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Republic of Poland

Effective allocation of high-cost medical equipment using optimization algorithms

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Agenda

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1. Addressing the issue
2. Subject of the analysis
3. Technologies and data sources used
4. Computed tomography scanner model
5. Linear accelerator model
6. Conclusions

Addressing the issue

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- With a growing number of high-cost medical devices, there is a risk that the equipment will not be used to an appropriate extent.
- New investments in medical equipment often do not translate into improved operation of the healthcare system.
- The funds should be allocated in the way to optimize patients' access to health services.

Subject of the analysis

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The model includes the data on:

- Computed Tomography scanners
- Linear accelerators

Ultimately, we plan to expand the model to :

- Magnetic resonance imagining
- Brachytherapy devices

Technologies and data sources used in the model

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Technologies

- Julia
- Microsoft Power BI

Data sources

- National Health Fund – healthcare infrastructure, number of examinations and procedures
- Statistics Poland – demographic data

Assumptions of the CT scanner model

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- Number of ICD-9 procedures performed using CT scanners, reflects the demand for medical examinations and showed the infrastructure capabilities of a given region.
- The algorithm does not take into account the number of CT scanners already stationed, creating new map with the best allocation of the equipment from ground up, focusing on the optimal level of use.
- Districts with no devices were combined with the nearest neighboring one (distances measured between centroids) within the same voivodeship. A maximum of two districts could be included in one group.
- For the minimum number of equipment, covering the health needs, median rate of CT scanners per 100,000 population among European Union countries was taken as a reference point (2 devices).

[1]ICD-9 - International Classification of Diseases Ninth Revision

Key findings of the CT scanner model

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- The number of CT scannerss across the country has decreased by 33 – most of the substractions concern big urban areas.
- While more remote parts of the country should get additional CT scanners, a key region like Warsaw has already an overabundance of them – according to the model we should remove 27 CT scanners from that area.
- The existing infastructure is enough for the healthcare needs of the population, it is the geographical distribution that needs to change (escpecially in distant parts of the country).
- Our findings are consistent with the Polish Diagnostic Imaging Expert's Annual Report.

Power BI visualization dashboard

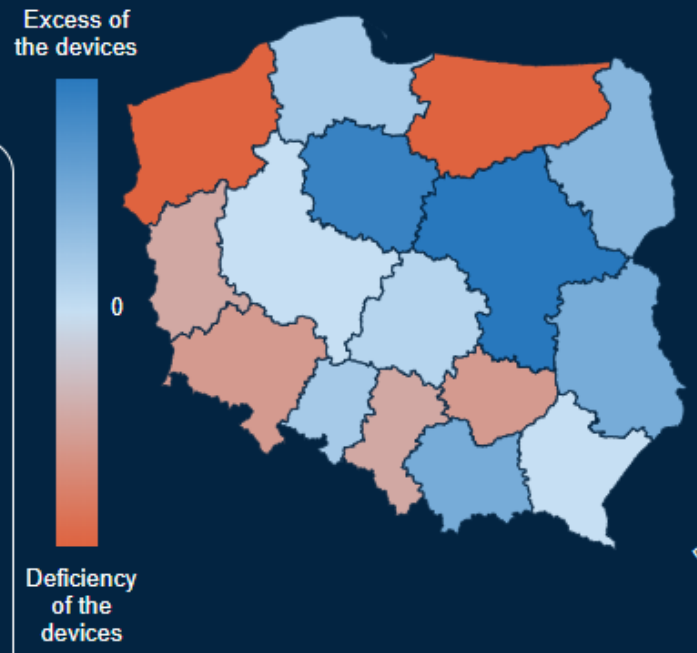
Model recommendation on allocation of CT scanners in 2022

