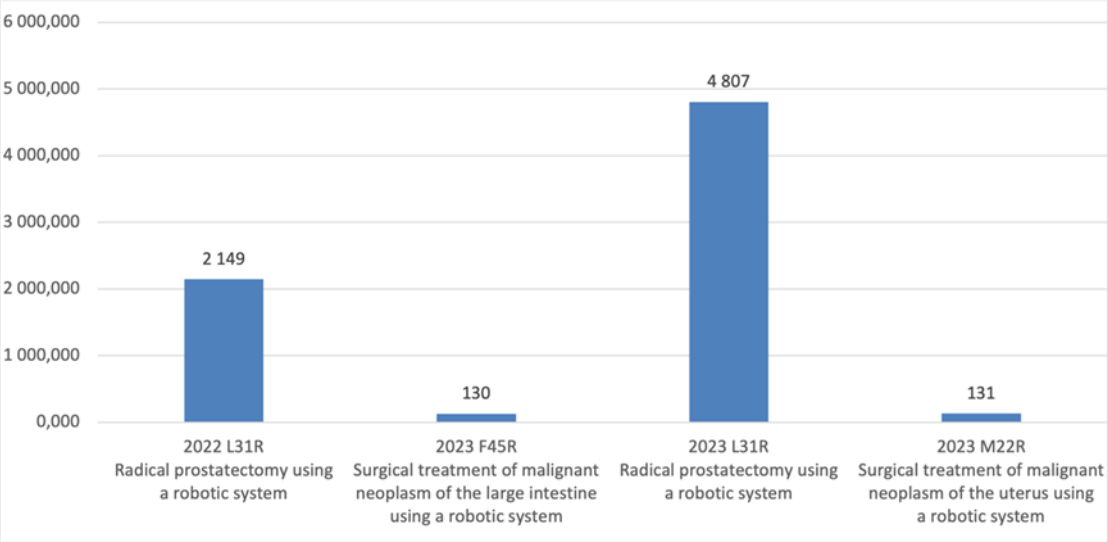

Figure 1. Number of patients receiving services using robotic technologies (own elaboration based on the National Health Fund (NFZ) databases).

Eligibility for patient qualifications involves a specific medical specialty and a confirmed malignant tumor diagnosis. Concurrently, the NFZ President's regulation [9] specified substantive conditions, particularly the surgeons' experience performing the procedures. In the initial period of financing (2022), more than 2,100 radical prostatectomies using a robotic system were performed, and in the subsequent year, an increase of more than 120% was noted (Figure 1). The rise in patient numbers correlates with public payer expenses (Figure 2), which amounted to 60,086 thousand PLN (33,207 thousand USD PPP) in 2022 and 121,262 thousand PLN (67,857 thousand USD PPP) in 2023.

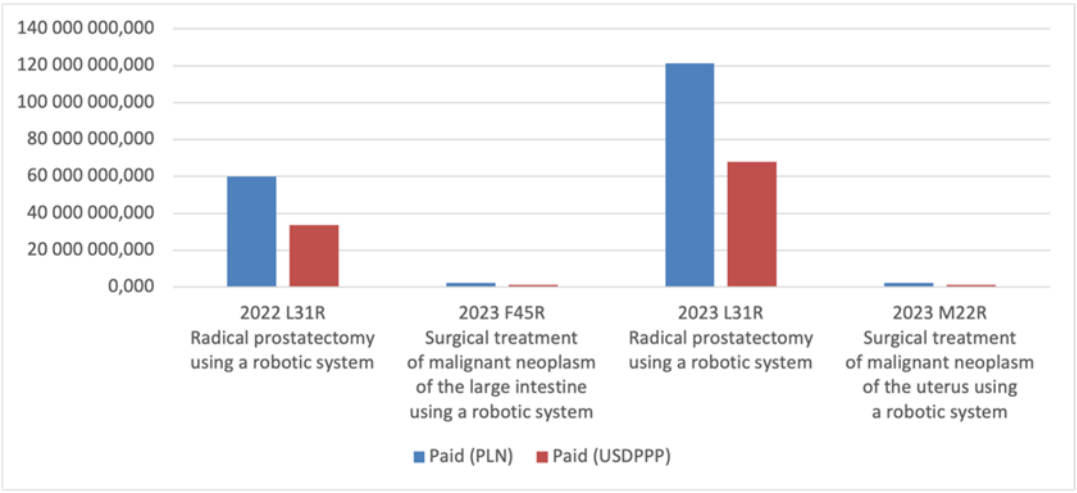

Figure 2. Public payer (NFZ) expenses related to financing healthcare services provided using robotic systems (own elaboration based on the National Health Fund (NFZ) databases).

The largest group of patients (80.79%) who underwent RARP surgery were 60 and older. The smallest group were patients aged 30-44 (0.47%) and 45-59 (18.74%). The

distribution of costs and financing in age groups was similar and amounted to an average of approximately PLN 25,000 per patient (USD 14,450 PPP).

