Current questions and challenges in healthcare of the post-socialist countries

Edited by
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Current questions and challenges in healthcare of the post-socialist countries

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Editorial: Current questions and challenges in healthcare of the post-socialist countries

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Editorial on the Research Topic
Current questions and challenges in healthcare of the post-socialist countries

In our Research Topic, the contributing authors discuss diverse issues related to the healthcare reforms in the post-Soviet bloc: Bulgaria, China, Croatia, Kazakhstan, Poland, Russia, and Syria. In all countries, healthcare has been an important determinant of the GDP growth in the last decades (1).

In 1991, Russia introduced mandatory health insurance (MHI) in place of the Semashko system. Shishkin and Sheiman assess the reform progress. The MHI model has contributed to more sustainable health funding and pooling through geographical equalization. However, the implementation of the purchasing function still has many problems. There is no accounting for the interventions' quality of care or cost-effectiveness. The current purchasing care approach hinders the development of new medical technologies. Among the challenges of the MHI regime is that it is not separated from the state budgetary system, and the state regulates its actual performance. The actors of MHI do not have sufficient motivation to improve the health care system's performance. Developing the competitive MHI model requires long-term efforts from health policymakers. Russia's health reform challenges are widely shared among the BRICS health systems (2).

Reforms brought other changes to the healthcare sector. Sheiman reports that the traditional hospital-centered service delivery model in Russia results in a shortage of doctors in outpatient care, for example, cardiologists [see (3)], and a surplus in hospital care. This surplus increased by 21% in 2016–2019. Another reason for the labor shortage in outpatient care is the lack of medium- and long-term labor planning by regional governments and medical universities. The author recommends policymakers to assess the needs of medical personnel in a region and then make commitments for subsidies for the education of students of the demanded professions and the employment of future graduates. The quotas for post-graduate training should be developed not 1.5 years before the start of admission

(as it is now), but 3–4 years before. It is also advised to shift the focus from inpatient care to outpatient care, including primary care. District physicians should be retrained as general practitioners (GPs). Such a measure will reduce the current shortage of medical specialists in outpatient care since a GP can partly fulfill the role of a specialist.

Another common challenge in the current healthcare of post-Soviet countries is little or no access to up-to-date international literature or opportunities for continuing medical education (4). Walkowiak et al. study the awareness of rare diseases (RDs) among medical students and practicing physicians in Kazakhstan. The authors surveyed 308 individuals at the Aktobe Medical University to assess the level of knowledge of RDs and their prevalence in Kazakhstan. The results demonstrate that students and medical doctors lack knowledge about the etiology, epidemiology, and prevalence of rare diseases in the country and are unaware of the existence of the central register of RD patients and reimbursement schemes for orphan drugs. The authors recommend moving away from the Soviet teacher-centered course-based approach and instead promoting student-centered methods of instruction and elective courses, including on RDs and orphan drugs. These measures will allow faster diagnosis of RDs and their treatment in Kazakhstan.

Franic presents the topic of COVID-19 vaccine hesitancy and explores the political and economic factors which shape the attitudes to vaccination in transition economies. The paper employs the data from Flash Eurobarometer conducted in May 2021 in EU countries. Transition economies recorded lower levels of immunization than developed countries. Using multinomial regression models, the author shows that the viewpoint on vaccination is shaped by distrust in the authorities and government related to the socialist legacy. Besides general trust in government, satisfaction with democratic principles in society, trust in science, and specific views on how the authorities handled the pandemic are the critical determinants of attitudes toward vaccination against COVID-19 in the EU. Transition countries require wide-ranging reform to restore citizens' trust in government.

The COVID-19 pandemic has altered how we interact with society from offline to online communication [see, e.g., (5, 6)]. Therefore, the concept of health literacy, the degree to which individuals can find, process, and use information to inform health-related decisions and actions, has become very relevant. Kaloyanova et al. assess the health literacy of university students from the faculty of mathematics and informatics at Sofia University (Bulgaria) based on a COVID-HL survey. The results show that although computing students are skilled at searching for, allocating, and evaluating health information, they do not feel confident about the future. Furthermore, they do not have a clear view and knowledge of what to do with the health information they have. The study demonstrates that important decisions relating to health should be taken by an individual together with a health professional.

Global environmental pollution is considered an international public health issue. China has made significant progress in improving its healthcare system and reducing pollution (7). Wu et al. discuss the impact of environmental pollution liability insurance (EPLI) on the corporate environmental performance of Chinese enterprises in heavily polluting industries. EPLI is a type of insurance that compensates for injuries and deaths caused by pollution. The study, employing fixed-effects regression analysis, shows that EPLI has a positive impact on corporate environmental performance. First, EPLI increases the pressure of stakeholders' environmental demands on company managers, thus prompting managers to adopt green measures to improve the company's environmental performance. Second, EPLI is more effective in improving the environmental performance of companies with higher public visibility. Finally, compared with state-owned enterprises, EPLI has a more significant positive effect on the corporate environmental performance of non-state-owned enterprises.

Very high growth rates of healthcare expenditure remain a hot issue in Central and Eastern Europe. Considering the case of Bulgaria, Mitkova et al. analyse the impact of budget capping in terms of overall budget expenditure and current and future trends in the healthcare and pharmaceutical budget. From 2016 to 2021, there was consistent growth of healthcare services and pharmaceutical spending: 82 and 80%, respectively. The largest expenditure was observed in a group containing chemotherapy medicines. The introduced budget cap is a relatively effective measure. Nevertheless, the high level of overspending and the pay-back amount requires better market environmental risk management.

Burzyńska and Pikala assess the mortality trends of senior Polish residents in the first two decades of the current century by the most frequent causes of death. The share of deaths due to diseases of the circulatory system decreased in all the subsamples. Among malignant neoplasms, lung and bronchial cancers accounted for the largest percentage of deaths. In this subgroup, the standardized death rates (SDRs) among males decreased, while those among females increased. In the 65–74 age group, the SDR value increased from 67.8 to 76.3, while in the 75-plus age group it increased from 112.1 to 155.2. As for influenza and pneumonia, the respective SDR demonstrated an upward trend. In recent years, rising trends in mortality driven by diseases of the digestive system were observed due to alcohol-induced liver disease for both genders in the 65–74 age group. In the 75-plus age group, falls were the most typical external cause of mortality.

Syria is the only country with an Arabic socialism legacy. Allaham et al. evaluate the perceived quality of healthcare services for two hospital types in Syria according to the five HEALTHQUAL dimensions. According to their results, service quality is better in private hospitals compared to public ones. Nevertheless, neither type of hospitals has exceptionally high scores in any of the examined HEALTHQUAL dimensions due to the crowded environment, the low wages of medical personnel, inadequate pricing policies, and, in general, the underdeveloped health insurance system.

Summing up, the articles in this Research Topic demonstrate that countries with a socialist legacy have a lot of similar problems related to the effective work of their respective

healthcare systems. Moreover, implications are to a large extent generalized to a few other countries in this group and to some of the rapidly developing low- and middle-income countries of the Global South (8). Physicians, nurses, patients, and policymakers would benefit from further research on efficient healthcare delivery in the post-pandemic context, which is characterized by rapidly growing rates of digitalisation and high political instability.

Author contributions

YT and MK prepared the manuscript draft, while MJ revised it for important intellectual content. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The Awareness of Rare Diseases Among Medical Students and Practicing Physicians in the Republic of Kazakhstan. An Exploratory Study

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Although national plans or strategies for rare diseases (RDs) have been implemented in many jurisdictions research show that one of the main barriers RD patients face during medical encounter is medical professionals' low level of knowledge and experience on the diagnosis, treatment and rehabilitation of RD patients. Consequently, there is a need to increase the standards of medical education in the field of RDs and to revise the undergraduate and postgraduate training programs. However, while studies on medical education in the field of RDs has been conducted in various countries across the both Americas, Asia or the European Union, still little is known about the awareness of RDs among healthcare professionals in the Republic of Kazakhstan. Thus, we conducted a survey among 207 medical students and 101 medical doctors from the West Kazakhstan Marat Ospanov Medical University, Aktobe, Kazakhstan. The study was conducted between March and May 2021. The questionnaire assessed their knowledge about the number, examples, etiology and estimated frequency of RDs. It also evaluated respondents self-assessment of competence in RDs. Although the majority of respondents agreed that RDs constitute a serious public health issue both medical students and medical doctors showed insufficient knowledge on the etiology, epidemiology and prevalence of RDs, and many had problems with separating RDs from more common disorders. Moreover, they also lacked knowledge about and the central register of RD patients and reimbursement of orphan drugs in Kazakhstan. Finally, while almost half respondents declared having had classes about RDs during their studies most perceived their knowledge about RDs as insufficient or poor and felt unprepared for caring for RD patients. Additionally, although majority of respondents in both groups believed that all physicians, regardless of their specialization, should possess knowledge on RDs many respondents did not look for such information at all.

Keywords: rare diseases, physicians, medical students, healthcare, Kazakhstan, medical education

INTRODUCTION

Ever since the Orphan Drug Act was passed in the United States in 1983 rare diseases (RDs) have been widely recognized as an urgent medical, legal, economic, social and public health problem (1). Consequently, countries around the world have developed many areas of health policy in the field of RDs, including the classification and codification of RDs and ICD-10 revision, improving prevention and recommendations in funding and the reimbursement of orphan drugs and the creation of national registrations of RD patients. Moreover, many jurisdictions have created or implemented national plans or strategies for RDs (2–12). However, although previous studies highlight how RDs have become a policy priority in various countries across the both Americas, Asia or the European Union (2, 6, 12–15), still little is known about health policy toward RDs in countries from Central Asia, including the Republic of Kazakhstan (RoK) (2, 12, 13, 15).