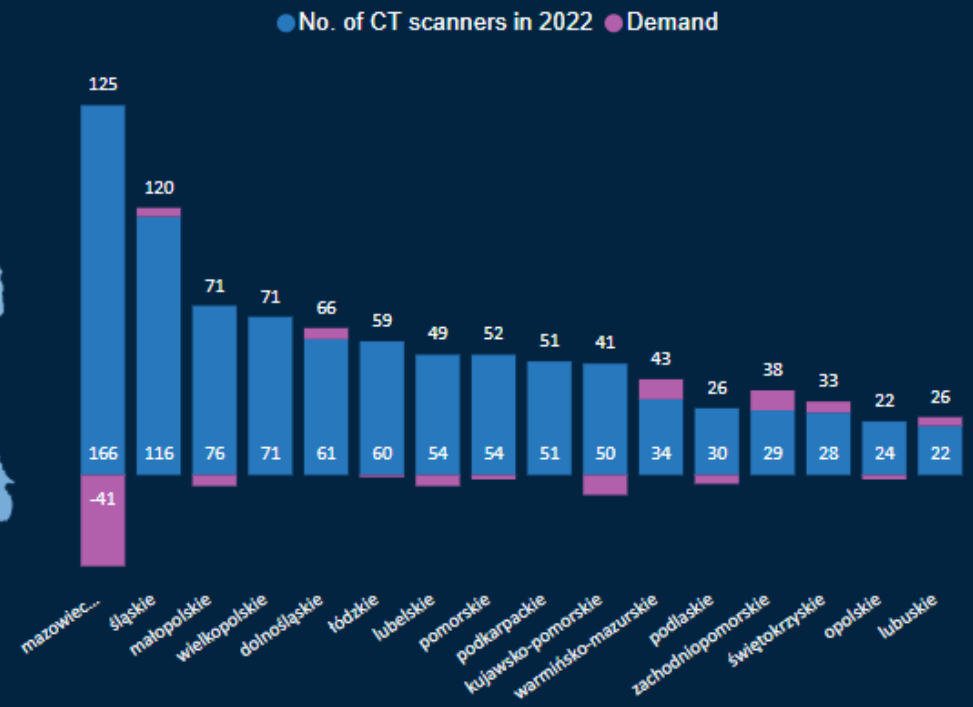
Voivodeship	No. of CT scanners in 2022	No. of CT scanners allocated by the model	Difference
mazowieckie	166	125	-41
śląskie	116	120	4
małopolskie	76	71	-5
wielkopolskie	71	71	0
dolnośląskie	61	66	5
łódzkie	60	59	-1
lubelskie	54	49	-5
pomorskie	54	52	-2
podkarpackie	51	51	0
kujawsko-pomorskie	50	41	-9
warmińsko-mazurskie	34	43	9
podlaskie	30	26	-4
zachodniopomorskie	29	38	9
świętokrzyskie	28	33	5
opolskie	24	22	-2
lubuskie	22	26	4
Suma	**926**	**893**	**-33**

District

Wszystkie

Map showing the demand for new CT scanners in the voivodeships





Voivodeship	Distric's code	Name of the district or the districts group	No. of CT scanners in 2022	No. of CT scanners allocated by the model	Difference	Imagining diagnostics doctors	Electroradiology technicians	Medical physicists
kujawsko-pomorskie	0401	aleksandrowski	1	1	0	0	11	2
podlaskie	2001	augustowski	1	1	0	5	23	0
warmińsko-mazurskie	2801	bartoszycki	2	1	-1	2	9	0
łódzkie	1001	bełchatowski	2	3	1	4	29	1
śląskie	2401	będziński	3	4	1	17	18	1
lubelskie	0601	bialski	1	1	0	0	8	0
zachodniopomorskie	3201	białogardzki	0	1	1	0	7	0
podlaskie	2002	białostocki	2	2	0	19	17	0
podlaskie	2003	bielski	1	1	0	1	12	0
śląskie	2402	bielski	2	2	0	1	23	0
Suma			**926**	**893**	**-33**			

Source: *data management system of National Health Fund*

Migrations to CT scanners

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- The addition of health spatial data (geolocation of CT scanners and patient's place of residence) and their combination with demographic data, allowed for better understanding of directions of medical migration as well as relations between place of medical services and the patient's place of residence.

- This knowledge is crucial for optimal decision-making regarding the location of new medical equipment. The results are used in current reports for the ministry's management.

