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USE OF GIS FOR PREVENTIVE MAMMOGRAPHY SCREENING IN RELATION TO THE CHANGE IN AGE BRACKET BY THE NATIONAL HEALTH FUND

Abstract: This paper discusses and demonstrates the use of GIS for the implementation of imaging-based preventive mammography screening due to the change in the age limit of women eligible for free mammography screening by the National Health Fund.
What follows is a presentation of how GIS, Business Intelligence systems and external databases storing key patient data were used to develop a new roadmap for the implementation of mammography screening in 2024, taking into account the change related to the decision of the Ministry of Health. The changes had to be implemented in a short period of time and it was necessary to decide where preventive screenings would be performed by stationary methods and where by mobile mammobus. Another challenge was the way in which the ongoing preventive screening campaign was communicated. The effectiveness of the campaign was influenced by a multi-criteria analysis of influencing factors.

Keywords: GIS, multi-criteria optimization, ideal point, data matching, computer algorithms

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Introduction

As of 1 November 2023, the age limit for women who are entitled to free preventive mammography screening by imaging has changed in Poland (Minister zdrowia, 2023). The previous age range was 50–69 years, while the new age range approved by the Ministry of Health is 45–74 years. In addition, from 1 January 2024, the breast cancer prevention program was also extended to women who had breast cancer five years ago and had undergone cancer therapy or surgery to remove the cancer (Mammografia i cytologia, 2023]. This decision was taken as a result of the increasing incidence of breast cancer among women. In 2023, the number of potential patients eligible for mammography screening is approximately 3.4 to 3.5 million women. Around 34 percent of those eligible participate in the preventive mammography program, while in other European countries, this rate is as high as 79 to even 95 percent. This change affected the ongoing planning of the free mammography imaging campaign and the form of its delivery. It was necessary to quickly analyses both the new territorial range in which number of potential patients are located and the change in the method of carrying out the screenings from stationary screenings in offices to mobile screenings using a mammobus. The GIS system, fed with data on the number of potential patients for mammographic screening by imaging, was used to identify the areas with the largest population number of potential patients, to find the optimal centre or location where screening could be carried out, taking into account the method of screening, and to select the form of contact with patients (Gotlib et al., 2007).

Method in approach

Currently, the likelihood of developing breast cancer increases with age, with around 80% of all cases occurring in women over the age of 50. However, breast cancer is increasingly affecting younger patients, so changes have been planned to the age limit for women eligible for free mammography screening. Preventive mammographic screening by imaging currently plays a very important role in the early diagnosis of breast cancer. More than 40 per cent of the results of preventive screening results are positive indicating the presence of cancer (Mammografia u 1/3 kobiet, cytologia – u 1/5, 2009). Such patients are referred for an in-depth screening or biopsy. In order to successfully complete the task set by the Ministry of Health, it is necessary to prepare a good database indicating where a campaign of free, preventive mammography screening has the greatest number of potential and where the number of potential patients will be able to benefit from such a campaign. In order to prepare an optimal action plan, many aspects need to be taken into account. From the quality of the data to the end result. The important in preparing for the campaign were the answers to the following two questions:

1. where to carry out the free preventive mammography screening campaign in the first and subsequent quarters of 2024?
2. what is the real number of potential patients who are qualified for preventive screening?

The research methodology was developed by adopting generalized systems analysis. For the purposes of this article, systems analysis is defined as a set of methods and techniques aimed at analyzing, evaluating and making decisions in order to rationally solve certain systemic problem situations (Ameljańczyk, 1984). The methodology of systems analysis involves the following steps:

1. identification of objectives;
2. exploration of the possibilities of achieving the identified objectives, taking into account new alternative solutions;
3. assessment of all possible impacts of each option taking into account uncertainties and risks;
4. comparative analysis of the options according to the selected criteria;
5. presentation of the results in a way that allows a decision to be made.

The following are the sources of data used to determine the optimal plan for the implementation of the campaign of free imaging-based preventive screening both in stationary facilities and with the use of a mobile mammography screening point:

1. patient data from internal systems;
2. data from the National Health Fund systems, which were made available with the consent of the patients;
3. data from the medical technicians who will perform the screenings and their availability at the selected sites;
4. data to determine the location of the mammobuses in terms of where they will be parked, access to electricity and water, and the freedom to use mammography screening;
5. data on screening that have been carried out and patients are not at the new defined the number of potential patients due to the time between screenings (min. 2 years interval).

The above data and information used to prepare a map of the locations where the screenings will be carried out and the routes and locations of the mammobuses for the next two quarters in 2024. The biggest challenge was to find the points with the greatest number of potential patients for mammography screening and places.