Nevertheless, due to the need to develop new solutions in the field of RDs during past few years the issue of rare diseases is attracting more and more attention in Kazakhstan. Consequently, in accord with the Regulation Order of the Ministry of Healthcare of the RoK a List of Orphan Drugs has been registered in 2009 (13) and in 2016-2017 regional rare disease coordinators were appointed and trained (16, 17). Their mission is to monitor the situation in each region, identify new patients with RDs, enter them into a database, and assist such patients in their needs (17). Additionally, there are media coverage of events, conferences, seminars, discussions and meetings of health professionals and higher-ups, websites created. For example, Sanofi Genzyme has launched a first-of-its-kind app in Kazakhstan called the Rare Disease Guide. It is a practical guide for health professionals for the early diagnosis and management of lysosomal accumulation diseases (18). What is also important is that between 2016 to 2019 five PhD theses on RDs were defended in the RoK (19).

Moreover, in 2014 various patient organizations from Kazakhstan joined celebration of Rare Disease Day[1], and in November 2020 the Association of Assistance to Patients with Orphan Diseases was organized in Kazakhstan. Its mission is to provide timely diagnosis, treatment and rehabilitation of patients with rare pathologies, as well as the organization of charitable assistance and social support.

Furthermore, a Roadmap for the implementation of new standards for diagnosis and treatment of RDs in children in the RoK for 2019-2020 was implemented. It aimed at developing methodological recommendations on the provision of medical care, revising and developing new clinical protocols, improving the laboratory service, monitoring the provision of patients with the necessary medicines, medical devices and medical nutrition, improving prevention and organizational measures, increasing staff capacity and conducting information and awareness-raising activities for the population (20). Presently, a Roadmap for improving the provision of comprehensive care for children with disabilities in the RoK for 2021-2023 is being implemented. It includes two main tasks: (1) expanding the list of medicines and medical devices for outpatient provision of children for all types of diseases, including rare diseases, and (2) training Primary Healthcare (PHC) physicians in diagnosis and treatment of ten specific rare diseases to create a multidisciplinary team in PHC medical institutions (21).

It is also worth noting that according to the Rules for development and revision of clinical protocols, the classification of a disease (condition) as a socially significant disease and/or rare disease is one of the main indications for prioritizing topics for development and revision of protocols (22).

However, although rare disease scene in the RoK has changed significantly, RD community in the country is still facing a number of challenges and unresolved problems which seriously halt the rate of progress and threaten the continued advancement of diagnostics, treatment and care for people with RDs. For example, the Scientific Center of Pediatrics and Pediatric Surgery has been aiming to establish a national register of RD patients in Kazakhstan, but it is still under the discussion (17). Consequently, while the Minister of Healthcare estimates the prevalence of RDs in Kazakhstan as 1 case per 2,000 (23) there are no official statistics on rare diseases in the country. At the same time, in the June 2021 the Head of the Department of Drug Provision and Standardization of the Ministry of Healthcare (MoH) declared that there were 46 362 RDs patients registered for follow-up in an Electronic Register of Dispensary Patients, of whom 71%, i.e., 32 936 were aged 18 or over, and 13 426 were children (29%) (24). Thus, while there is some progress in diagnosis of RD patients in RoK, this relatively low number of RD patients registered in the country results from both lack of awareness and knowledge on RDs among healthcare professionals and lack of appropriate coding systems, as Kazakhstan still does not relay on Orphacodes that can facilitate the classification and coding of RDs.

Simultaneously, in regards to newborn screening used to identify and effectively treat certain RDs at an early stage and to prevent irreversible damage, Kazakhstan only screens for phenylketonuria and congenital hypothyroidism (12). Moreover, although treatment of RDs is covered with the national healthcare budget no special reimbursement rules exist for orphan medicinal products (OMPs). However, OMP funding needs to be applied for by the regions, after which budget is granted by the State, based on individual patient characteristics (e.g., body mass/dosing). Moreover, although all medical interventions are supervised by the MoH no specific health technology assessment (HTA) process for OMPs exist in Kazakhstan (12, 25).

RDs patients in Kazakhstan also face problems with access to diagnosis and treatment which include a lack of quality diagnostics in the regions for certain types of RDs. Problems exist both at the initial stage of disease diagnosis and in the process of dynamic monitoring and treatment of RD patients. In addition, there is a need to improve the register to include all patient

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Abbreviations: RD, Rare disease; EU, The European Union; CEE, Central Eastern Europe; ICD-10, International Statistical Classification of Diseases and Related Health Problems; MDs, Medical doctors; RoK, the Republic of Kazakhstan; PHC, Primary healthcare; MoH, the Ministry of Healthcare; HTA, health technology assessment; OMP, orphan medicinal products; SCES, State Compulsory Education Standards; HEI, higher education institution.

[1]https://www.rarediseaseday.org/countries/kazakhstan/ (accessed January 5, 2022).

data, drugs, doses and dosages, to reflect continuity between services, to monitor the patient's condition during relocation and transfer to the Republican Medical Organization. The main problems of drug provision are: lack of registration of drugs in Kazakhstan; lack of a set ceiling price for procurement of drugs, interruptions in supply from "SK-Pharmacia" LLC (unified distributor, provides medicines to healthcare organizations and the population of the country under the Guaranteed Volume of Free Medical Care); insufficient work of Health Authorities to provide drugs from the local budget (12).

At the same time, it should be stressed that while RDs constitute a serious problem for patients and their families they also affect physicians and the healthcare system in general. While both the government and medical authorities stress that one of the most urgent areas in the health policy toward RDs is improving the medical education of healthcare students and professionals in RoK, still many healthcare professionals, including physicians, lack knowledge about RDs and are not prepared for caring for RD patients. The scarcity of knowledge, guidelines, and training on RDs of healthcare practitioners, seriously impede the diagnosis process, access to healthcare facilities and treatment options and management of such diseases. Consequently, RD patients themselves complain over the endless "diagnostic and therapeutic odyssey" (26, 27) and stress that it hampers timely diagnosis and treatment of patients suffering from a rare disease, especially when RD patients experience more common symptoms. This in turn results in the delays in referring patients for treatment, negatively affects their health, reduces patients' quality of life, and increases healthcare costs.

Thus, this study aims to assess the awareness of RDs among medical students and practicing physicians in the Republic of Kazakhstan (RoK).

MATERIALS AND METHODS

The study was conducted between March 2021 and May 2021 among students and medical doctors taking their specialization courses and medical doctors working at the West Kazakhstan Marat Ospanov Medical University, Aktobe, Kazakhstan. A previously developed questionnaire was used (28, 29), with which we had earlier tested the knowledge of Polish students and physicians. The questionnaire, which followed the guidelines of the European Statistical System (30), was translated into Russian, one of the two official languages of the Republic of Kazakhstan, and adapted to the Kazakh conditions. On the basis of the results of an online focus group, a working team (consisting of four general practitioners and one sociologist) decided which RD-related issues will be dealt with. Next, a provisional questionnaire was assessed by two external reviewers: one physician and one sociologist. Afterwards, our questionnaire was pre-tested by four other physicians using an online platform, which led to the reformulation of three questions. The final version of the questionnaire was again evaluated by two other external reviewers of the same specialty. The ethics approval and research governance approval were also obtained from the West

Kazakhstan Marat Ospanov Medical University (Conclusion $N\underline{o}$ 6, protocol $N\underline{o}$ 2 of 02/18/2021). After the acceptance of the final version of the questionnaire, the survey was made available online. When recruiting doctors, invitations were sent to them via social media. In this group, the response rate was 100%. In the case of students, contact was made through group leaders, who were asked to provide their fellow students with a link to the questionnaire. Assuming that all students received this link, the response rate was 46%. However, it was most likely higher, since due to the fact that we have guaranteed our respondents full anonymity of the survey, we do not have any tool to verify the fact if a specific group of students has actually shared the link.

The questionnaire consisted of three sections. The first group of questions comprised the definition, etiology and estimated prevalence of RDs worldwide and in Kazakhstan. In this part of the questionnaire respondents were also asked to separate RDs from more common disorders from a list comprising 29 diseases. The second section addressed physicians' education about RDs and their self-assessment of their knowledge and competence in the field of these diseases. The last section referred to physicians' demographic data. The questionnaire consisted of 26 questions, of which we eventually used 25.

The data collected in the questionnaires were verified and checked for completeness, quality and consistency. Then they were coded and exported into the statistical packages JASP (Version 0.15.0.0). The results were presented as descriptive statistics. A Likelihood Ratio Chi-square was used to assess differences in the distribution of answers among the groups. A 5% level of significance was used for all hypothesis tests.

RESULTS

Our study group included 308 subjects, 207 (67.2%) of whom were students and 101 (32.8%) physicians (**Table 1**). Women predominated among both physicians (89.1%) and students (74.9%). In the group of students 152 (73.4%) were in their 5th year of study, while 55 (26.6%) were in their intern years. In the group of physicians, 40 (39.6%) were residents, and 61 (60.4%) professionally active physicians working at the university. Moreover 50.7% of the students and 37.6% of physicians have not met anyone suffering from RDs. Simultaneously, in both groups very few respondents declared having a family member suffering from such disease (4.8 and 3% respectively).

The majority of respondents were acquainted with the term 'rare diseases', which was known to 96% of physicians and 97.6% of students (**Table 2**). However, only 4.9% of physicians knew the frequency of the prevalence of RDs, whereas 4.9% correctly estimated the number of RDs. In the student group the results were equally poor, with 5.8% of students who knew the prevalence of RDs and 7.3% who correctly estimated the number of RDs. Similarly, a low number of respondents in both groups knew that RDs affect mostly children (17.8% of physicians and 14% of students). Moreover, both physicians and students had problems with estimating both the number of RD patients worldwide (1 and 4.4% respectively) and in Kazakhstan (2 and 2.4% respectively). Finally, while in both groups over 50% of

TABLE 1 | Socio-demographic characteristics of respondents.

