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*Section: **PREVENTIVE MEDICINE FROM INNOAGON PERSPECTIVE*** *Original Paper*

Demographically adjusted demand for health care hospital treatment services for the years: 2027; 2033; 2039 and 2045 in Poland

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Authors' Contribution:

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B Data Collection
C Statistical Analysis
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Dictionary:

Preventive medicine (in the narrow sense) – the branch of medicine whose main aim is prevention of dental disease. This is a wide field, in which workers tackle problems ranging from the immunization of persons against infectious diseases, such as diphtheria or whooping cough, to finding methods of eliminating vectors such as malaria-carrying mosquitoes [42, p. 533].

Healthcare – noun the provision of medical and related services aimed at maintaining good health, especially through the prevention and treatment of disease [43].

Innovative agonology – is an applied science dedicated to promotion, prevention, and therapy related to all dimensions of health and the optimization of activities that increase the ability to survive (from micro to macro scales) [39].

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Abstract:

Background and Study Aim: Changes taking place in health systems, including the increasing life expectancy of the population, have for many decades forced researchers and analysts to take into account many factors when planning the organization and financing of health care. The cognitive aim of this paper is demand knowledge for hospital health services in medical specialties up to 2045 in Poland. The application goal is recommendations based on a more complex approach to estimate future demand for health care services of a certain type that involves age-specific health cohorts and presumed macro demographic trends.

Material and Methods: According to the position of the Polish Bioethics Commissions, the retrospective analysis of depersonalized and aggregated data does not constitute a medical experiment under current regulations and does not require an opinion of the Bioethics Commission. We used a more complex approach – Shift-Share Analysis (SSA) method. An extrapolation analysis of the demand for health services within hospital care in individual medical specialties was performed, taking into account demographic forecasts in individual age groups and data on the provision of medical services in Poland in 2015-2021, divided into medical specialties. The construction of the forecast was based on the concept of weighing the expected number of patients with appropriate correction factors that resulted from global change, age structure of patients and characteristics of medical specialties.

Results: The health care system should expect the greatest decline in the number of patients in the specialties 'neonatology' and 'infectious diseases' (average annual rate −16.75% and −13.28%, respectively). An increase in the number of patients is forecast in the specialties 'pediatric oncology and hematology' and 'audiology' (average annual rate 5.39% and 5.13%, respectively).

Conclusions: The projections presented provide a set of visions for the future of population health needs. Despite the high level of uncertainty regarding future forecasts, they provide a better assessment of the consequences of currently observed trends for health and health policy, as well as the likely impact of future trends, such as the aging of the population or the continuation of epidemiological changes.

Keywords: age groups, COVID-19 pandemic, global burden of disease, health systems, SSA method;

1. Introduction

Changes taking place in health systems, including the increasing life expectancy of the population, have for many decades forced researchers and analysts to take into account many factors when planning the organization and financing of health care [1]. Issues related to the decline in the fertility rate, the aging of the population, or the impact of unusual events, such as the COVID-19 pandemic, indicate that planning the burden on the health care system should be carried out on many levels. Despite existing knowledge about age-related trends in health, health system planning models often rely on the assumption that only current levels of health service usage are the basis for estimating resource needs to serve future populations. The limitations of these static planning models have long been recognized by health systems planning experts [2-6].

The Seyedin et al. [7] attempted to identify the key factors of demand induced by health care providers, which made it possible to identify more than 20 factors that affect the demand for health care services from the side of the health care system, payer, provider and recipient of health care, such as income levels, prosperity, technical progress and age composition of the population.

More sophisticated examples of tools for analysing future demand for health services indicate [8], the authors reach for approaches using hierarchical generalized additive models, which can provide even more flexibility to modify the model in accurate – time point. In our proposed study, we present a more complex approach to estimating future health care needs that introduces age-specific health cohort demographic trends. The overall demand for health care for the population increases as the number of the population and the average age of the population increases. The effects of the increase are mitigated by trends in the increase in the availability of health services generated mainly by economic growth, which results in the rise in health care expenditure). The presented study is a continuation of the previously initiated research on the impact of the COVID-19 pandemic on hospital health care services in Poland [9] and complements in a way, the questions related to the future demand for selected inpatient health services.