The greatest challenge was to find the points with the greatest number of potential patients for mammographic screening and the locations where the placement of the mammobus would be optimal from the point of view of accessibility to mammography screening. Taking into account the studies carried out to date and the locations where the mammobus was usually used, the new data on the number of potential patients for change due to the change of the age range age range did not indicate the previous locations. The change was due to the change in the age range of women who could undergo free mammography and their places of residence.

In addition, some medical screening from the inpatient model performed in specialist mammography offices was transferred to medical screenings performed in a mobile basis. This is due to the fact that number potential new patients were available in a different territory than before.

Results and discussion: The data analysis process

Data analysis began with collecting large data sets from various sources after determining the data quality requirements and defining the result we want to achieve and how we plan to achieve it. In this case, data attributes such as: patient's age, gender, date of the last screening, contact details and method and possibility of contact were necessary. An additional category of data analysis is the availability of doctors and technicians to perform imaging mammography screening and ultrasound.

Then, the collected data was sorted according to specific criteria so that it could be processed in a logical manner. The next step in the analysts' work was to prepare data, detect errors, incomplete or duplicate information – this task requires considerable skills and knowledge to properly assess which data is useful and which is not. Analysts then prepared tables and charts with data to visualize them. In the next step, access to information necessary to make directional decisions was obtained using multiple analysis methods. The last process of this project is cyclical reporting, which allows decision-makers to receive the results of the analysis and visualize the conclusions and effects of the actions taken. Thanks to the reports, it is possible to correct activities on an ongoing basis and make decisions that influence a favorable final result and the achievement of the assumed goals.

A team of analysts started planning activities and how to distribute the number of potential patients both in time and on the map of Poland. Another major challenge was the quality and completeness of data, which was often incomplete and incorrectly assigned to tables. Very often, the contact details included landline phones and did not include other contact details, especially mobile phone numbers. The information that was often the only possible identification was the postal code of the town where the patient lived. The postal code is information that allows you to make the first selection of the region with an assumed the number of potential patients of over 500. This number of potential patients allows us to achieve optimal results by using the capabilities of doctors, technicians and the mammography screening center.

After determining the appropriate number of potential patients who qualify for free breast cancer prevention, the next step was to determine two key pieces of information and data that would allow answering the following questions:

1. With which institution (municipal office, fire brigade, non-governmental organizations) to organize a parking space for the Mamombus with appropriate resources, including: electricity and water?
2. What will be the beneficial method of communication so that as many patients as possible can benefit from free prevention through mammography?
3. In which region should a stationary point be used and in which a mobile point (mammobus)?

Most often, the place of stopping of the mammbus is the commune office or the seat of the local government. Very often a good place is a building with a fire brigade, very rarely it is a church. Data on the location of the above facilities were used from the GIS class system. The GIS system also indicated the number of potential patients in

territorial terms, and analysts determined on this basis the points of optimal use of this potential.

Providing information about the possibility of preventive, free mammographic screenings to elderly women is difficult. Because older women are not prone to breast screenings. This is due to old stereotypes, fear and shame. Breast ultrasound is not a complete screening of the lesions, which is why imaging mammography is such an important screening. In rural areas in Poland, many people do not use preventive screenings but use natural methods, which unfortunately fail in the case of difficult disease entities with cancer symptoms.

In addition, an appropriate awareness campaign is needed before the possibility of screening with the use of devices such as ultrasound or mammography, because it gives a chance for a greater number of patients covered by prevention. Such awareness-raising actions increase the success of the campaign by up to 40%, depending on the method and people involved in such a campaign (Kallalas, 2023). The local authority that can help you communicate effectively is either a local authority or a firefighter. The communication campaign should be simple and the message should be addressed to the right recipients, i.e. patients who are covered by a prevention program in a given area. The following tables present the number of potential patients divided into voivodships obtained after analyzes from the following systems: GIS, own internal system, external databases and after analyzing the team of analysts.

The number of potential patients for the Lower Silesian Voivodeship is presented in Fig. 1. The number of patients divided into individual smaller cities in a given voivodeship.