Characteristics	N (%)	
	MD **n = 101**	**Students** **n = 207**
Year of study		
5th		152 (73.4)
Interns 1st year		28 (13.5)
Interns 2nd year		27 (13.1)
Years of professional experience		
Residents 1st year	16 (15.8)	
Residents 2nd year	24 (23.8)	
<5	6 (5.9)	
6–10	4 (4)	
11–15	7 (6.9)	
16–20	10 (9.9)	
More than 20	34 (33.7)	
Gender		
Female	90 (89.1)	155 (74.9)
Male	11 (10.9)	52 (25.1)
Have you ever met a person suffering from RD		
Yes	55 (54.5)	94 (45.4)
No	38 (37.6)	105 (50.7)
I do not know	8 (7.9)	8 (3.9)
Is anyone in your family suffering from RD?		
Yes	3 (3)	10 (4.8)
No	93 (92.1)	194 (93.7)
I do not know	5 (4.9)	3 (1.5)

TABLE 2 | Respondents' knowledge about rare diseases.

Characteristics	N (%)	
	MD **n = 101**	**Students** **n = 207**
Have you ever heard the term 'rare diseases'?		
Yes	97 (96)	202 (97.6)
No	4 (4)	5 (2.4)
A rare disease is the one that affects less than:		
1 person in 1,000	5 (4.9)	24 (11.6)
1 person in 2,000	**5 (4.9)**	**12 (5.8)**
1 person in 3,000	2 (2)	3 (1.5)
1 person in 5,000	5 (4.9)	5 (2.4)
1 person in 10,000	60 (59.5)	123 (59.4)
I do not know	24 (23.8)	40 (19.3)
What is the estimated number of rare diseases?		
100–500	19 (18.8)	25 (12.1)
1,000–2,000	10 (9.9)	16 (7.7)
3,000–5,000	2 (2)	11 (5.3)
6,000–8,000	**5 (4.9)**	**15 (7.3)**
9,000–10,000	1 (1)	2 (1)
Over 10,000	4 (4)	16 (7.7)
I do not know	60 (59.4)	122 (58.9)
In what age group do rare diseases most frequently appear?		
Newborns	8 (7.9)	22 (10.6)
Children	**18 (17.8)**	**29 (14)**
Adolescents	3 (3)	2 (1)
Adults	1 (1)	7 (3.4)
They are present in all age groups equally	57 (56.4)	129 (62.3)
I do not know	14 (13.9)	18 (8.7)
How many people suffer from rare diseases worldwide?		
10–15,000,000	12 (11.9)	27 (13)
50–75,000,000	9 (8.9)	10 (4.8)
100–150,000,000	4 (4)	10 (4.8)
200–250,000,000	1 (1)	4 (1.9)
300–350,000,000	**1 (1)**	**9 (4.4)**
Over 500,000,000	3 (3)	9 (4.4)
I do not know	71 (70.2)	138 (66.7)
How many people suffer from rare diseases in Kazakhstan?		
250–500	9 (8.9)	17 (8.2)
5–7,500	9 (8.9)	24 (11.6)
25–40,000	7 (6.9)	11 (5.3)
50–75,000	4 (4)	7 (3.4)
150–250,000	2 (2)	13 (6.2)
500,000	4 (4)	3 (1.5)
1–1,500,000	**2 (2)**	**5 (2.4)**
Over 2,500,000	0 (0)	3 (1.5)
I do not know	64 (63.3)	124 (59.9)
What is the most common cause of rare diseases?		
Infectious and bacterial	4 (4)	9 (4.3)
Genetic	**65 (54.3)**	**123 (59.4)**
Autoimmune	14 (13.8)	37 (17.9)
Mitochondrial	2 (2)	1 (0.5)

(Continued)

respondents knew the most common cause of RDs, few were aware that the vast majority is of genetic character (physicians: 15.8%; students 16.9%).

From the presented list of 29 diseases (including 19 RDs), respondents chose those they considered to be rare (**Table 3**). In the group of physicians Duchenne muscular dystrophy, Pompe disease and Gaucher disease were most frequently recognized (40.6, 38.6, and 38.6% respectively), while students pointed to Niemann-Pick disease, Huntington disease and Pompe disease most often (44.0, 33.3, and 32.9% respectively). Only in the case of Niemann-Pick disease, students recognize it better than physicians. In all other cases, the results were similar, or the physicians indicated RDs better than students. Simultaneously, physicians from the study often classified Munchausen syndrome, halitosis and fibromyalgia as RDs, while students erroneously indicated to Munchausen syndrome, halitosis and Down syndrome.

Approximately 60% of respondents in both groups did not know whether Kazakhstan has a central register of RD patients (**Table 4**). Simultaneously, 33.8% of medical students and 40.65% of physicians falsely believed that there is a central register of RD patients in the country. Moreover, while very few respondents

TABLE 2 | Continued

Characteristics	N (%)	
	MD n = 101	Students n = 207
Environmental	3 (3)	11 (5.3)
I do not know	13 (12.9)	26 (12.6)
What percentage of rare diseases are of a genetic origin?		
5–10%	19 (18.8)	35 (16.9)
20%	12 (11.9)	32 (15.5)
50%	13 (12.9)	38 (18.4)
80%	**16 (15.8)**	**35 (16.9)**
100%	3 (3)	5 (2.4)
I do not know	38 (37.6)	62 (29.9)

Correct answers are written in bold characters.

(4% of doctors and 7.2% of medical students) knew what percentage of RDs can be treated with drugs less than half knew that only some orphan drugs are reimbursed in RoK (48.5 and 43.5% respectively).

Although more than 80% of the respondents in both groups agreed that RDs constitute a serious public health issue (**Table 5**), only 9.9% of physicians and 12.1% of students rated their knowledge about RDs as sufficient and the majority felt unprepared to care for RD (67.3 and 56.1% respectively). Interestingly, while almost half respondents declared having had classes about RDs during their studies, a statistically significant difference between the groups was found in primary source of knowledge on RDs: while only 11.9% physicians acknowledged past university classes, 25.6% of students believed university provided them with such knowledge. Moreover, while for most physicians the Internet, scientific symposia and literature was the prime source of information on RDs students pointed to the Internet, scientific literature and mandatory courses at the university. What was also significant, is that many physicians (16.8%) declared that they were not looking for information about RDs at all. At the same time, while in both groups the respondents believed that it is primarily family physicians (48.5 and 36.7%) and geneticists (33.7 and 44.9%) who should be uniquely educated and trained in RD, very few indicated to such specialists as pediatrician (24.8 and 23.7%), neurologist (15.8 and 16.4%) or psychiatrists (9.9 and 9.2%). Surprisingly, however, 64.4% of physicians and 72.5% of students believed that all physicians, regardless of their specialization, should possess such knowledge.

DISCUSSION

Over the last few years the problem of rare diseases has been actively discussed in Kazakhstan. Consequently, both the government and medical authorities have recognized that RDs constitute an important public health and social issue (2, 12, 13, 15, 31). However, even though the Republic of Kazakhstan gained its independence in 1991 up till 2007 its medical education has

TABLE 3 | Which of the following diseases are considered to be rare in Kazakhstan?

Diseases	N (%)		p
	MD n = 101	Students n = 207	
Sickle cell anemia	18 (17.8)	40 (19.3)	
Cystic fibrosis	26 (25.7)	53 (25.6)	
Acromegaly	7 (6.9)	23 (11.1)	
Hemophilia	21 (20.8)	35 (16.9)	
Down syndrome	6 (5.9)	31 (15)	0.02
Niemann-Pick disease	30 (29.7)	91 (44)	0.02
Halitosis	16 (15.8)	39 (18.8)	
Glaucoma	3 (3)	5 (2.4)	
Progeria	37 (36.6)	43 (20.8)	<0.01
Neurofibromatosis	16 (15.8)	28 (13.5)	
Craniodiaphyseal dysplasia	17 (16.8)	31 (15)	
Cerebral palsy	4 (4)	23 (11.1)	0.04
Fibromyalgia	9 (8.9)	7 (3.4)	0.04
Huntington disease	32 (31.7)	69 (33.3)	
Duchenne muscular dystrophy	41 (40.6)	59 (28.5)	0.03
Acquired immunodeficiency syndrome	5 (5)	12 (5.8)	
Munchausen syndrome	24 (23.8)	68 (32.9)	
Mucopolysaccharidoses	13 (12.9)	24 (11.6)	
Achondroplasia	19 (18.8)	16 (7.7)	<0.01
Galactosemia	8 (7.9)	7 (3.4)	
Pompe disease	39 (38.6)	68 (32.9)	
Gaucher disease	39 (38.6)	49 (23.7)	<0.01
Fragile X syndrome			
Marfan syndrome	23 (22.8)	49 (23.7)	
Schizophrenia	3 (3)	14 (6.8)	
Alzheimer's disease	3 (3)	27 (13)	<0.01
Osteogenesis imperfecta	27 (26.7)	14 (6.8)	<0.001
Phenylketonuria	23 (22.8) 8 (7.9)	35 (16.9)	
Lactose intolerance		17 (8.2)	

Correct answers are written in bold characters.

continued to develop under the conditions of the methodological basis, structure and content established while being the republic of the Soviet Union (32). Moreover, Kazakhstan inherited the teacher-centered discipline-based system of medical education aimed to educate very large numbers of students in a few medical schools. Additionally, the traditional system was characterized by the development of a common schedule for all academic disciplines during the semester and the session. The development of individual study plans for each individual student was not envisaged. The notions of "elective disciplines," "tutor," "advisor," "registrar's office" were absent in the traditional educational system, as well as the opportunity to choose disciplines, teachers and individual educational trajectory (4, 32–34).