The analysis in this paper is proposes an assessment of future demand for health services within medical specialties and not a proposal for a systemic solution along the lines of agent based modelling (ABM) or system dynamics modelling (SDM) [10]. but the results of which can be incorporated into these systemic solutions as input or output data [11].

The cognitive aim of this paper is demand forecast for hospital health services in medical specialties up to 2045 in Poland. The application goal is the potential for recommendations based on a more complex approach to estimate future demand for health care services of a certain type that involves age-specific health cohorts and presumed macro demographic trends.

2. Materials and methods

Due to the multidimensional nature of socio-economic processes, one- or two-dimensional analyses are often deprecating, hence the need to use tools enabling simultaneous examination of changes in time and structure. An example would be the group of Analysis of the share of the shift (Shift-Share Analysis – SSA). The classic Shift Share analysis was introduced at the turn of the 1950s by Dunn to analyse regional economic growth [12, 13]. SSA divides the relative change (often defined as the rate of change) in values between two time points into three components: global (overall change), structural (column cross-sectional), and structural (row cross-sectional). The test values are weighted by the proportion of the reference variable from the first or second time point to standardize them. The SSA model is defined as follows:

$$tx_{r\bullet} - tx_{\bullet\bullet} = \sum_i w_{r\bullet(i)}(tx_{\bullet i} - tx_{\bullet\bullet}) + \sum_i w_{r\bullet(i)}(tx_{ri} - tx_{\bullet i}) \qquad (1)$$

where: r – index corresponding to the row cross-sections of data, i.e. r-th medical specialty, i – index of the i-th group according to the cross-sectional column division, i.e. individual age group, tx – absolute change (rate of change) of the variable x, $(tx_{r\bullet} - tx_{\bullet\bullet})$ – net effect (difference between the average change for medical specialties and the global/overall change; $(tx_{\bullet i} - tx_{\bullet\bullet})$ – structural growth factor for age groups, $(tx_{ri} - tx_{\bullet i})$ –factor differentiating growth in the i-th age group of the r-th medical specialty. On this basis, the columnar structural effect (sr) is as follows:

$$s_r = \sum_i w_{r\bullet(i)}(tx_{\bullet i} - tx_{\bullet\bullet}) \qquad (2)$$

while the differentiating effect (gr) is equal:

$$g_r = \sum_i w_{r\bullet(i)}(tx_{ri} - tx_{\bullet i}). \qquad (3)$$

Structural effect, indicates differences in structures according to specialties and explains the variability in average growth rates for specialties, while the differentiating effect occurs when changes in age structure in the first medical specialty exhibit greater dynamics than in the second specialty. Although it is possible to determine the extent to which the overall change results from structural changes and to what extent from factors differentiating specialties depending on age groups, that was not the cognitive direct goal of the study.

The Shift Share analysis can be briefly called a multidimensional index of dynamics. However, it provides much more information than, for example, aggregate group indexes. In addition to the obvious result for the components indicated earlier: global momentum, entity, and columnar structure, it allows to go deep and look for answers to what the changes are due to – whether they are the result of the of general trends or structural changes taking place (e.g., the aging of societies), or are they the result of other differentiating factors, such as those arising from specifics of a particular medical specialty. An undeniable feature of the tool, is also its analytical flexibility, which does not require any additional standardization, as this is carried out automatically inside the analytical procedure [12].

The SSA method is not an econometric model in which further explanatory variables are implemented to explain the variation of an endogenous variable. It is mainly a quantitative analysis tool that allows simultaneous analysis of a multivariate contingency table. The data contained in the contingency table are related to a single analytical category but distributed according to the structural subjective division of the table. In this way, the tool needs single variable, as presented in this study of the number of patients treated in medical specialties in at least two time points, without having to analyse the causal structure.

All methods were performed in accordance with the relevant guidelines and regulations. The character of the study constitute of an extrapolation analysis of the demand for health services within hospital care in individual medical specialties taking into account demographic forecasts in individual age groups. The analysis used data on the provision of medical services in Poland in 2015-2021, divided into medical specialties (Table 1).