Power BI visualization dashboard

Migrations to healthcare facilities using CT scanners in 2022

HEALTHCARE PROVIDER

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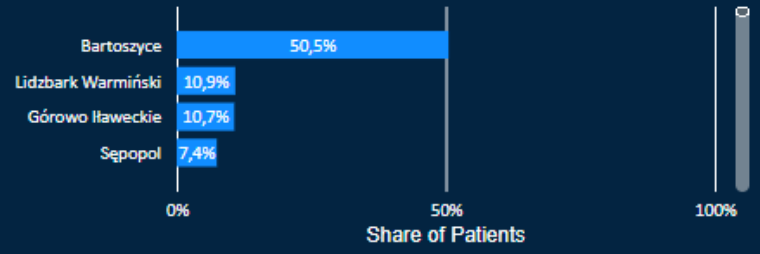
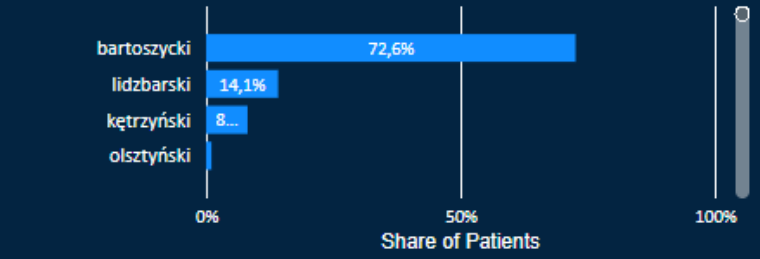
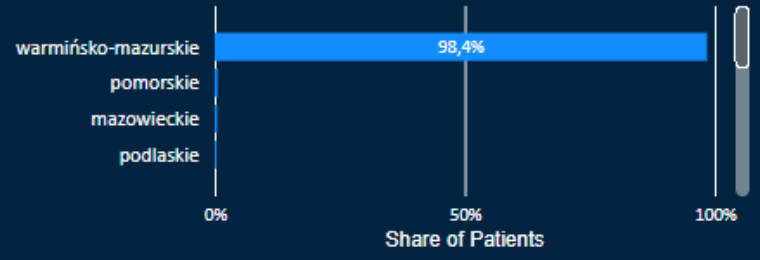
Share of Patients by Commune:



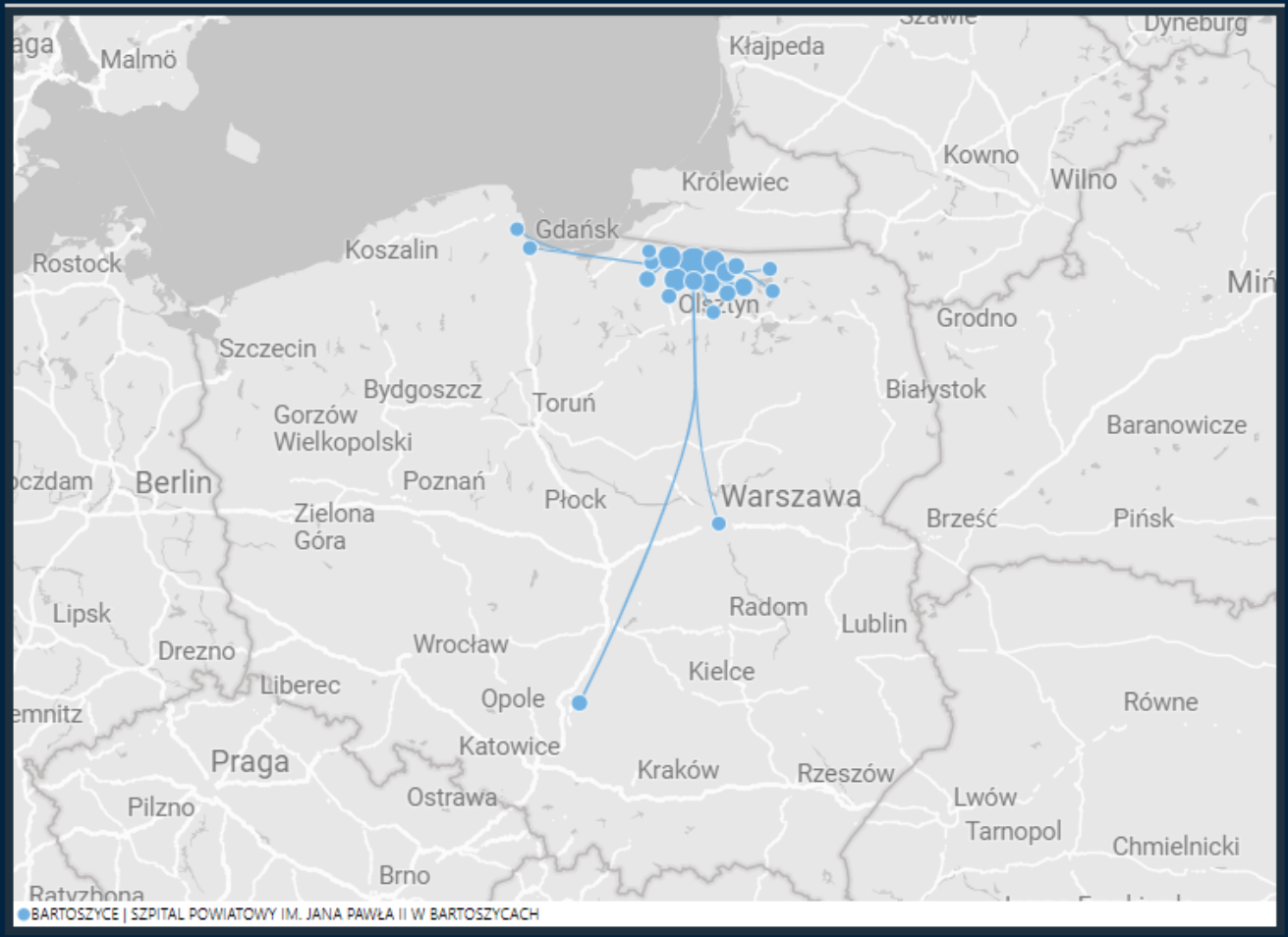
Share of Patients by District:



Share of Patients by Voivodeship:



Patient Migration to Healthcare Provider by Commune of Residence



Notes: the figure incidates communes for which the number of patients was greater than 5 people. The location of the commune is represented as its centroid (central point). The location of the healthcare provider (address) was determined based on information provided as part of reports to the National Health Fund (NFZ).

Healthcare Provider	No. of CT Scanners	No. of ICD-9	No. of Patients
BARTOSZYCE | SZPITAL POWIATOWY IM. JANA PAWŁA II W BARTOSZYCACH	1	3855	3831

Assumptions of the linear accelerator model

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- The number of accelerators in a given city in the forecasted year cannot be less than the number of accelerators already installed (i.e., the number of equipment is not reduced).
- The initial state in the model consist of 175 devices (including accelerators which will be delivered to the medical centers in near future).
- The number of patients per accelerator in the forecasted year cannot exceed 450.
- Each radiotherapy center must have at least 2 accelerators (requirement of Polish nuclear law).

Key findings of the linear accelerator forecast model

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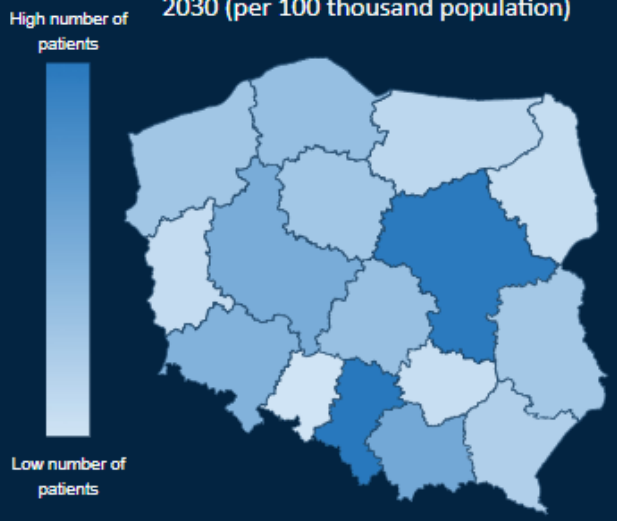
- The number of accelerators should be increased by 17 by the year 2030.
- Overall number of the accelerators will be 192 which (considering the forecast of Statistics Poland) will mean one device per 193 000 people.
- That result is consistent with recommendation of European Society of Radiotherapy and Oncology (1 device per 200 000 people).