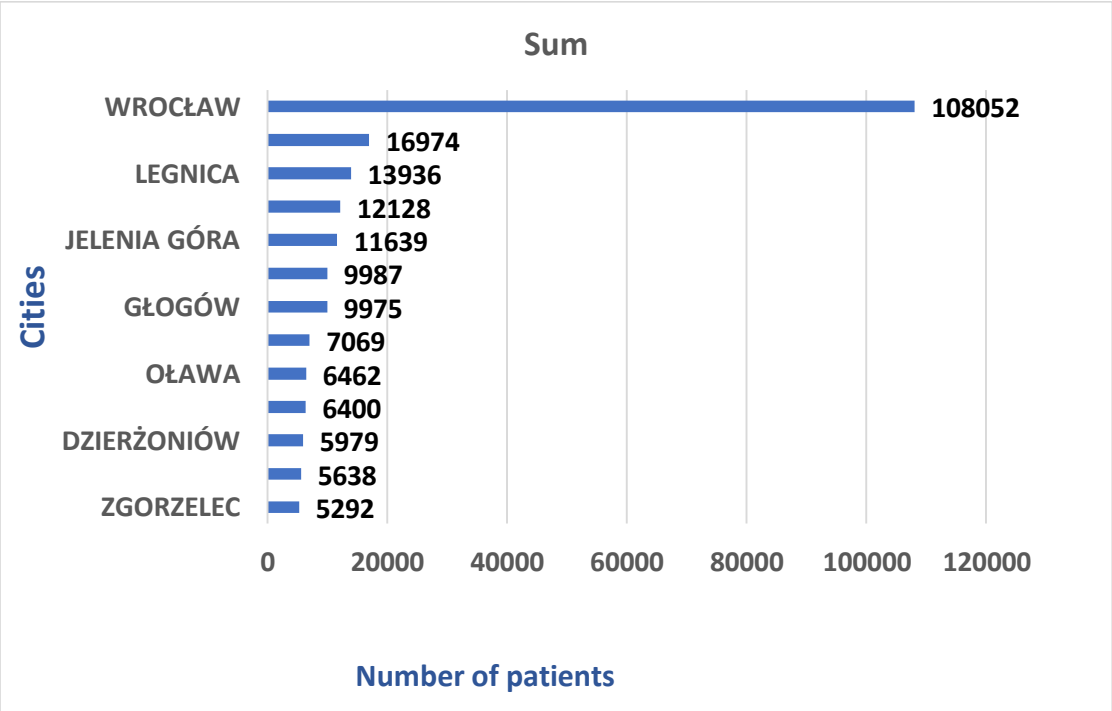

Fig. 1. Data from Lower Silesia district
Source: own study based on company data

Masovian district and data showing its number of potential patients assuming that these are cities with over 5000 patients.

The number of potential patients in other voivodeships is presented in Fig. 2 and Fig. 3.