Table 1. The list of medical specialties included in the analysis (in alphabetic order).

	Medical specialty		Medical specialty		Medical specialty
1	allergology	15	geriatrics	29	oncological surgery
2	anesthesiology	16	gynecological oncology	30	ophthalmology and pediatric ophthalmology
3	angiology	17	hematology	31	orthopedics and pediatric orthopedics
4	audiology	18	highly specialized services and surgeries for heart defects and thoracic aorta	32	otolaryngology and pediatric otolaryngology
5	cardiac surgery and pediatric cardiac surgery	19	immunology and pediatric immunology	33	pediatric oncology and hematology
6	cardiology and pediatric cardiology	20	infectious diseases and childhood infectious diseases	34	pediatric surgery
7	chest surgery	21	infectious diseases and childhood infectious diseases	35	pediatrics
8	clinical oncology and pediatric clinical oncology	22	internal diseases	36	plastic surgery and pediatric plastic surgery
9	clinical toxicology	23	lung diseases and pediatric lung diseases	37	radiotherapy and brachytherapy
10	dermatology and pediatric dermatology	24	maxillofacial surgery and pediatric maxillofacial surgery	38	rheumatology and pediatric rheumatology
11	diabetes and pediatric diabetes	25	neonatology	39	transplantology and pediatric transplantology
12	endocrinology and pediatric endocrinology	26	nephrology and pediatric nephrology	40	urology and pediatric urology

	Medical specialty		Medical specialty		Medical specialty
13	gastroenterology and pediatric gastroenterology	27	neurology and pediatric neurology	41	vascular surgery
14	general surgery	28	obstetrics and gynecology		

The need to use different divisions of structures was related to the generally prevailing opinion, e.g. of the decreasing demand for specialist services for children, with the dynamically increasing demand for geriatric services and oncological care. In order to determine the appropriate forecast correction factors, the Shift-Share tool was used, which allowed the determination of three components for the total change, the so-called general change resulting from the overall tendency of changes in a complex phenomenon, change resulting from structural division and change resulting from subject division, comparing two time points for multivariate data [15].

The construction of the forecast was based on the concept of weighing the expected number of patients with appropriate correction factors:

$$y_i^{r*} = (\sum(w_i, w_r + 1 + t_x) y_i^r,$$

Where: y_i^{r*} is the value of the forecast of the patients population in the r-th medical specialty and i-th age group, wi – correction parameter for column-row structure, wr – correction coefficient for row structure, tx. is the overall/global rate of change, and y_i^r is the actual value of the number of patients. The structure of the forecast shows that the expected population number in particular age groups and medical specialties changes both according to column-row correction coefficients and at the assumed rate of change estimated for the total patients population. The coefficients are calculated on an ongoing basis, which allows for taking into account, for example, demographic trends or health needs for specific types of services. In order to include the demographic trends in HHS data base firstly was recalculated in accordance with prognosis of Statistics Poland Forecast. This was possible due to the similar age group division structure according to which public administration units collect and share data.

The construction of a forecast takes into account the value of the actual number of patients adjusted by the demographic forecast of the Statistics Poland as well as the corresponding correction factors w_{ij}. The SSA enables to capture the actual value of change that results from overall change, from the age group affiliation and the changes in given r-th medical specialty. That is why the current total correction factor is different for each i-th r-th data cell in the contingency table. The forecast algorithm can be described as follows:

1. CSO (**Central Statistical Office – Statistics Poland**) data on demographic forecast in age groups allowed to obtain information on changes in the age structure of the Polish population for 2015 and 2021.

2. Then the predictions were transferred to changes in the age structure of patients treated within medical specialties.

3. The adjusted data were used for SSA analysis, which made it possible to estimate the correction coefficients for each r-th medical specialty, for each i-th age group, and the overall 6-year rate of change tx in the number of patients.

4. Subsequently, the final forecast was estimated taking into account changes in the value of the predicted variable simultaneously: the global change, the change in the subject structure for a given medical specialty and the change in the age structure of patients.