Indeed, it was not until 2006 when the Ministry of Healthcare launched the reform of medical education and developed

TABLE 4 | Respondents knowledge about the healthcare system for RD patients in RoK.

	N (%)		p
	MD $n = 101$	**Students** $n = 207$	
Does Kazakhstan have a National Program for Rare Diseases?			ns
Yes	**31 (30.7)**	**62 (30)**	
No	10 (9.9)	21 (10.1)	
I do not know	60 (59.4)	124 (59.9)	
Is there a central register of RD patients in Kazakhstan?			ns
Yes	41 (40.6)	70 (33.8)	
No	**10 (9.9)**	**18 (8.7)**	
I do not know	50 (49.5)	119 (57.5)	
What percentage of rare disease can be treated with drugs?			ns
0%	5 (4.9)	4 (1.9)	
5%	**4 (4)**	**15 (7.2)**	
10%	2 (2)	17 (8.2)	
15%	9 (8.9)	19 (9.2)	
20%	10 (9.9)	37 (17.9)	
50%	19 (18.8)	18 (8.7)	
I do not know	52 (51.5)	97 (46.9)	
Are orphan drugs reimbursed in Kazakhstan?			ns
Yes	23 (22.8)	40 (19.3)	
Yes, some	**49 (48.5)**	**90 (43.5)**	
No	6 (5.9)	17 (8.2)	
I do not know	23 (22.8)	60 (29)	

Correct answers are written in bold characters.

the new curriculum for all medical schools. For the very first time it introduced such new elements as integrated systems-based learning, early clinical contact, structured teaching of communication skills and promoted the development of student-centered methods of instruction (33). Hence, new State Compulsory Education Standards (the SCES) were introduced for medical specialties in higher education institutions (HEIs), but students of General Medicine and Dentistry specialties were trained according to the linear (traditional) system (35). Consequently, in order to obtain MD degree in general medicine, pediatrics or dentistry in Kazakhstan, there is currently a Bachelor's degree and internship program (5+1). This six-year of compulsory training is followed by residency which enables the future doctor to choose a specialization (36, 37).

However, although according to the SCES and the Model Curriculum the content of medical education program includes several blocks of disciplines, including general education disciplines (primarily socio-humanitarian disciplines), basic disciplines (natural sciences) and principal (clinical) disciplines, some of which are compulsory while other are elective (35, 37)

TABLE 5 | Respondents' self-assessment of their knowledge about RDs.

	N (%)		p
	MD $n = 101$	**Students** $n = 207$	
Do RDs constitute a serious public health issue?			ns
Definitely yes	46 (45.5)	102 (49.3)	
Yes	39 (38.6)	69 (33.3)	
No	5 (5)	9 (4.3)	
Definitely not	3 (3)	3 (1.5)	
I do not know	8 (7.9)	24 (11.6)	
How would you rate your knowledge about rare diseases?			ns
Very good	4 (4)	8 (3.9)	
Fair enough	6 (5.9)	17 (8.2)	
So, so	39 (38.6)	94 (45.4)	
Insufficient	36 (35.6)	69 (33.3)	
Very poor	16 (15.8)	19 (9.2)	
Do you feel prepared for caring for a patient with a rare disease?			ns
Definitely yes	9 (8.9)	14 (6.7)	
Rather yes	12 (11.9)	43 (20.8)	
Rather not	47 (46.5)	84 (40.6)	
Definitely not	21 (20.8)	32 (15.5)	
I do not know	12 (11.9)	34 (16.4)	
Would you like to broaden your knowledge about rare diseases?			ns
Yes	86 (85.1)	183 (88.4)	
No	5 (5)	11 (5.3)	
I do not know	10 (9.9)	13 (6.3)	
Do you think that there should be a mandatory course on rare diseases in the medical curricula?			ns
Definitely yes	52 (51.5)	87 (42)	
Rather yes	38 (37.6)	96 (46.4)	
Rather not	3 (3)	7 (3.4)	
Definitely not	2 (2)	4 (1.9)	
I do not know	8 (7.9)	24 (11.6)	
Did you / do you have any classes about rare disease during your studies?			ns
Yes	48 (47.5)	98 (47.4)	
No	42 (41.6)	87 (42)	
I do not know	11 (10.9)	22 (10.6)	
Where do you / did you get your knowledge about rare diseases from?			
Mandatory courses at the university	12 (11.9)	53 (25.6)	<0.01
Facultative courses at the university	11 (10.9)	34 (16.4)	ns
Scientific literature and research	31 (30.7)	56 (27.1)	ns
Scientific conferences, symposia	20 (19.8)	15 (7.2)	<0.01
Internet	52 (51.5)	140 (67.6)	<0.01
Other	8 (7.9)	13 (6.3)	ns
I do not search for such information	17 (16.8)	12 (5.8)	<0.01

(Continued)

TABLE 5 | Continued

	N (%)		p
	MD **n = 101**	**Students** **n = 207**	
Which physicians should be uniquely trained in RDs?			
Family physician	49 (48.5)	76 (36.7)	0.05
Pediatrician	25 (24.8)	49 (23.7)	ns
Neurologist	16 (15.8)	34 (16.4)	ns
Geneticist	34 (33.7)	93 (44.9)	ns
Psychiatrist	10 (9.9)	19 (9.2)	ns
Immunologist	19 (18.8)	50 (24.2)	ns
Other	16 (15.8)	34 (16.4)	ns
Every physician regardless of their specialization	65 (64.4)	150 (72.5)	ns

there is no separate compulsory subject for RDs. Nevertheless, almost all diseases included in the List of Orphan Diseases and Medicines For Their Treatment can be found on the lists of Model residency curricula depending on the specialty. Additionally, examination of the Catalog of elective disciplines for residency of Medical University of Astana between 2017 and 2020 showed three elective disciplines on rare diseases in the profile tracks. They were "Orphan diseases in the Republic of Kazakhstan" and "Orphan diseases in pediatric practice" for Pediatrics specialty and "Orphan lung diseases and accumulation diseases" for Pulmonology specialty. Thus, apart from some limitations in the study programs HEIs can regulate and organize part of the content of their education programs.

It should be also stressed that the route of a RD patient in Kazakhstan is as follows: a patient with a suspected disease is referred by general practitioner or pediatrician to the regional level (to the Regional or City Children's Hospital), where one is examined by a regional coordinator and narrow profile specialists. At this level, the patient undergoes initial diagnosis, follow-up care, follow-up examinations and rehabilitation. After that, final verification of the diagnosis, primary therapy, monitoring within the specified timeframe and correction of therapy is required. This takes place at the national level: in Research Institutes, Science Centers, University Clinics or Rare Disease Coordination Centers, including Scientific Center of Pediatrics and Children's Surgery for children and Research Institute of Cardiology and Internal Medicine of the Ministry of Healthcare of the RoK for adults (37).

All in all, while Kazakhstani healthcare system suffers from the imbalance and low-skilled personnel it seems that one of the most important need in reference to RDs is that the standards of medical education require a revision both at the undergraduate and postgraduate level (33, 34). However, similar problems were found in other countries in the region. For example, a recent study from Russia showed that the main problems that prevent the full development of a public health strategy for RDs in the Russian Federation are insufficient organization of the process, lack of knowledge, lack of diagnostic expertise, lack of information on point prevalence and distribution of

RDs by medical areas. It also showed that medical doctors, and those in primary care in particular, lack knowledge and experience on the diagnosis, treatment and rehabilitation of RD patients (31). Also in Turkey national policy for rare diseases and orphan drugs requires urgent updating as Turkish RD patients struggle with lack of knowledge and experience from healthcare practitioners, lack of specialist physicians and difficulties in patients' treatment and follow-up which in turn result in late or misdiagnosis, delayed access to appropriate treatment centers and inadequate number of orphan drugs (38). Finally, although awareness of RDs in many countries of Southeast Asia, including the Philippines, Singapore, Malaysia, Indonesia, Vietnam, and Thailand, is grounded on patient support and advocacy group they also suffer from insufficient number of genetic specialists, lack clinical RD expertise and possess only a few institutional centers that offer specific services to treat RDs. Consequently, clinical expertise and patient management for such diseases in these countries also need to be improved (39).

Moreover, this research supports findings from other countries that have shown that both medical students and healthcare professionals lack training and experience on RDs and that many problems of RD patients result from their negative experiences with healthcare system (40–44). For example, several Polish studies conducted among nursing, physiotherapy and medical students and practicing physicians and nurses showed that they possess insufficient knowledge about RDs and do not feel prepared to care for such patients (28, 29, 45–49). Also research conducted in Spain (50, 51) and Belgium (52) showed that most physicians do not possess adequate knowledge on RDs and rarely use Orphanet or other reliable sources on the Internet. Finally, recent surveys from China indicated the importance of improving awareness of RDs among physicians as only 5.3% were "moderately or well aware of" rare diseases (53).

Consequently, 73% of RD patients in China were misdiagnosed and waited an average more than 4 years for the right diagnosis and reported visiting three hospitals before receiving it. Additionally, 67% were diagnosed outside their home city and had to traveled an average of 562 km (54). Similarly, while an average time Polish patients suffering from Huntington disease had to wait for diagnosis was 10 years (55), for Australian children with RD it was up to 18 years (56). Finally, a research conducted among American and British caregivers showed that RD patients waited approximately 3 years before receiving a correct diagnosis (57–59).