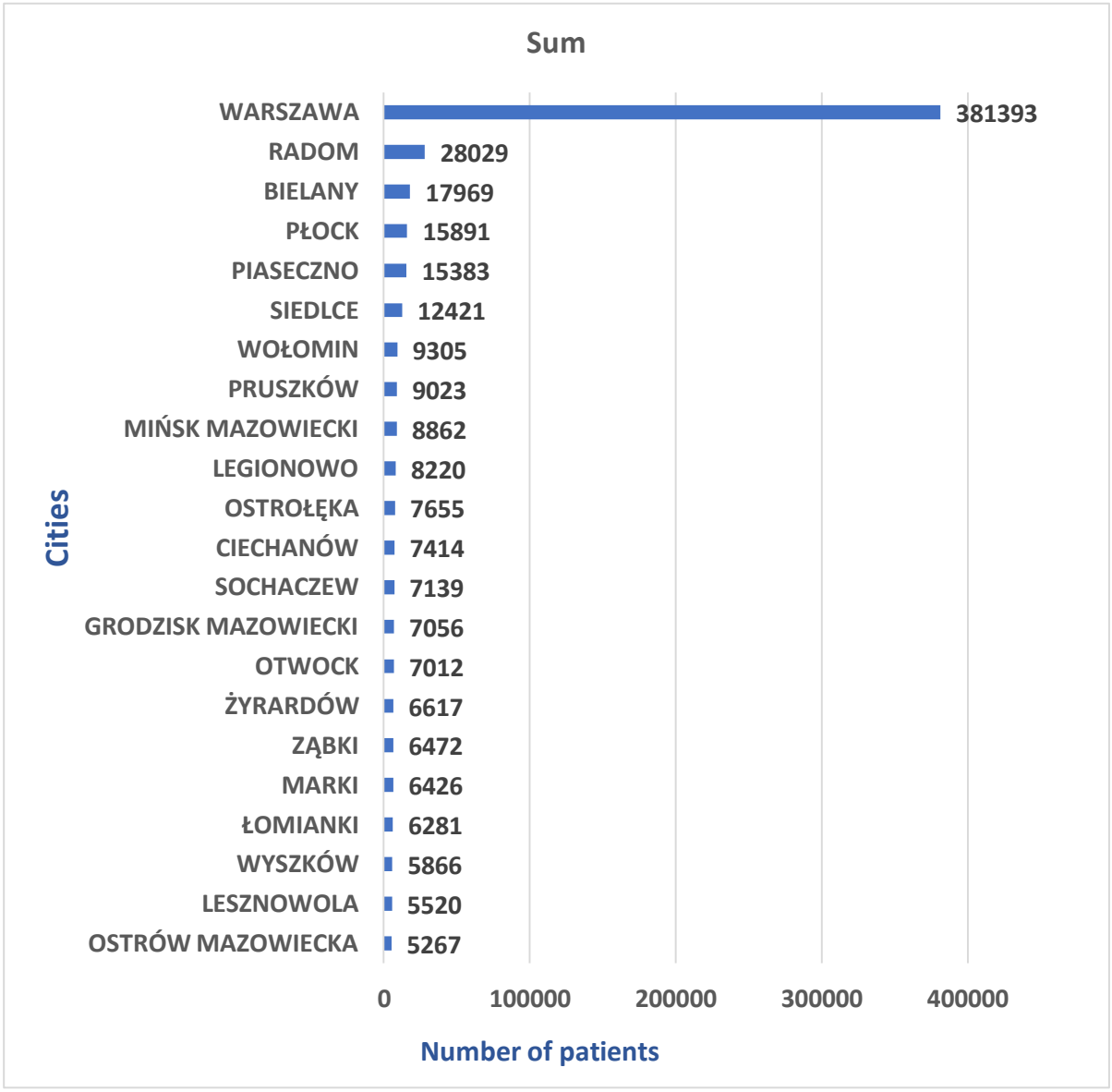

Fig. 2. Data from Mazovian district
Source: own study based on company data

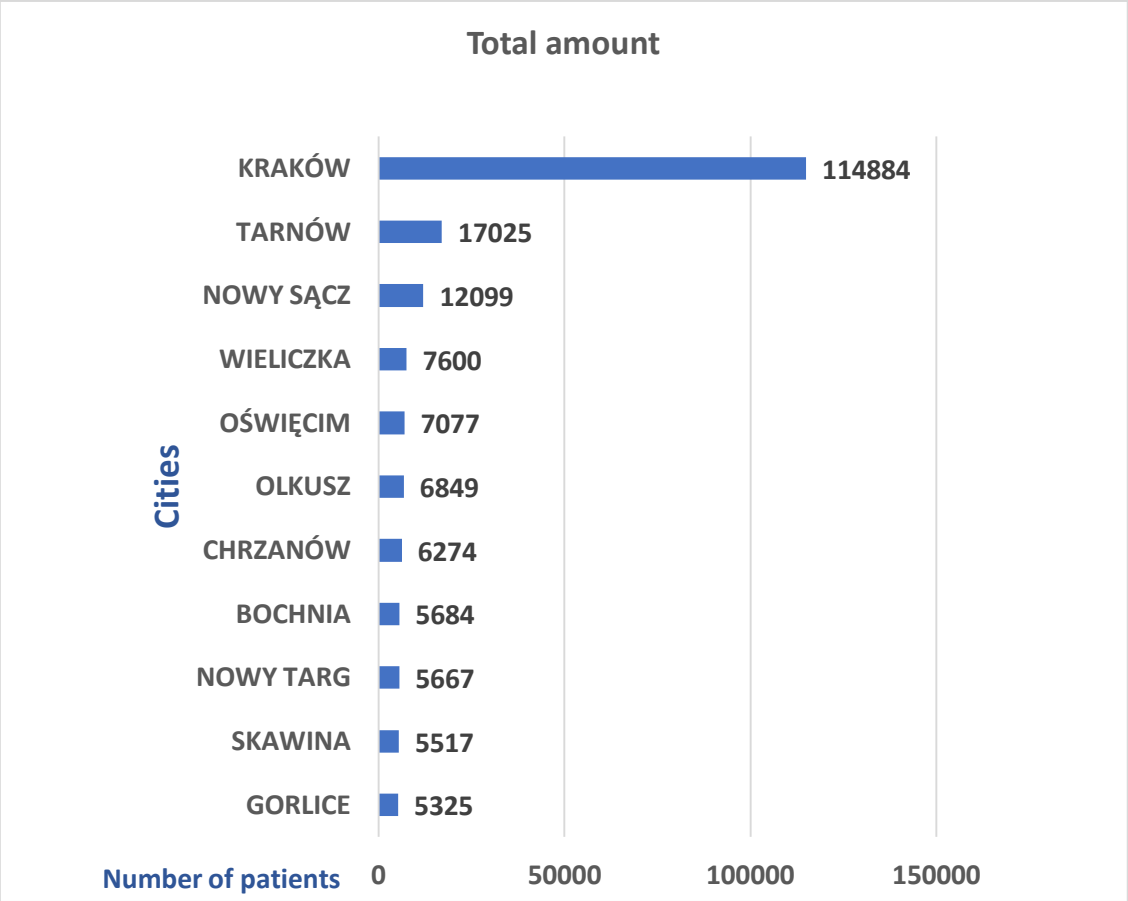

Fig. 3. Data from Małopolskie district
Source: own study based on company data

As can be seen in the above tables, there is great number of potential patients in major cities, where mammography screenings are possible at stationary points. However, smaller cities are difficult to consolidate into one point. Therefore, there was a need to add another category of data, i.e. number of potential patients from screenings from two years earlier. The repeatability of ultrasound or mammography screenings every two years will allow for the presumption that these screenings can be repeated. This overlap of data allowed us to select places where the arrival of the mammobus would be optimal. A photo of a mammobus prepared for mobile mammography screenings is shown in Fig. 4.