3. Results

The negative dynamics did not occur equally in all age groups. The lowest dynamics characterized the group of patients aged 20-24 years (−24.02%) and 55-59 years (−19.08%), while the highest positive dynamics was observed in the age group 70-74 years (51.60%) and 45-49 years (13.52%) (Table 2).

Table 2. Forecast correction factors for changes in the number of service patients in 2015 vs. 2021.

Rate of overall change −21.50%									
Rate of change in age groups									
Age group	**[0;4]**	**[5;9]**	**[10;14]**	**[15;19]**	**[20;24]**	**[25;29]**	**[30;34]**	**[35;39]**	**[40;44]**
Rate of change	−1.21%	−12.06%	1.65%	−15.97%	−24.02%	−12.94%	−7.51%	6.20%	10.69%
Age group	**[45;49]**	**[50;54]**	**[55;59]**	**[60;64]**	**[65;69]**	**[70;74]**	**[75;79]**	**[80;84]**	**[85+]**
Rate of change	13.52%	−4.55%	−19.08%	−7.92%	10.58%	51.60%	−2.98%	−6.33%	4.11%

The number of patients occurred in the specialties ‘infectious diseases and pediatric infectious diseases’ (−51.45%) and ‘clinical toxicology’ (−23.04%). The highest positive dynamics was recorded in the specialties ‘hematology’ (44.94%) and ‘ophthalmology and ‘pediatric ophthalmology’ (34.74%) (Table 3).

Table 3. The pace of changes in individual medical specialties in 2015 vs. 2021 (ordinal variable: alphabetical set of 'medical specialty').

Medical specialty	**Rate of change**	**Medical specialty**	**Rate of change**	**Medical specialty**	**Rate of change**
allergology	−2.11%	geriatrics	−5.15%	oncological surgery	16.16%
anesthesiology	25.22%	gynecological oncology	27.21%	ophthalmology and pediatric ophthalmology	34.74%
angiology	−10.93%	hematology	44.94%	orthopedics and pediatric orthopedics	16.95%
audiology	19.23%	highly specialized services and surgeries for heart defects and thoracic aorta	18.92%	otolaryngology and pediatric otolaryngology	−10.90%
cardiac surgery and pediatric cardiac surgery	1.62%	immunology and pediatric immunology	20.76%	pediatric oncology and hematology	32.69%
cardiology and pediatric cardiology	7.72%	infectious diseases and childhood infectious diseases	−51.45%	pediatric surgery	−4.02%
chest surgery	19.15%	infectious diseases and childhood infectious diseases	22.91%	pediatrics	−5.85%
clinical oncology and pediatric clinical oncology	27.87%	internal diseases	−20.99%	plastic surgery and pediatric plastic surgery	1.05%

clinical toxicology	−23.04%	lung diseases and pediatric lung diseases	−13.08%	radiotherapy and brachytherapy	22.68%
dermatology and pediatric dermatology	−13.42%	maxillofacial surgery and pediatric maxillofacial surgery	9.60%	rheumatology and pediatric rheumatology	0.95%
diabetes and pediatric diabetes	2.26%	neonatology	−3.79%	transplantology and pediatric transplantology	8.93%
endocrinology and pediatric endocrinology	12.66%	nephrology and pediatric nephrology	4.64%	urology and pediatric urology	7.60%
gastroenterology and pediatric gastroenterology	3.73%	neurology and pediatric neurology	−5.96%	vascular surgery	8.80%
General surgery	−1.40%	obstetrics and gynecology	−0.46%		

The largest decrease in the number of patients in 2027 can be expected in the age groups 20-24 years (−29.19%) and 15-19 years (−21.34%). The largest increase in the number of patients may occur in the age groups 70-74 years (52.19%) and 65-69 years (10.59%). The trend in the population of children and adolescents is clearly negative (on average approx. −14.30%), in the case of professionally active people (age group 20 - 60 years) the average decrease in the number of patients is lower (−8.77%), and in the group of people after professional activity (60+) the number of patients increases by approx. (+6.91%) (Table 4).

Table 4. Forecast correction factors for changes in the number of patients for 2027.