Limitations

Although to best of our knowledge this is the first study on the knowledge and awareness of RDs among medical students and practicing physicians in the Republic of Kazakhstan, it has some limitations. First, because responses from only one medical university in the Kazakhstan were analyzed the study has a local dimension. Consequently, it would be desirable to compare the findings from other medical universities in the country. Second, because the response rate was not very high the results represent solely the opinions of those who agreed to participate in the study and cannot be generalized for the entire population of medical students enrolled in the West Kazakhstan

Marat Ospanov Medical University or medical doctors practicing in Aktobe, Kazakhstan. Thus, in order to clarify the issues of education for RD a more in-depth study is required. Third, non-random sampling is another limitation as it prevented an analysis of the socio-demographic, structural and socio-cultural background of the issues discussed in our research. However, some advantages of this study should also be acknowledged. Most importantly, as there is a scarcity of previous work on the topic it gives some highlight on the knowledge of Kazakhstani medical students and medical doctors about RD. Moreover, we believe that because this is a pilot study, it may stimulate further research on the topic and provoke discussion on the educational needs related RDs.

Conclusions

Even though in the past 10 years Kazakhstan has made some progress in the management of RDs, still they are neglected by medical education in the country. Consequently, neither medial students nor physicians are offered special training on rare diseases and there is an urgent need to revise standards of medical education at the undergraduate, internship and residency level. Moreover, while the government should define clear guidelines regarding list of knowledge and skills in the field of RDs that future healthcare professionals should acquire during their studies, physicians (in training) should be offered opportunity to acquire experience in managing RD and interdisciplinary observation teams comprising of various specialists should be organized. Simultaneously, as the Internet seems the main source of information on RDs, special web pages with reliable information on RDs should also be organized.

Additionally, to ensure that RDs are adequately coded and traceable in Kazakhstani health information systems, the country should use experiences from other countries, including France, Germany, Spain or Poland, that alongside the existing coding system for RDs have decided to utilize the Orphanet nomenclature (ORPHAcodes), a comprehensive classification and coding system for RDs developed by the international consortium Orphanet, with cross-references to the ICD-10. Thus, RoK should put more effort to steer, maintain and promote the adoption of Orphacodes [60]. Moreover, specially designed free mobile apps that would help physicians to diagnose RDs, find links to resources like disease information and connect RD patients, parents and caregivers with their physician would be also desirable. Finally, in order to support the decision process and overcome barriers that affect the diagnostic odyssey machine learning and artificial intelligence can be used for automatic surveillance for RD patients [61, 62].

Simultaneously, there are several other areas in the field of RDs that require substantial development. First, while RDs should be further be recognized and an important public health issue providing medical care for patients with specific RDs should be prioritized. Second, regional, national, and global health programs for the most common RDs need to be developed.

Third, standards for RD treatment guidelines should be developed. Fourth, as Kazakhstan suffers from inadequate number of medical geneticists in a number of regions, special courses on both clinical genetics and RDs should be organized,

as it would foster the timely diagnosis, prevention of some RDs and referral of RD patients to specialized medical centers. Fifth, because many physicians do not possess knowledge on orphan drugs also pharmaceutical education on orphan drugs should be included in the medical curricula. Moreover, as pharmacists are credible sources of information on orphan drugs they should be also included in education and prevention programs on RDs [41, 43]. Sixth, a system of follow-up facilities for RD patients must be developed. One possible way to achieve that is the development of telemedicine and telepharmacy services which can give RD patients the opportunity to continue treatment, to be followed-up by family physicians and specialists and to receive further recommendations about the therapy [63, 64]. Additionally, a psychological, social and economic assistance and support for both the patients and their parents/caregivers needs to be developed [65]. Seventh, an effective unit of the Ministry of Healthcare for RDs and orphan drugs should work actively to establish the necessary examinations, inspections, and relevant legislation. Eighth, because challenges faced by RD patients in RoK are similar to other countries in the region, including Russian Federation or China, the country should establish closer collaboration with other neighbor countries. Finally, further development and implementation of HTA for RD patients registries is required.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by West Kazakhstan Marat Ospanov Medical University (Conclusion No 6, protocol No 2 of 02/18/2021). Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

DW supervised conceptualization of the study and performed the statistical analyses. JD designed of the research questionnaire. AM and KB collected the data. All authors conducted the literature search and analyses, had full access to all of the study data, discussed the results of the questionnaire, assisted in the interpretation of the data, wrote the original draft of the manuscript, critically revised and edited the various drafts of the manuscript and approved its final version before submission. All authors read and approved the final manuscript and contributed equally to the study.

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What Lies Behind Substantial Differences in COVID-19 Vaccination Rates Between EU Member States?

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Background: Despite the billions of doses at disposal, less than three-quarters of EU citizens received a COVID-19 vaccine by the end of 2021. The situation is particularly worrying in transition societies, which experience much stronger opposition to vaccination compared to their Western counterparts. To understand whether and to what extent this has to do with the socialist legacy, in this paper we explore wider economic, political, and cultural determinants of the COVID-19 vaccine uptake in the EU.

Methods: Data from Flash Eurobarometer 494 conducted in May 2021 were used to model the attitudes of EU citizens toward COVID-19 vaccination. Based on their views and intentions, each of 26,106 survey participants was allocated into one of the following categories: (1) already vaccinated/plan to get vaccinated; (2) indecisive; (3) refuse vaccination. Multilevel multinomial logit was employed to understand what underlies the reasoning of each group.

Results: The survey revealed that 13.4% of Europeans planned to delay vaccination against COVID-19, while 11.2% did not intend to get vaccinated. Although numerous demographic and socio-economic factors jointly shape their viewpoints, it is trust (in the authorities, science, peers, and online social networks above all) that strongly dominates citizens' reasoning. Given that most transition societies are witnessing the pandemic of distrust at various levels, this seemingly unrelated feature appears to be vital in explaining why newer member states record lower vaccination rates. Education was also found to play a pivotal role, which is reflected in an individual's ability to critically assess information from various sources.

Conclusion: The study results clearly illustrate how long-lasting structural problems (specific for, but not confined to, transition countries) can manifest themselves in unforeseen circumstances if left unaddressed. It is hence of vital importance to learn the lesson and prevent similar issues in the future. Above all, this would require wide-ranging reforms aiming to repair the imperceptible psychological contract between citizens and the state authorities.

Keywords: COVID-19, vaccine hesitancy, anti-vaccinationism, socialist legacy, EU, multilevel modeling

INTRODUCTION

Notwithstanding the rising general aversion to vaccination[1], the approval of the Comirnaty vaccine on December 21, 2020, was celebrated as a turning point in the fight against Coronavirus disease 2019 (COVID-19) in the European Union (EU) (2, 3). Scientists, medical experts, politicians, and the wider community mistakenly assumed that common sense in combination with economic, social, and psychological distress caused by the pandemic would take the victory over fear, skepticism, and conspiracy theories (4–6). On the contrary, the term "herd immunity," which dominated media reports and political speeches at that time, has gradually evaporated from the public sphere during the following year. With less than three-quarters of EU citizens receiving their dose(s) by the end of 2021 (7), the virus managed to survive within the population and eventually mutate to a worrying degree. As a result, 2 years after the onset of the pandemic the member states have witnessed record numbers of new infections on a day-to-day basis owing to the fast-spreading Omicron variant.

However, a closer look at the official data by the European Center for Disease Prevention and Control (ECDC) reveals noticeable discrepancies between EU countries concerning vaccination rates. The share of the population receiving at least one dose of vaccine against COVID-19 ranges from as low as 28.5% in Bulgaria to as high as 90.8% in Denmark (**Figure 1**). In fact, post-socialist countries lag far behind in this regard. For instance, while the majority of citizens in Portugal, Malta, and Spain have been immunized to date, the fight against the disease in Romania, Slovak Republic, and Croatia has been impeded by disturbingly low coverage rates (accounting for 41.3%, 50.2%, and 55.3%, respectively). Given noteworthy coordination in the acquisition and distribution of vaccines at the EU level on the one hand, and ease of access for all EU citizens on the other, the difference in vaccine acceptance appears to be the only reasonable explanation for this state of affairs.

Whether and how the attitudes toward vaccination against COVID-19 are exactly related to the socialist legacy, however, has not been evaluated so far. Previous studies on the matter were mainly concerned with socio-demographic aspects of vaccine uptake in the EU and safety concerns related to the speed of vaccine development (8, 9), while cultural, political, and economic determinants were left aside. It is precisely this gap we aim to fill in the rest of this paper. Specifically, the idea is to evaluate to what extent the standpoints and actions of EU citizens are shaped by personal characteristics and to what extent they arose from the environment in which an individual lives and operates.

To do so, we build upon the results of existing studies from around the world, which have identified a range of factors underlying views, opinions, and intentions of citizens regarding COVID-19 vaccination. In addition to demographic peculiarities, such as gender (10–12), age (8, 13, 14), and ethnicity (15, 16), it was found that one's formal and informal education also play important roles in this respect. More precisely, evidence suggests that people with a university diploma generally demonstrate lower vaccine hesitancy than low-skilled individuals (14, 17, 18). Moreover, resistance to vaccination appears to have a lot to do with reliance on unverified sources of information (e.g. online social networks), and in particular with susceptibility to conspiracy theories (14, 19, 20). Political orientation and religion are also significant determinants, as anti-vaccination sentiment was found to be more ingrained among conservative voters and highly religious people (15, 21, 22).

Some recent inquiries as well revealed that individuals who have experienced severe psychological, economic, and/or health distress during the pandemic are more open to vaccination, and the same applies to those expressing pro-social behavior (9, 23, 24). Finally, and most importantly, a number of studies identified trust as the key piece of this compound puzzle. This applies not only to the assessment of the tools chosen by the authorities to combat the ongoing pandemic (9, 20, 22), but also to a general confidence in the ruling elites, modern science, the media, and fellow citizens (8, 9, 25). Given that a growing body of research has identified the "pandemic of distrust" as the main factor explaining the rise of "anti-systemic behavior" in transition societies[2], this issue owes to be given due attention in our case as well.