Fig. 4. LUX MED mobile mammography medical screening point
Source: Mammobus..., LUX MED, 2016

After the National Health Fund introduced changes to the age limit for women eligible for free mammography screening, a new age group appeared, which covers an additional 10 years the number of potential patients to be included in the preventive program. The lower and upper limits of the range have been moved by 5 years. Analysts did not face any challenges with the lower limit because younger patients are highly aware of the need for preventive screenings, and diagnostics in this age group are quite common, but older women and encouraging them to undergo screenings were a challenge. The biggest problem was the lack of direct contact – often the representative of such an elderly lady is her daughter or son. Secondly, lack of trust in people whom the person does not know. An additional problem in telephone communication was the distrust of older people resulting from various currently very popular scams. Thirdly, the means of communication of the campaign are completely different than those aimed at younger people. New number of potential patients after changes in Poland presented in Fig. 5.

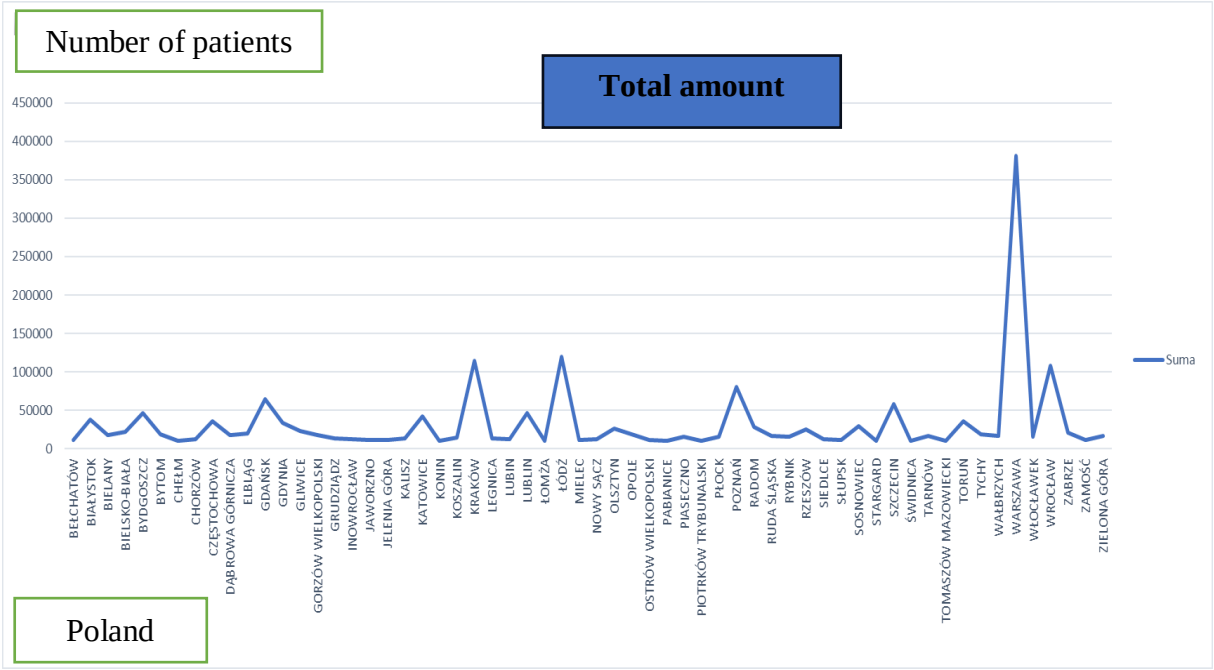

Fig. 5. New number of potential patients after changes in Poland
Source: own study based on company data

After selecting the appropriate algorithms, a database was obtained, divided into appropriate years and their potential. The effectiveness of the screenings is also influenced by the time in which the preventive screenings should be carried out. The National Health Fund provided specific funds and time for research. Therefore, all medical entities authorized to conduct screenings that have won the tender to perform these screenings must periodically report on the implementation of tasks divided into age categories and the location where they screening were performed. New number of potential patients after changes in Poland by age group presented in Fig. 6.