4. Discussion

The interest and reason for conducting the study resulted from the fact that, while following the literature, it was noticed that robotic surgery had revolutionized surgical procedures, significantly improving radical prostatectomy. Robot-assisted radical prostatectomy (RARP) has become the leading surgical approach for the treatment of prostate cancer owing to its precision and minimally invasive nature. Prostate cancer remains the second leading cause of cancer-related death in men, underscoring the importance of advances in surgical treatment to improve patient outcomes [29]. Although robotic systems were introduced in Poland in 2010, their widespread use remained limited until public funding for the RARP was introduced in 2022. Prostatectomy is one of the most frequently performed procedures assisted by robotic systems [28] worldwide, including Poland. The use of robotic technology in the surgical treatment of malignant tumors highlights the need for its implementation by patients and healthcare professionals [28].

Our analysis showed a significant increase in procedures after public funding was obtained, doubling the number of patients in one year. This highlights the critical role of healthcare funding in expanding access to advanced medical technologies.

The application of robotics in medicine is global and increasingly common; this surgery technology allows for high precision, reduced operative field size, and minimized bleeding, pain, or infection risk post-surgery. The development of robotic surgery is most noticeable in the United States, where many companies focus on surgical procedures [30]. Prostatectomy is a recognized procedure in the U.S. urology field that uses surgical robots [31].

Since the U.S. Food and Drug Administration (FDA) approved the innovative da Vinci robotic platform, a fourth-generation platform has been introduced [32]. A literature analysis indicates that laparoscopic radical prostatectomy using a robotic system is the preferred form of this procedure for many patients [33, 34, 13].

Data analysis conducted in the U.K. from 2017-2019 shows that 88% of all radical prostatectomy services were performed using a robotic system [13]. As indicated, the number of radical prostatectomy procedures using surgical robots in Poland doubled after these procedures were included in the public funding catalog (Figure 1). The Minister of Health's decision results from societal demand for technological solutions in clinical practice [28]. Moreover, the increase in services the year after public funding introduction may be due to growing public awareness [28].

Over 80% of the patients in Poland who underwent radical prostatectomy using a robotic system were aged over 60 years. Factors influencing this result include the average age of cancer onset and the increasing incidence rate (at diagnosis) with age [35]. Although technological advancements are less ‘acceptable’ to older individuals (there is still a need for an essential personal patient-doctor relationship in this group) [36], they are the primary beneficiaries of services using medical robots (Figure 3). It is important to note that the application of robotic surgical systems worldwide is not limited to radical prostatectomy procedures [37, 2, 13, 4, 15. 5]. Due to its minimally invasive nature, the da Vinci robotic surgical system is also used in paediatric urology for urinary tract reconstruction procedures [38].

Studies have consistently demonstrated the ability of RARP to minimize complications, such as urinary incontinence and erectile dysfunction, which are common challenges in prostate cancer surgery. Nerve-sparing RARP has been shown to provide equivalent oncologic outcomes, such as biochemical recurrence and tumor-specific survival, compared to non-nerve-sparing techniques, even in high-risk patients. This highlights the role of RARP in preserving critical structures while maintaining effective cancer control. RARP is associated with a comparable [39] or reduced [40] incidence of lymphocele formation compared to standard open or laparoscopic surgery. Reduced incidence is primarily achieved through advanced surgical techniques, prophylactic measures [36], and specific interventions within RARP procedures implemented during RARP [41, 42]. International comparisons and cost-effectiveness: International data further support the superiority of RARP over the traditional laparoscopic methods. Robot-assisted prostatectomy has resulted in better long-term cancer control, justifying the high initial costs of robotic systems [6-8, 11]. Additionally, RARP can be safely and effectively performed in patients with comorbidities requiring anticoagulant or antiplatelet medication [43].

The relationship between funding levels and RARP adoption rates is multifaceted, including capital investment, operating costs, and institutional priorities. Bolenz et al. [44] emphasize that higher direct costs associated with RARP, including surgical instruments and robotic platforms, are a financial barrier to adoption, especially in facilities with limited budgets. Horn et al. [25] reported that institutions with increased funding can better absorb robotic surgery's initial and ongoing costs, thereby accelerating its uptake. Niklas et al. [45] noted that institutions with better financial support in Germany showed lower long-term insurance costs after RARP, providing a convincing economic argument for investing in robotic systems. Okhawere et al. [23] indicate that RARP has higher initial hospitalization costs. Still, the total annual healthcare costs are comparable to those for open radical prostatectomy (ORP) due to reduced postoperative healthcare utilization. The rapid adoption of RARP in the United States, marketing, and funding availability support the transition from open to robotic surgery Huang et al. [22]. The literature unequivocally demonstrates that the level of funding within healthcare institutions is a pivotal factor influencing the adoption rate of RARP.