To sum up, in line with the findings from previous studies on the matter, the following five hypotheses will be evaluated in the rest of this paper:

> Hypothesis 1: The readiness of EU citizens to receive a COVID-19 vaccine is closely related to the effect the pandemic has had on their well-being.
> Hypothesis 2: Substantial differences in vaccine-acceptance rates can be ascribed to the uneven quality of both formal and informal education across the EU.
> Hypothesis 3: Strong opposition to COVID-19 vaccination in some EU countries reflects the low quality of the psychological contract between citizens and the authorities.
> Hypothesis 4: Individual's attitude toward vaccination is substantially shaped by the strength of social ties within their community.
> Hypothesis 5: Individual's (un)willingness to get vaccinated is under a strong influence of their political and religious views.

The ultimate goal of this research article goes beyond informing and assisting the current vaccination campaigns, as the intention

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[1]Vaccine hesitancy, which is defined as a delay in acceptance or refusal of vaccination despite availability of vaccination services (1), is not a novel phenomenon. In addition to certain demographic and socio-economic characteristics, the level of one's vaccine hesitancy is also strongly influenced by confidence (in the effectiveness/safety of vaccines, in vaccine providers and health authorities in general), complacency (i.e. perceived risks of vaccine-preventable diseases and/or reasoning about the importance of vaccination), and convenience (availability, affordability and readiness to pay for a vaccine). Since the latter is not relevant for EU citizens, in this paper the focus is only on complacency and confidence.

[2]Notable examples of informal activities that not only stem from, but also contribute to, the state's failure to deliver high-quality goods/services on time are string-pulling, petty corruption in healthcare (i.e. gratuity and gifts to medical practitioners), and undeclared work (26–29). The roots of detachment from the authorities trace back to the period of socialism, which was characterized by vast and inefficient public administration (30–32). The gap additionally deepened during the initial phases of transition due to the flourishing of corruption, clientelism, nepotism and akin practices.
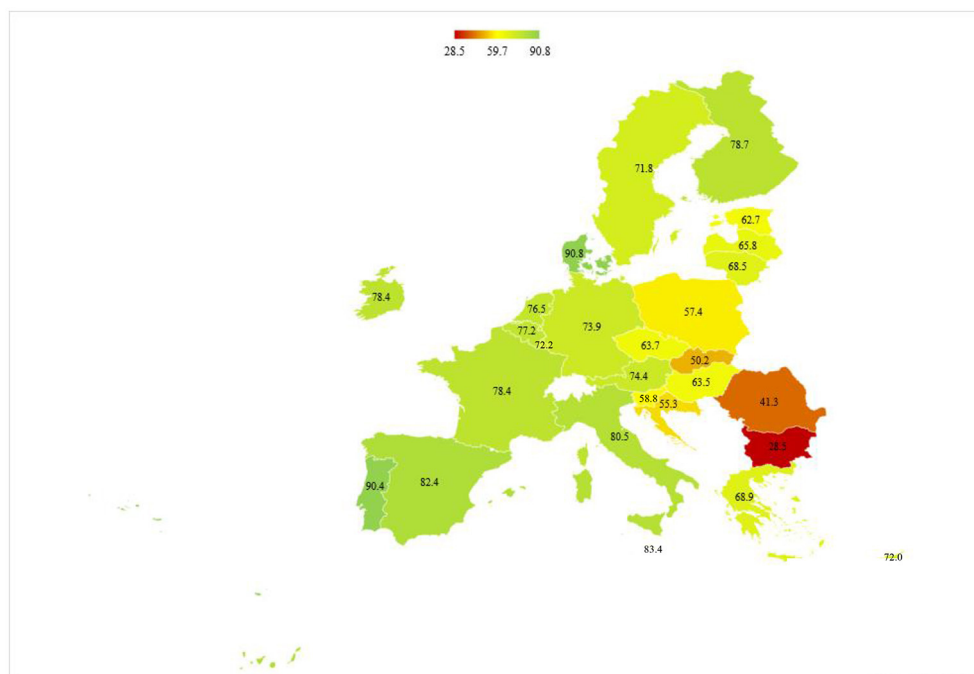
FIGURE 1 | Vaccination rates across the EU, % of the population. The figure shows the percentages of the total population receiving at least one dose of the COVID-19 vaccine by January 4, 2022. Source: Author's own calculations based on data from ECDC (7).

is to shed light on certain leftovers from previous political and economic regimes whose adverse effects could easily surpass the current anti-vaccination movement if not properly addressed. In addition to advancing our knowledge of the mechanisms underlying vaccination attitudes, the study is, therefore, also expected to resonate in other academic fields. This particularly applies to research on the issues of trust, governance, social cohesion, and quality of education, which are often neglected in discussions of the challenges modern healthcare systems (and societies in general) are facing. When it comes to methodological advancements, to the best of the author's knowledge this paper represents the very first attempt to explore non-medical factors responsible for such extensive discrepancies in vaccination rates at the EU level.

To achieve the enumerated objectives, the next section describes the data used and statistical methods applied to test research hypotheses, while Section 3 brings the results of the conducted analysis. This is followed by a discussion and concluding remarks, which are given in the last section of the paper.

METHODS

The analysis is grounded on data from Flash Eurobarometer 494: "Attitudes on vaccination against COVID-19." This survey, conducted in May 2021 on a sample of 26,106 individuals, represents the first and thus far the only publicly available EU-wide inquiry into the matter. Approximately 1,000 respondents above the age of 15 were recruited following the quota sampling

approach in the majority of member states. The exceptions were Malta, Cyprus, and Luxembourg, with the final samples accounting for 515, 513, and 511 respectively[3].

Among a range of questions related to the pandemic, each interviewee was asked when they would like to get vaccinated against COVID-19, with the following options offered: (1) as soon as possible; (2) sometime in 2021; (3) later; (4) never; (5) already vaccinated; (6) do not know; (7) prefer not to answer[4]. Since the survey took place at the moment when vaccines were not fully accessible (i.e. in most countries the focus was still on the elderly and individuals with comorbidities), it is rational to assume that interviewees stating "as soon as possible" or "sometime in 2021" had received their dose(s) by the end of 2021. For the purpose of the analysis, we hence made no distinction between individuals from categories (1), (2), and (5) above. Following the approach applied in similar studies (10, 18), besides this "pro-vaccination" group we also distinguish indecisive individuals (answers "later" and "do not know") and those who refuse vaccination (answer "never"). On the other hand, the option "prefer not to answer" was treated as a missing response and accordingly imputed using the Markov Chain Monte Carlo method[5].

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[3] A detailed overview of the methodology can be found in the accompanying report (33).

[4] The resulting dataset contains post-stratification weights, which were employed in our analyses so as to obtain generalized national-level results.

[5] The same procedure was applied in case of explanatory variables with missing values.

The preliminary tests showed that proportional odds assumption does not hold, which implies that individuals not intending to get vaccinated significantly differ from the indecisive ones in terms of the mechanisms underlying their reasoning. Following this, multinomial logistic regression appeared as a natural choice in the search for the factors explaining variability in vaccination rates across the EU. The results of the null model revealed that 9.3% (Wald test = 3.282, $P < 0.001$) of variance in likelihood to delay vaccination and 15.1% (Wald test = 3.203, $P < 0.001$) of variance in likelihood to refuse vaccination can be ascribed to the particularities of the country in which a respondent lives. This highlighted the need to pursue a multilevel approach so as to obtain unbiased results. Given this, we made use of the two-level random intercept multinomial logit model, which is defined as follows:

$$\ln\left(\frac{P(y_i = m)}{P(y_i = 0)}\right) = \beta_{0j} + \sum_{k=1}^{K} \beta_k X_{ijk} + \sum_{s=1}^{S} \gamma_s Z_{js}, m = 1, 2$$

$$\beta_{0j} = \beta_0 + u_j, \quad j = 1, 2, \ldots, 27$$

where y_i represents the value of the dependent variable for an individual i (0: Already vaccinated/Plan to get vaccinated; 1: Indecisive; 2: Refuse vaccination) and X_1-X_K are individual-level covariates exerting effects β_1-β_K on the dependent variable. Since data are given on two levels, the intercept value is allowed to vary from country to country by including the group-level residuals $u_j \sim N(0, \sigma^2)$.

Besides controlling for the hierarchical nature of data, the multilevel modeling also offered the opportunity to explore which country-level factors ($Z_1 - Z_S$ in the equation above) are responsible for the aforementioned variability in vaccination coverage. To exploit the full potential of this research paradigm, a mix of individual-level (i.e. level-1) variables available directly from the survey and country-level (level-2) variables compiled from other sources were hence used in the analysis.

Specifically, to evaluate Hypothesis 1, the following explanatory variables were included: binary indicator designating whether a respondent had been seriously ill because of COVID-19, binary indicator capturing one's subjective perception about the ability to avoid being infected by COVID-19 without vaccination (level-1 variables), the number of cumulative COVID-19 deaths in a country (adjusted for population size), the measure of the stringency of national policies to suppress COVID-19 (on a scale from 0 to 100), and GPD growth rates for 2020 (level-2 variables)[6]. On the other hand, age when finishing education (level-1) and average PISA scores for 2018 (a proxy for the overall quality of the national education system, level-2 variable) were used to test whether formal education is important in this respect (Hypothesis 2). To further explore how the individual's ability to critically assess information influences their viewpoints, we also included level-1 binary variables signifying whether they find online social networks and media as trustworthy. These two were supplemented with a level-2 variable denoting the portion of the population that tends to trust conspiracy theories.

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[6]More details about explanatory variables are given in **Supplementary Table 1**.