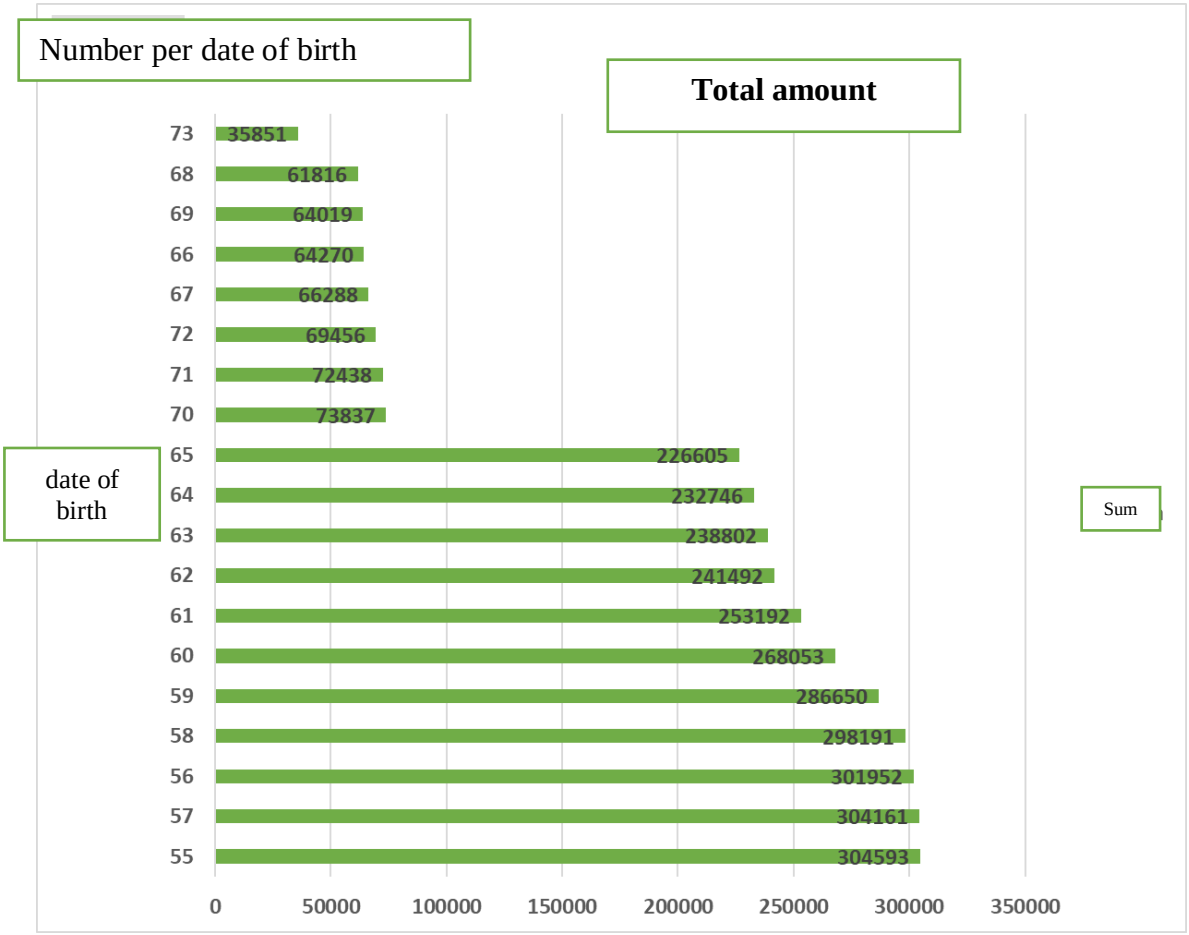

Fig. 6. New potential after changes in Poland by age group
Source: own study based on company data

After analysing the number of potential patients resulting from available data sources, an action plan was established and, using the GIS system, optimal routes and stopping places for three mammobuses were determined. Before starting activities in a given area, assistants and call centers ensured proper communication and confirmation of the campaign. This table Fig.7 shows the estimated distribution of women aged 45-74, eligible for free mammography screenings in 2024.

Voivodeship	Estimated number of eligible women
Mazowieckie	470,000 - 490,000
Śląskie	370,000 - 390,000
Wielkopolskie	290,000 - 310,000
Małopolskie	270,000 - 290,000
Dolnośląskie	240,000 - 260,000
Łódzkie	210,000 - 230,000
Pomorskie	190,000 - 210,000
Kujawsko-Pomorskie	170,000 - 190,000
Lubelskie	150,000 - 170,000
Zachodniopomorskie	140,000 - 160,000
Podkarpackie	140,000 - 160,000
Świętokrzyskie	90,000 - 110,000
Podlaskie	90,000 - 110,000
Opolskie	80,000 - 100,000
Lubuskie	80,000 - 100,000
Warmińsko-Mazurskie	80,000 - 100,000

Fig. 7. New potential after changes in Poland by voivodeship
Source: own study based on company data

It is estimated that around 20-30% of all mammography screenings under preventive programs are conducted in mobile mammography units (mammobuses). This number may vary depending on the region and the availability of mammobuses in a given voivodeship.