Although RARP requires a significant initial investment, its ability to reduce biochemical recurrence rates and improve patient outcomes over time makes it a cost-effective treatment option for prostate cancer. These global trends are consistent with our findings in Poland, where public funding significantly increased access to robotic surgery. In addition to improving cancer control, RARP improves patient recovery and postoperative outcomes. Studies have indicated that RARP leads to shorter hospital stays, less blood loss, and faster recovery than open surgery [2, 6-11]. The minimally invasive nature of robotic surgery lowers complication rates and benefits patients and healthcare systems by reducing the costs associated with extended hospital stays and postoperative complications. Demographically, more than 80% of patients undergoing RARP in Poland are aged 60 years or older, reflecting the typical demographics of patients with prostate cancer. Older patients may be less familiar with technological advances and less likely to ask about robotic procedures if they have already undergone surgery. However, the precision and reduced invasiveness of RARP make it particularly beneficial for this age group, which is more susceptible to postoperative complications. There is also an increasing demand for RARP among older patients in Poland, which suggests an increase in public awareness of the benefits of robotic

surgery. Despite the advantages of the RARP, expanding its use in Poland is associated with financial challenges. The high cost of robotic systems, maintenance, and associated consumables still limits widespread adoption. Although public funding has significantly improved access, financial constraints may limit the availability of these procedures in some regions or patient groups.

Nevertheless, cost-effectiveness analyses in the U.K. indicate that RARP is a worthwhile long-term investment, further underlining the need for strategic resource allocation to sustain this growth [6]. In addition to its clinical and financial benefits, robotic surgery can reduce the environmental impact on healthcare. Studies indicate that RARP produces less carbon dioxide owing to shorter operating times, reduced resource consumption, and reusable materials, making it a more environmentally sustainable option [6]. Minimal invasiveness is beneficial for the postoperative recovery process. Initially, radical prostatectomy was associated with extensive blood loss [46]. With the introduction of laparoscopic and robotic surgery procedures, morbidity has been reduced [47-50]. Increased precision in preserving neural and vascular structures and improved visualization during robot-assisted surgery have reduced the rates of urinary incontinence or erectile dysfunction following robot-assisted surgery [21].

The growing environmental awareness may influence the future increase in robotic surgical system procedures [51,52]. A multicentre study conducted in 2023 [53] comparing laparoscopic and robotic surgery indicated that robotic surgical systems positively impact the global climate. The study showed that the radical prostatectomy procedure using a surgical system generates less carbon dioxide emissions due to shorter operation times, hospital stays, and reusable materials [52].

Exceptionally high interest in performing such procedures with the payer's consent was observed in the National Health Fund in Poland. Therefore, an effective attempt was made to obtain electronic data on this subject, which requires a precise description of these data for the data administrator. Only data organized in the scope accepted by the data administrator were received. Therefore, only the analysis of the obtained electronic medical data was described. In Poland, data on performed medical procedures are not combined with social data due to data collection discrepancies. Due to the full coverage of the costs of performed procedures by the payer, no correlation of such data has been sought. The above limitations also constitute a particular weakness of the research.

As healthcare systems increasingly prioritize environmental sustainability, this may further accelerate the adoption of robotic surgery. Following global trends, the use of robotic systems in Poland will likely expand to other surgical specialties. Further investment in robotic technology and research on cost-effectiveness and sustainability will be crucial for integrating robotic surgery into the Polish healthcare system.

The growing number of robotic systems services indicates the progressive development of robotics in medicine. The implemented solutions can respond to the ever-increasing demands for medical services. The precision and effectiveness of robotic technology procedures, shortening recovery and hospitalization time, can increase the availability of medical services. The increased availability of prostatectomy procedures combined with reduced postoperative complications demonstrates that RARP is an effective treatment option for prostate cancer, especially in older patients, who are the primary beneficiaries of these minimally invasive procedures. However, high robotic systems and maintenance costs remain

significant barriers to their wider adoption. Despite the long-term cost-effectiveness of RARP, further research on resource allocation and cost management is necessary to ensure its sustainable expansion.

5. Conclusions

The development of robotics in medicine and the implementation of robotic systems in clinical practice in Poland are still at an early stage compared with other countries. Meeting the challenges and needs resulting from technological progress and the direction of its development is possible owing to further implementation and improvement of solutions in the field of robotic applications in medicine in various medical specialties. Public funding for RARP in Poland has significantly increased access to this advanced surgical technology, doubling the number of procedures during the first year of implementation. The results of this study are consistent with global trends. The expected benefits of using RARP, like in the earlier technology users, include increased precision, reduced postoperative complications, faster recovery, shorter hospital stay, and significantly reduced complications, such as urinary incontinence and erectile dysfunction.

The implementation of public funding for RARP in Poland has been crucial to expanding access to advanced surgical technologies, as evidenced by the doubling of the number of procedures in the second year after implementation.

The role of stable public funding in enabling the rapid adoption of robotic surgery reflects a broader trend towards precise, minimally invasive procedures that are designed to improve patient outcomes, particularly among the older patients most affected by prostate cancer, who accounted for over 80% of those treated.

Future research into optimizing resource allocation and reducing operational costs will be essential to ensure that further expansion of robotic surgery remains economically viable and widely accessible, meeting the evolving needs of healthcare systems in Poland and beyond. Continued investment in robotic technology and research into cost management and environmental sustainability are critical to expanding access to services and improving patient outcomes across the healthcare spectrum.

Data Availability Statement: The data supporting this study's findings are available from the corresponding author upon reasonable request.

Source of support: not applicable

Conflicts of Interest: The authors declare no conflicts of interest.

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