Turning to the role of the psychological contract between citizens and the authorities (Hypothesis 3), included are also binary variables indicating whether a person thinks public authorities have been sufficiently transparent about COVID-19 vaccines and whether they are satisfied with the way the government has handled the vaccination strategy (level-1). The broader effects of trust were scrutinized through interval variables measuring the overall support for the work of the government (not specific to COVID-19), the share of the population contented with the way democracy works in their country, and the share of citizens who distrust science (level-2).

To check how views and experiences of people in their surroundings affect one's standpoints (Hypothesis 4), the following level-1 covariates were also examined: binary variable indicating whether an individual relies on their colleagues, friends, and family when seeking information on COVID-19 vaccines, binary variable denoting whether they have people from close social circle who have been seriously ill because of COVID-19 and the categorical variable for the total number of adults in the household. To explore the role of social cohesion on a wider scale, we also included a level-2 variable representing the percentage of citizens who feel very attached to their country.

The effects of religion and political orientation (Hypothesis 5) were examined using country-level variables that indicate the percentage of people attending religious services at least once a week and the average positioning of the population on the political scale (where 1 is fully left and 10 is fully right). Finally, to control for other factors known to affect COVID-19 vaccine uptake, we also included age, gender, place of residence, migrant status, and history of previous vaccinations as explanatory variables in the models.

To sum up, a total of 12 models were constructed in a cumulative model-building fashion (25, 26). Model 1 comprises individual-level covariates only, while Models 2–12 sequentially include each of the enumerated country-level variables. The following section brings the most important findings from the conducted analysis.

RESULTS

As expected, the survey revealed that people from transition societies indeed exhibit much lower enthusiasm for vaccination than their western counterparts (**Figure 2**). More importantly, the ordering of countries based on the share of the population willing to get vaccinated in a due time closely matches the one based on true vaccination rates (as illustrated in **Figure 1**). For instance, survey respondents from Malta, Spain, Denmark, and Portugal were highly supportive of this strategy to combat the virus, which translated into high coverage rates at the end of 2021. The situation is diametrically opposite in post-socialist countries, where a substantial portion of residents either fully oppose vaccination or are indecisive.

To understand why this is so, **Table 1** presents the results of the multilevel multinomial logit model. Starting with Hypothesis 1, our findings challenge the hypothesized link between pandemic fatigue and the readiness of EU citizens to receive
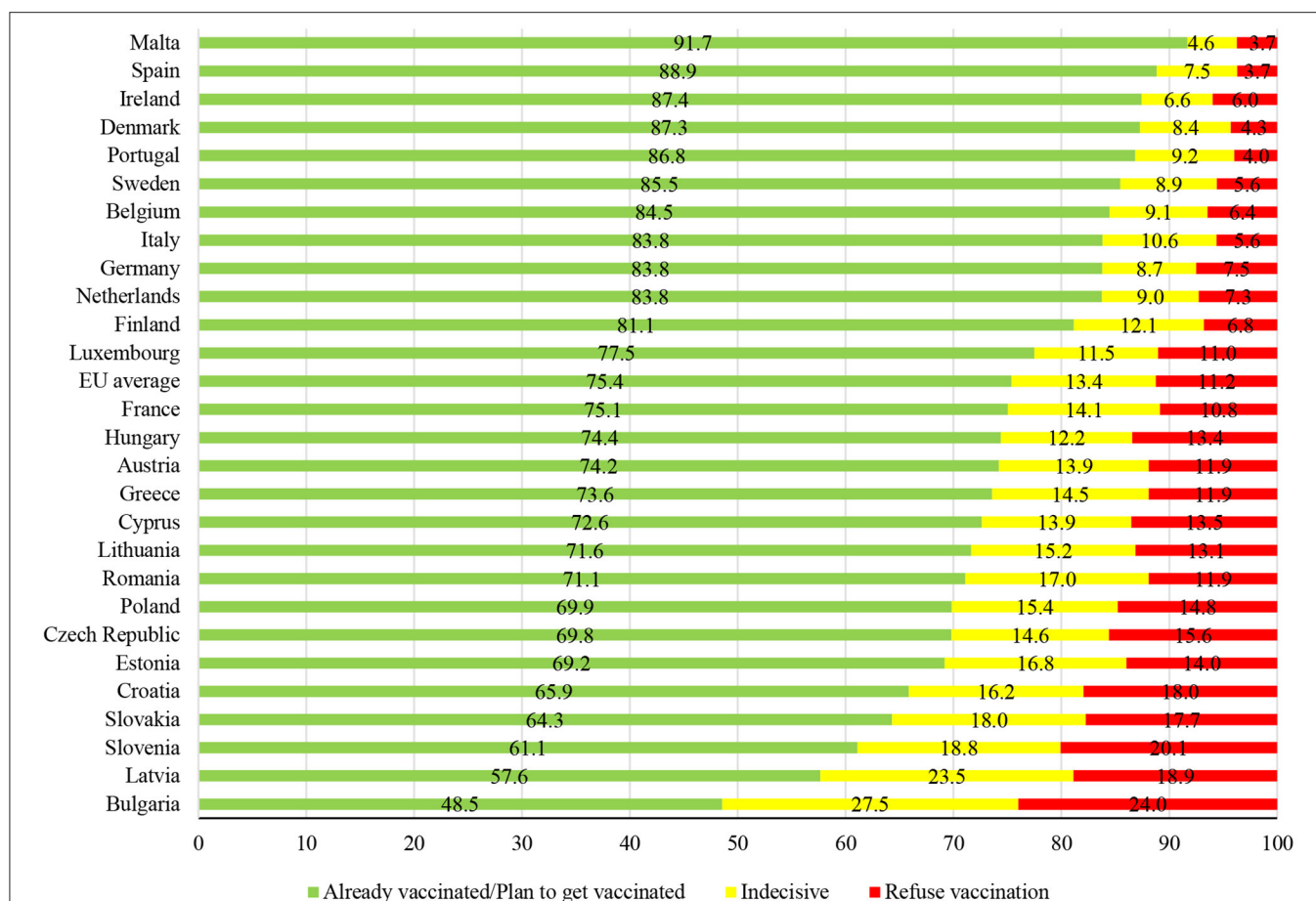
FIGURE 2 | Attitudes toward vaccination against COVID-19 across the EU, % of population. Source: Author's own calculations based on data from Flash Eurobarometer 494.

COVID-19 vaccines. Specifically, cumulative death rates, GDP growth rates, and the stringency of restrictions appear not to be particularly helpful in explaining why certain member states were more successful in vaccination. This, however, does not mean that Hypothesis 1 should be rejected. Quite the opposite, the findings on the remaining two variables highlight egocentrism as the key factor in this respect. More precisely, persons confident in their ability to avoid infection were found to be less keen on vaccination. The same is true for the ones who recently recovered from COVID-19. While expected for individuals wishing to delay vaccination (owing to a natural immunity gained), in the case of those opposing vaccination the latter actually points to important knowledge gaps.

This brings us to Hypothesis 2, which is fully supported by the results of the analysis. That is to say, we found that more educated persons are less likely to have doubts about vaccination (see **Table 1**). On the other hand, the quality of formal education in a country seems not to directly matter, although the resulting *p*-value is close to the cut-off point for "anti-vaxxers." An indirect effect, however, must exist given that the prevalence of conspiracy theories in society was also found to significantly influence citizens' views on vaccination. As a matter of fact, trust in

information from online sources was identified as the main factor discriminating persons who utterly reject vaccination from the indecisive ones. While hesitant citizens do not find websites and online social networks relevant, these two information channels are vital for the opponents of vaccination.

Another important element distinguishing the two groups is confidence in the information received from friends, colleagues, and relatives. Individuals who tend to trust people they interact with are more inclined to delay vaccination, but at the same time are less likely to fully oppose it. The importance of social ties is further demonstrated by the finding that those who know someone seriously ill from COVID-19 are more positive about vaccination. These results are in favor of Hypothesis 4, at least from a micro-level perspective. The same, however, does not hold on a wider scale given that no significant effect of the variable measuring the level of social cohesion within the country was found.

Further endorsing the role of trust, and offering the most plausible explanation for differences between older democracies and post-socialist societies are the findings related to Hypothesis 3. In short, we found that general trust in government, satisfaction with democratic principles in society, and trust in

TABLE 1 | Results of the multilevel multinomial logit.