To develop optimal routes for mobile mammography units (mammobuses) in Poland, several key factors need to be considered:

- Population density: Mammobuses should primarily visit areas with low population density, where access to stationary centers is limited.
- Distance from stationary mammography centers: Priority should be given to areas remote from cities where stationary facilities are located.
- Participation rates in preventive screenings: Routes should focus on regions with low participation rates to increase access to screenings.
- Logistics and travel time: Routes should be planned to maximize the number of locations visited while minimizing travel time.

Using GIS tools, the optimal routes have been divided as follows:

- North-eastern Poland (Podlaskie, Warmińsko-Mazurskie): Routes focusing on rural areas and small towns.
- South-eastern Poland (Podkarpackie, Lubelskie): Routes covering mountainous regions and smaller towns, especially those farther from Rzeszów and Lublin.
- Western Poland (Lubuskie, Zachodniopomorskie): Routes in rural areas and smaller towns, far from larger centers like Zielona Góra and Szczecin.

- Central Poland (Łódzkie, Świętokrzyskie): Routes in smaller towns and villages, particularly those distant from Łódź and Kielce.

For example, in the second quarter of 2024, the mammography buses will be stationed in Mazowieckie Voivodeship at the following locations:

- Białobrzegi County
  Stara Błotnica 23 (near the library)

- Łosice County
  Huszlew 77 (near the municipal office)

- Mińsk County
  Plac Kilińskiego in Kałuszyn

- Ostrołęka County
  ul. Dzieci Polskich 1 in Myszków
  Targowa 4 in Kadzidło
  ul. Wyspiańskiego 2a in Olszewo-Borki
  ul. 3 Maja 66 in Ostrów Mazowiecka

- Ostrołęka City
  ul. Traugutta 1 in Ostrołęka

- Radom County
  ul. Bodzentyńska 17 in Iłża
  Kowala-Stępocina 105 (near the clinic)

- West Warsaw County
  ul. Piłsudskiego 2/4 in Błonie
  ul. Szkolna 2 in Kampinos
  ul. Szkolna in Leszno (near the volunteer fire brigade)
  ul. Stołeczna 145 in Zaborów

- Wołomin County
  ul. Korsaka 4 in Wołomin

- Wyszków County
  ul. Komisji Edukacji Narodowej 1 in Wyszków

Below is the map of the Mazowieckie Voivodeship and two optimal routes for the mammography buses, determined using GIS tools – Fig. 8.

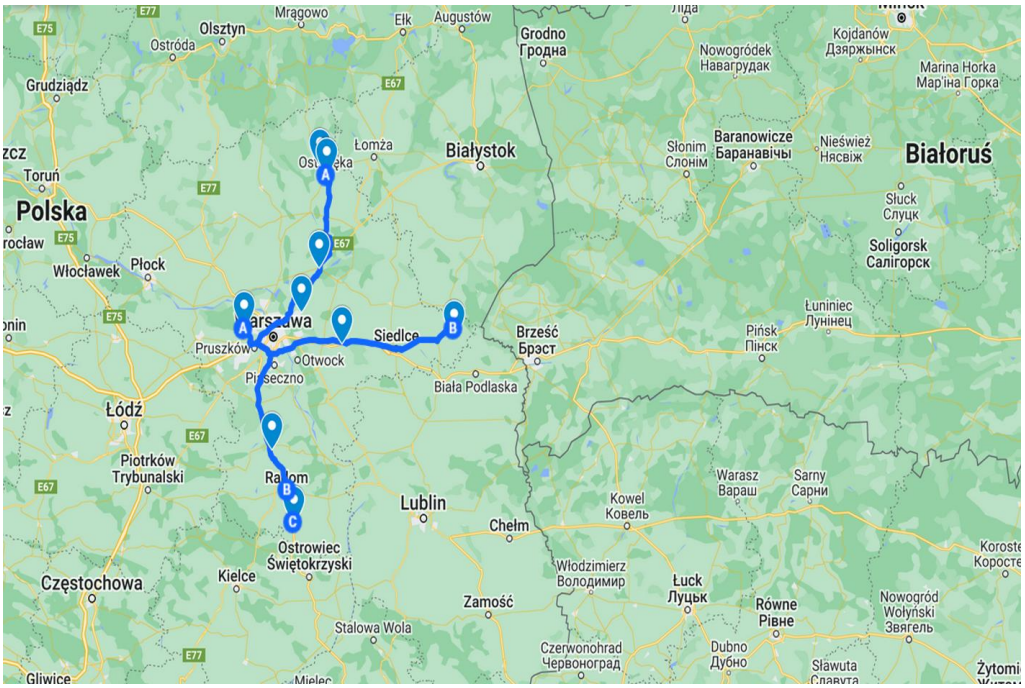

Fig. 8. Routes for the mammography buses in the Mazowieckie Voivodeship
Source: own study based on company data

The order of patients to be contacted in the Call Center system was adjusted and these queues depended on the territorial scope of the campaign planned for a given week. The percentage result of registrations for mammography screenings on 07/2023 is presented in Fig. 9.