Rate of overall change −14.98%									
Rate of change in age groups									
Age grup	**[0;4]**	**[5;9]**	**[10;14]**	**[15;19]**	**[20;24]**	**[25;29]**	**[30;34]**	**[35;39]**	**[40;44]**
Rate of change	−11.59%	−20.13%	−4.12%	−21.34%	−29.19%	−18.53%	−13.03%	1.48%	6.77%
Age grup	**[45;49]**	**[50;54]**	**[55;59]**	**[60;64]**	**[65;69]**	**[70;74]**	**[75;79]**	**[80;84]**	**[85+]**
Rate of change	10.30%	−7.18%	−20.77%	−8.84%	10.59%	52.19%	−2.61%	−8.02%	−1.83%

The highest negative dynamics will occur in relation to the specialties ‘Infectious diseases and pediatric infectious diseases’ (−57.82%) and ‘clinical toxicology’ (−34.31%). The highest positive dynamics will occur in relation to ‘hematology’ (45.32%) and ‘ophthalmology and pediatric ophthalmology’ (38.78%) (Table 5).

Table 5. Forecast correction factors for changes in the number of patients in medical specialties for 2027 (ordinal variable: alphabetical set of 'medical specialty').

Medical specialty	**Rate of change**	**Medical specialty**	**Rate of change**	**Medical specialty**	**Rate of change**
allergology	−11.11%	geriatrics	−3.88%	oncological surgery	16.10%
anesthesiology	24.95%	gynecological oncology	24.94%	ophthalmology and pediatric ophthalmology	38.78%
angiology	−8.27%	hematology	45.32%	orthopedics and pediatric orthopedics	13.79%

Medical specialty	Rate of change	Medical specialty	Rate of change	Medical specialty	Rate of change
audiology	8.25%	highly specialized services and surgeries for heart defects and thoracic aorta	18.29%	otolaryngology and pediatric otolaryngology	−18.39%
cardiac surgery and pediatric cardiac surgery	3.58%	immunology and pediatric immunology	12.19%	pediatric oncology and hematology	20.04%
cardiology and pediatric cardiology	9.15%	infectious diseases and childhood infectious diseases	−57.82%	pediatric surgery	−16.31%
chest surgery	21.03%	infectious diseases and childhood infectious diseases	20.42%	pediatrics	−16.48%
clinical oncology and pediatric clinical oncology	30.67%	internal diseases	−20.55%	plastic surgery and pediatric plastic surgery	−2.76%
clinical toxicology	−34.31%	lung diseases and pediatric lung diseases	−13.35%	radiotherapy and brachytherapy	24.97%
dermatology and pediatric dermatology	−17.55%	maxillofacial surgery and pediatric maxillofacial surgery	1.61%	rheumatology and pediatric rheumatology	−2.11%
diabetes and pediatric diabetes	−5.65%	neonatology	−11.52%	transplantology and pediatric transplantology	2.35%
endocrinology and pediatric endocrinology	5.18%	nephrology and pediatric nephrology	1.37%	urology and pediatric urology	8.51%
gastroenterology and pediatric gastroenterology	0.72%	neurology and pediatric neurology	−7.66%	vascular surgery	12.33%
general surgery	−3.39%	obstetrics and gynecology	−9.48%		

Based on the data from Table 2 and Table 3 the health care system should expect the greatest decline in the number of patients in the specialties ‘neonatology’ (average annual rate −16.75%), ‘infectious diseases and pediatric infectious diseases’ (average annual rate −13.28%). An increase in the number of patients is forecast in the specialties ‘pediatric oncology’ and ‘haematology’ (average annual rate 5.39%) and ‘audiology’ (average annual rate 5.13%) (Table 6).

Table 6. Patient volume projections for 2027, 2033, 2039 and 2045 (according to increasing rate of change from lowest to highest values).