Power BI visualization dashboard

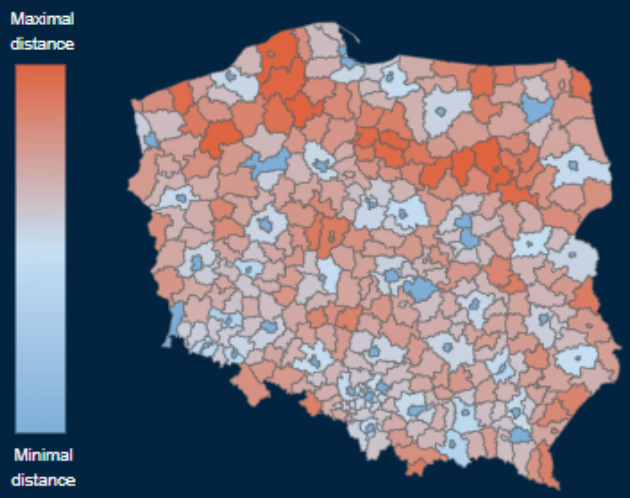
Model for optimal distribution of linear particle accelerators in year 2030

The numbers and distribution of linear particle accelerators (Accelerators 2022) were estimated based on report regarding the state of polish radiation therapy published by national consultant in the field of radiation therapy for cancer.
Two accelerators purchased in year 2023 for cancer treatment center in Płock were also included in the numbers of active linear particle accelerators presented in this publication. Model also accounts for the imminent opening of center for radiation therapy in Biała Podlaska as well as future creation of facilities dedicated to teleradiotherapy in Ełk and Leszno.
Model is based on the prognosis of patients undergoing radiation therapy treatments up to the year 2030 and minimal distances they need to travel in order to reach the nearest accelerator. The number of accelerators per 100 thousand of population should be interpreted in reference to the minimal number of a single accelerator per 200 thousand of population stated in the guidelines developed by the The European Society for Radiotherapy and Oncology. Measures of accelerator numbers were based on demographic prognosis of Statistics Poland for the year 2030.

Estimated number of patients requiring radiation therapy in year 2030 (per 100 thousand population)



Distance to the closest linear particle accelerator by county in year 2030



Voivodeship	Number of accelerators in year 2022	Demand for accelerators in year 2030
⊟ zachodniopomorskie	7	10
Koszalin	2	4
Szczecin	5	6
⊞ wielkopolskie	14	17
⊞ warmińsko-mazurskie	8	11
⊞ świętokrzyskie	5	5
⊞ śląskie	25	30
⊞ pomorskie	8	8
Suma	175	192

Voivodeship	Number of accelerators per 100 thousand population in year 2022	Number of accelerators per 100 thousand of population in year 2030
podlaskie	0,26	0,27
opolskie	0,32	0,33
pomorskie	0,34	0,34
łódzkie	0,38	0,39
małopolskie	0,44	0,44
podkarpackie	0,43	0,45
świętokrzyskie	0,42	0,45
mazowieckie	0,49	0,48
Suma	0,46	0,52

Voivodeship	District	Radiotherapists	Electroradiology technicians	Medical physicists
zachodniopomorskie	białogardzki	0	7	0
zachodniopomorskie	choszczeński	0	7	0
zachodniopomorskie	drawski	0	0	0

Source: data managment system of polish National Health Fund;
population numbers are based on data from Statistics Poland

Conclusions

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- Using data from multiple sources, we are able to forcast the demand for high-cost medical equipment and verify if the actual allocation of medical devices across Polish regions is optimal.

- Optimization provided by the algorithm can support key investments in medical equipment, identifying the demand for the high-cost medical devices of each region. It can lower the risk of misallocating resources and improve the patients' access to healthcare services.

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Let us know if you have any questions

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