Fig. 9. Registration for mammography screenings 07.2023
Source: own study based on company data

The first quarter of providing services according to the new guidelines showed what additional challenges the analyst team will face in the following quarters. The analysis of the call center's efficiency number of potential patients also had an impact on the results of the next quarter. The multitude of screenings performed influenced the number and order in which the screening results were described by imaging technicians. According to medical law, such screenings must be verified by at least 2 doctors, which affects the deadline for the patient to receive the results of preventive screenings. The percentage result of mammography screenings performed in 2021 is presented in Fig. 9. This is the result from the period of 2 years earlier, before the new planning, taking into account the fact that mammography screenings should not be performed more often than every 2 years.

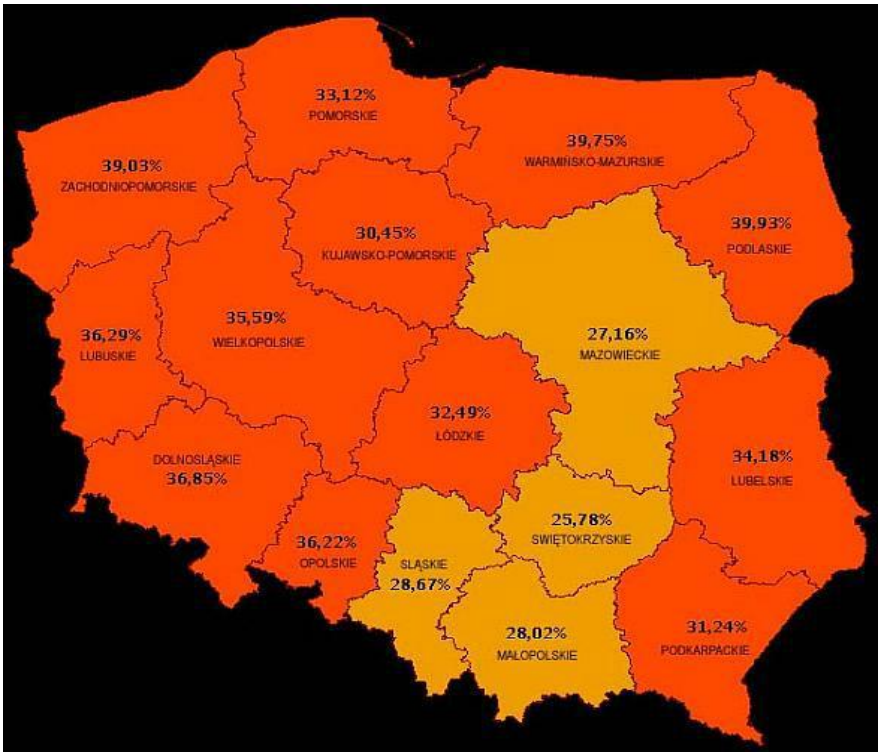

Fig. 10. Mammography in women
Source: Majewska, 2021

Conclusion

To summarize the case description, it is worth emphasizing that the use of a GIS system, together with integration with the existing data, allowed for the effective and quick reorganization of existing plans and optimization of the activities of teams responsible for the implementation of the preventive mammography imaging campaign. We managed to achieve the goal of maximum use of available resources, including teams of technicians and doctors. Thanks to this, it was possible to efficiently start the implementation of the new regulation and carry out the tasks entrusted under the new regulation.

Thanks to the integration of data from several systems, a main table was created, on the basis of which the GIS system prepared a current map, which indicated the regions that showed the greatest potential. Additionally, the created tool had an impact on the queuing of regions in terms of the greatest number of potential patients for implementing a preventive campaign of imaging screenings such as mammography. Without the GIS class tool and other tools from which data was collected, the result for the first two quarters after the changes would be based on experience and due to the new age range, the organization did not have such experience.

The use of modern systems that have AI mechanisms is helpful in carrying out multi-criteria analyzes and achieving the intended results, and, as the above example shows, it allows for the efficient implementation of changes that are unpredictable but necessary to be implemented. Thanks to such possibilities, we can influence the risk of disruption of the business continuity plan.

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