Medical specialty	Output data		Patient number forecasts				average annual dynamics of change
	2015	2021	2027	2033	2039	2045	2015-2045
neonatology	99224	26835	7299	2259	1053	406	−16.75%
infectious diseases and childhood infectious diseases	377724	274433	188111	105127	27580	5258	−13.28%
obstetrics and gynecology	123460	91951	63179	35321	10066	2146	−12.64%
clinical toxicology	9835	5454	2766	1290	552	188	−12.36%
pediatrics	359575	268654	197479	122265	37649	8898	−11.60%
dermatology and pediatric dermatology	238075	160932	107232	69898	44242	24826	−7.26%
transplantology and pediatric transplantology	825587	644317	486733	347692	219653	123035	−6.15%
allergology	52040	33866	22850	16585	13512	10031	−5.34%
lung diseases and pediatric lung diseases	6174	6034	5628	4601	2624	1297	−5.07%
internal diseases	806905	464066	299183	228121	217174	191200	−4.69%
rheumatology and pediatric rheumatology	17259	13939	11064	8552	6319	4211	−4.59%
otolaryngology and pediatric otolaryngology	173428	113450	81312	66707	65472	59567	-−3.50%
neurology and pediatric neurology	10289	11440	12019	10998	6911	3843	−3.23%

Medical specialty	**Output data**		**Patient number forecasts**				**average annual dynamics of change**
	2015	**2021**	**2027**	**2033**	**2039**	**2045**	**2015-2045**
angiology	22355	19695	17062	14537	12099	9196	−2.92%
cardiac surgery and pediatric cardiac surgery	289347	209905	162384	137903	133610	119880	−2.89%
diabetes and pediatric diabetes	7600	6645	5806	5078	4400	3488	−2.56%
maxillofacial surgery and pediatric maxillofacial surgery	15969	12704	10451	9070	8499	7345	−2.56%
plastic surgery and pediatric plastic surgery	4055	4025	3913	3569	2784	1965	−2.39%
cardiology and pediatric cardiology	27726	21180	15656	10529	11620	13648	−2.33%
General surgery	55271	50387	45452	40338	34620	27226	−2.33%
anesthesiology	723033	557484	455114	404294	402102	371132	−2.20%
nephrology and pediatric nephrology	62278	49481	41026	36499	35857	32651	−2.13%
endocrinology and pediatric endocrinology	48444	40275	34794	31516	30499	27322	−1.89%
pediatric surgery	4215	2848	2186	2002	2271	2407	−1.85%
gastroenterology and pediatric gastroenterology	105021	86361	74051	67323	66353	60639	−1.81%
geriatrics	26636	19538	15853	14452	15456	15415	−1.81%
highly specialized services and surgeries for heart defects and thoracic aorta	16642	13333	11814	12002	14427	16300	−0.07%
ophthalmology and pediatric ophthalmology	406849	388335	383743	397807	439125	453294	0.36%
urology and pediatric urology	196910	169532	158565	166101	200632	227969	0.49%
neurosurgery and pediatric neurosurgery	400354	345178	325085	344173	422819	489163	0.67%
chest surgery	13639	13287	13727	15164	18143	20399	1.35%
radiotherapy and brachytherapy	86340	81731	82648	91150	111959	129495	1.36%
oncological surgery	69733	70713	74561	82394	95936	104828	1.37%
orthopedics and pediatric orthopedics	58753	51292	49933	55928	74094	92851	1.54%
hematology	20310	21469	23609	27079	32254	36101	1.94%
vascular surgery	30765	30042	31860	37671	50859	65016	2.53%
immunology and pediatric immunology	75500	78312	86120	101774	131398	160231	2.54%
gynecological oncology	75846	76741	84411	103358	144219	190902	3.12%
clinical oncology and pediatric clinical oncology	61293	65197	75431	97048	141850	197174	3.97%
audiology	289567	327906	405967	558641	872020	1298772	5.13%
pediatric oncology and hematology	26325	32496	42358	58961	88728	127167	5.39%

4. Discussion

Predictive analysis in healthcare is a very important element, it supports health institutions in creating effective and personalized treatment programs and meeting the health needs of the population tailored to demand. Anticipating healthcare needs and assessing patient flow trends using predictive analytics can lead to significant savings through the reduction of unnecessary procedures, optimal resources usage, and timely coordination of staff and distribution of medical supplies, ultimately benefiting the entire healthcare system. Providing healthcare professionals with actionable insights from predictive analytics in healthcare using big data supports evidence-based decision-making.

Our projections for the Polish healthcare system show that if current trends continue the need for oncology, audiology, haematology and surgery will rise substantially over the next 20 years. At the same time a decrease in other specialties, particularly neonatology, infectious diseases, gynaecology, and toxicology is predicted.

The forecast presented in the article was constructed taking into account multidimensional structural divisions according to age groups and medical specialties, considering three components for the total change: the so-called general change resulting from the overall tendency of changes in a complex phenomenon, the change resulting from the structural division and the change resulting from the subject division. The SSA approach allowed not only to identify unique rates of change for the predicted number of patients for medical specialties, or age group. Due to the possible disaggregation of the net variability for medical specialties according to the SSA equation, it is possible to indicate whether changes in the projected medical specialty are the effect of changes in the age structure of the patient population or will be the result of other differentiating factors, which could include, for example . the impact of the Covid-19 pandemic or the war in Ukraine.

The results of our analysis are specific to Polish conditions, so it is difficult to compare them with the results of research conducted in other countries. Most published predictive analytics are limited to specific patient groups, e.g. predicting future health care use among older with higher needs and higher costs, (high-need high-cost (HNHC) patients) [16], they focus on a selected disease [17-21] or a single segment of health care [22, 23] or specific health problems such as multimorbidity [24-26]. Publications that describe forecasts for hospital care differ from our study in terms of the scope of data analysed [27-31].

In the Hong Kong study, it was assumed that the length of hospital stay depends solely on demographic factors, and hospital services were divided into acute hospital care (medical, surgical, intensive) and non-acute hospital care (mainly rehabilitation/psychiatric) and day hospital care (chemotherapy, peritoneal dialysis) [32].

A Danish study described the current demographic profile of hospital care use and estimated expected number of days spent in hospital by age and gender in Denmark by 2050 [30].

The German study highlighted that in the context of hospital resource planning, it is important to take into account changes in hospital infrastructure in addition to demographic effects such as time trends and differences between diagnostic groups. The modelling approach presented in this study tracks the impact of changing infrastructure and regional competition among hospitals [31].

The Slovenian study covers two effects of population aging: the first is an increase in overall demand (total number of treatments) for each of the four main groups of health services (primary care, specialized outpatient care, hospital day care and hospitalizations), the second is a change in the structure of treatments depending on the type of disease that prompted treatment [28].

Despite the differences described, all studies indicate that an increase in the number of older people in the population will inevitably lead to an increase in the burden on the hospital system. An analysis presented appropriately in advance also allows for earlier actions to be taken to increase population safety, including health safety. Measurements obtained during the first Global Burden of Disease Study from 2000-2002 [29] and repeating the analyses in 2010 [33] prove that multi-aspect analyses of medical data, taking into account demographic data, allow for earlier preparation of the infrastructure for providing health services, which increases the health security of a given population [34].

The question which modelling is most useful for finding appropriate strategies is best confirmed in terms of clinical usefulness and country specific demographic and organizational characteristics. Although results of our study cannot be generalized to other countries, proposed methodological approach can be replicated internationally and may serve to refine the methods for hospital planning in different settings. The introduction of demographic trends in terms of age groups make it possible to assess the resource requirements of medical specialists in each specialty. Earlier estimation of changes that will occur in the size of the treated population allows decision-makers to actively support specialties in which an increase in the number of treated patients is estimated, and to actively reduce financial resources in segments for which stagnation or regression is predicted.

In our opinion, the analysis presented in the study is partly characterised by a complementary approach [35]. As the recommendations and conclusions are directed towards the future, so in a sense there is an element of convergence with the demands to replace the counterproductive paradigm of physical education in all types of schools with the subject of 'preventive medicine' [36]. The frequent references in our work to pediatric problems provide additional argumentation that this postulate is valid in the perspective of the whole ontogeny. Also, the results of earlier analyses by some of the authors of this work indicate the possibility of increasing the effectiveness of spa treatment in a modern way, enriched with universal elements of preventive health care (preventive medicine in the broad sense) that apply to all people, regardless of age [37]. The totality of these publications shows the unique contribution of Polish solutions recommended in the global scientific space, within the prestigious AHFE (Applied Human Factor and Ergonomics) project, as a separate track on Preventive Medicine and Innovative Agonology [38-41] that is to be inaugurated in Orlando, Florida, USA from 26-30 July 2025.

Strengths and limitations

This study provides national projections of changes in the number of patients in individual medical specialties in hospital treatment for selected years in period 2015-2045. The national and comprehensive database of the official hospital statistics offers a complete overview regarding general hospitals and their services in Poland. Due to the legal basis of data, a low potential for bias due to non-reporting can be assumed. We analysed 6 years of hospital statistics between 2015-2021, this enabled conclusions to be drawn that are valid for the long term and likely remain relevant today and for the future. The biggest advantage of the applied tool is its flexibility and the absence of any software requirements other than a spreadsheet that is fed with statistical data. Thus, as soon as a new demographic forecast is published by the CSO, it is possible to quickly update trends and correct indicators and thus projections of demand for health services

A limitation was the restriction of the database to inpatient care only. Conclusions about the outpatient sector and the substitution of inpatient by outpatient services could not be drawn. Furthermore, our analysis does not consider the direct demographic impact of the COVID-19 pandemic and the war in Ukraine. These limitations result from the failure of the Central Statistical Office to extrapolate demographic data for future years, which would take into account these factors. In the analysis, however, the impact of the Covid-19 pandemic on hospital services in Poland was included, as our predictive model utilized data regarding the provision of medical services in Poland from 2015 to 2021, broken down by medical specialties.

5. Conclusions

Our study showed that in the period 2015-2045 Polish health care system should expect the greatest decline in the number of hospitalized patients in the specialties 'neonatology' and 'infectious diseases and pediatric infectious diseases' (with average annual rate −16.75% and −13.28%, respectively). An increase in the number of hospitalized patients is predicted in the specialties 'pediatric oncology and hematology' (with average annual rate 5.39%) and 'audiology' (with average annual rate 5.39% and 5.13%, respectively). These findings can serve as the starting point for planning investments in medical specialties for which forecasts indicate an increase in demand for health and allow us to prepare the resources for new challenges. Additionally, research on the impact of reducing some health services may help health care system appropriately allocate financial resources. The analysis of the entire health care market allows for balancing the needs in individual specialties. This approach avoids favouring specific groups of patients and medical professionals. On average the structural change impact share of age structure was approx. −3.01% in net change. And following that the overall predicted change for medical specialties in accordance with the SSA results would have its origins in other sources than the age structural changes. Despite limitations of the analysis indicated by the authors, decision making supported by reasonable data is superior to decision-making unsupported by such data.

Institutional Review Board Statement: According to the position of the Polish Bioethics Commissions, the retrospective analysis of depersonalized and aggregated data does not constitute a medical experiment under current regulations and does not require an opinion of the Bioethics Commission.

Informed Consent Statement: Patient consent was waived because patient data were aggregated and not analysed individually, which allowed for compliance with the condition of protecting sensitive personal Data Availability Statement: Data on health services provided in individual medical specialties, considered the age groups, were obtained from the National Health Fund (NFZ) in the field of hospital treatment. The National Health Fund is the only public payer of health services in Poland. Only by submitting a request for data, an individual query to the SQL database is constructed. The datasets on health services provided in individual medical specialties, considered the age groups analysed during the current study are available in the National Health Fund (https://ezdrowie.gov.pl/portal/home/badania-i-dane/zdrowe-dane) (NFZ) in the field of hospital treatment. Whereas the set allowing for extrapolation of data for subsequent years is the demographic forecast of the Statistics Poland (CSO) for 2014-2050 [15] developed in 2014 the (only forecast currently available: https://stat.gov.pl/en/topics/population/population-projection/population-projection-2014-2050,2,5.html). Forecasts of the demand for health services were constructed by age groups and medical specialties, which required the use of a two-dimensional form of source data.

Conflicts of Interest: The authors declare no conflicts of interest

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