	Model 1		Model 2		Model 3		Model 4	
	Indecisive	**Refuse vaccination**	**Indecisive**	**Refuse vaccination**	**Indecisive**	**Refuse vaccination**	**Indecisive**	**Refuse vaccination**
Intercept	1.542*** (0.161)	−1.291*** (0.189)	1.531*** (0.162)	−1.276*** (0.188)	1.536*** (0.159)	−1.295*** (0.188)	1.545*** (0.161)	−1.295*** (0.188)
Gender (RC: Male)	0.256*** (0.038)	0.186*** (0.042)	0.257*** (0.038)	0.187*** (0.042)	0.256*** (0.038)	0.186*** (0.042)	0.256*** (0.038)	0.186*** (0.042)
Age (group centered)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)
Age when finalizing education (RC: <16)								
16–19	−0.099 (0.112)	−0.195 (0.118)	−0.101 (0.112)	−0.201 (0.118)	−0.104 (0.112)	−0.193 (0.118)	−0.099 (0.112)	−0.197 (0.118)
20+	−0.302** (0.112)	−0.445*** (0.118)	−0.307** (0.112)	−0.453*** (0.118)	−0.306** (0.112)	−0.446*** (0.118)	−0.300** (0.112)	−0.448*** (0.118)
Still studying	−0.417*** (0.122)	−0.676*** (0.131)	−0.421*** (0.122)	−0.685*** (0.131)	−0.420*** (0.122)	−0.678*** (0.131)	−0.416*** (0.122)	−0.678*** (0.132)
Never had formal education	−0.005 (0.153)	−0.126 (0.169)	−0.011 (0.153)	−0.129 (0.169)	−0.008 (0.153)	−0.125 (0.169)	−0.001 (0.154)	−0.128 (0.169)
Number of adults in the household (group centered)	−0.006 (0.015)	0.032* (0.016)	−0.006 (0.015)	0.032* (0.016)	−0.006 (0.015)	0.033* (0.016)	−0.006 (0.015)	0.033* (0.016)
Place of residence (RC: Rural area)								
Small or middle-sized town	0.022 (0.048)	−0.252*** (0.051)	0.021 (0.048)	−0.255*** (0.052)	0.021 (0.048)	−0.254*** (0.052)	0.022 (0.048)	−0.253*** (0.051)
Large town	−0.165** (0.051)	−0.415*** (0.055)	−0.168** (0.051)	−0.418*** (0.055)	−0.165** (0.051)	−0.417*** (0.055)	−0.165** (0.051)	−0.415*** (0.055)
Living abroad	0.360*** (0.100)	0.180 (0.121)	0.357*** (0.100)	0.186 (0.121)	0.355*** (0.100)	0.182 (0.121)	0.360*** (0.100)	0.179 (0.121)
Vaccinated in adult age	−0.510*** (0.040)	−0.717*** (0.044)	−0.514*** (0.040)	−0.721*** (0.044)	−0.509*** (0.040)	−0.720*** (0.044)	−0.510*** (0.040)	−0.717*** (0.044)
Seriously ill because of COVID-19	0.277 *** (0.054)	0.225*** (0.062)	0.278*** (0.055)	0.223*** (0.062)	0.276 *** (0.054)	0.226*** (0.062)	0.277 *** (0.054)	0.224*** (0.062)
Knowing people who were seriously ill because of COVID-19	−0.411*** (0.045)	−0.698*** (0.048)	−0.412*** (0.046)	−0.705*** (0.048)	−0.412*** (0.045)	−0.701*** (0.048)	−0.410*** (0.045)	−0.699*** (0.048)
Satisfaction with the way government has handled the vaccination strategy	−0.745*** (0.040)	−1.497*** (0.050)	−0.749*** (0.040)	−1.502*** (0.050)	−0.746*** (0.040)	−1.501*** (0.050)	−0.745*** (0.040)	−1.499*** (0.050)
Public authorities not sufficiently transparent about COVID-19 vaccines	0.349*** (0.044)	0.413*** (0.051)	0.350*** (0.044)	0.414*** (0.051)	0.349*** (0.044)	0.414*** (0.051)	0.348*** (0.044)	0.414*** (0.051)
Websites provide reliable information on COVID-19 vaccines	0.029 (0.068)	0.194** (0.072)	0.028 (0.068)	0.195** (0.072)	0.029 (0.068)	0.194** (0.072)	0.029 (0.068)	0.193** (0.072)
Online social networks provide reliable information on COVID-19 vaccines	0.052 (0.077)	0.391*** (0.078)	0.053 (0.077)	0.394*** (0.079)	0.054 (0.077)	0.393*** (0.077)	0.053 (0.077)	0.392*** (0.079)
Colleagues, friends and family provide reliable information on COVID-19 vaccines	0.127** (0.048)	−0.249*** (0.056)	0.128** (0.048)	−0.249*** (0.056)	0.126** (0.048)	−0.250*** (0.056)	0.127** (0.048)	−0.251*** (0.056)

(Continued)

TABLE 1 | Continued

	Model 1		Model 2		Model 3		Model 4	
	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination
Can avoid COVID-19 infection without being vaccinated	0.969*** (0.042)	1.545*** (0.052)	0.971*** (0.042)	1.551*** (0.052)	0.968*** (0.042)	1.549*** (0.052)	0.969*** (0.042)	1.546*** (0.052)
Country-level variables								
Cumulative COVID-19 deaths per 100 million people			0.017 (0.014)	0.028 (0.019)				
Stringency of national measures to suppress COVID-19					−0.017 (0.009)	−0.018 (0.013)		
GDP growth rate for 2020							0.049 (0.039)	0.075 (0.051)
Quality of education system								
General trust in government								
Satisfaction with democracy								
Distrust in science								
Proneness to conspiracy theories								
Political orientation								
Religiosity								
Social cohesion								
σ^2	0.256*** (0.073)	0.456*** (0.128)	0.256*** (0.073)	0.441*** (0.128)	0.233*** (0.067)	0.439*** (0.124)	0.249*** (0.071)	0.443*** (0.125)
Variance partition coefficient (VPC)	0.0722	0.1217	0.0722	0.1181	0.0661	0.1177	0.0704	0.1187
Covariance	0.333*** (0.094)		0.328*** (0.092)		0.312*** (0.088)		0.323*** (0.091)	

	Model 5		Model 6		Model 7		Model 8	
	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination
Intercept	1.537*** (0.158)	−1.297*** (0.187)	1.521*** (0.156)	−1.269*** (0.181)	1.534*** (0.156)	−1.287*** (0.181)	1.544*** (0.157)	−1.295*** (0.185)
Gender (RC: Male)	0.256*** (0.038)	0.187*** (0.042)	0.256*** (0.038)	0.186*** (0.042)	0.255*** (0.038)	0.186*** (0.042)	0.255*** (0.038)	0.186*** (0.042)
Age (group centered)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)
Age when finalizing education (RC: <16)								
16–19	−0.102 (0.112)	−0.199 (0.118)	−0.100 (0.112)	−0.197 (0.118)	−0.098 (0.112)	−0.195 (0.118)	−0.095 (0.112)	−0.195 (0.118)
20+	−0.307** (0.112)	−0.453*** (0.118)	−0.303** (0.112)	−0.450*** (0.118)	−0.300** (0.112)	−0.445*** (0.118)	−0.298** (0.112)	−0.445*** (0.118)
Still studying	−0.421*** (0.121)	−0.684*** (0.131)	−0.418*** (0.121)	−0.681*** (0.131)	−0.415*** (0.121)	−0.677*** (0.131)	−0.413*** (0.122)	−0.677*** (0.131)
Never had formal education	−0.009 (0.153)	−0.133 (0.169)	−0.006 (0.153)	−0.128 (0.169)	−0.003 (0.153)	−0.125 (0.169)	−0.003 (0.153)	−0.127 (0.169)

(Continued)

TABLE 1 | Continued

	Model 5		Model 6		Model 7		Model 8	
	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination
Number of adults in the household (group centered)	−0.007 (0.015)	0.032* (0.016)	−0.006 (0.015)	0.032* (0.016)	−0.007 (0.015)	0.032* (0.016)	−0.007 (0.015)	0.033* (0.016)
Place of residence (RC: Rural area)								
Small or middle-sized town	0.019 (0.048)	−0.254*** (0.052)	0.021(0.048)	−0.254*** (0.051)	0.021 (0.048)	−0.253*** (0.051)	0.022 (0.048)	−0.253*** (0.051)
Large town	−0.170** (0.051)	−0.418*** (0.055)	−0.166** (0.051)	−0.417*** (0.055)	−0.165** (0.051)	−0.416*** (0.055)	−0.165** (0.051)	−0.416*** (0.055)
Living abroad	0.356*** (0.100)	0.179 (0.121)	0.363*** (0.101)	0.189 (0.121)	0.363*** (0.101)	0.185 (0.121)	0.361*** (0.100)	0.179 (0.121)
Vaccinated in adult age	−0.511*** (0.040)	−0.723*** (0.044)	−0.510*** (0.040)	−0.719*** (0.044)	−0.508*** (0.040)	−0.717*** (0.044)	−0.510*** (0.040)	−0.718*** (0.044)
Seriously ill because of COVID-19	0.276 ***(0.054)	0.224*** (0.062)	0.276 ***(0.054)	0.223*** (0.062)	0.276 ***(0.054)	0.225*** (0.062)	0.277 ***(0.054)	0.224*** (0.062)
Knowing people who were seriously ill because of COVID-19	−0.415*** (0.045)	−0.704*** (0.048)	−0.412*** (0.045)	−0.702*** (0.048)	−0.411*** (0.045)	−0.700*** (0.048)	−0.411*** (0.045)	−0.699*** (0.048)
Satisfaction with the way government has handled the vaccination strategy	−0.750*** (0.040)	−1.505*** (0.051)	−0.744*** (0.040)	−1.499*** (0.050)	−0.744*** (0.040)	−1.498*** (0.050)	−0.744*** (0.040)	−1.497*** (0.050)
Public authorities not sufficiently transparent about COVID-19 vaccines	0.347*** (0.044)	0.416*** (0.051)	0.348*** (0.044)	0.413*** (0.051)	0.346*** (0.044)	0.412*** (0.051)	0.347*** (0.044)	0.413*** (0.051)
Websites provide reliable information on COVID-19 vaccines	0.029 (0.068)	0.194** (0.072)	0.030 (0.068)	0.195** (0.072)	0.030 (0.068)	0.194** (0.072)	0.030 (0.068)	0.193** (0.072)
Online social networks provide reliable information on COVID-19 vaccines	0.053 (0.077)	0.395*** (0.079)	0.053 (0.077)	0.393*** (0.078)	0.053 (0.077)	0.392*** (0.078)	0.052 (0.077)	0.391*** (0.079)
Colleagues, friends and family provide reliable information on COVID-19 vaccines	0.128** (0.048)	−0.250*** (0.056)	0.126** (0.048)	−0.250*** (0.056)	0.126** (0.048)	−0.250*** (0.056)	0.127** (0.048)	−0.250*** (0.056)
Can avoid COVID-19 infection without being vaccinated	0.970*** (0.042)	1.551*** (0.052)	0.968*** (0.042)	1.549*** (0.052)	0.968*** (0.042)	1.547*** (0.052)	0.968*** (0.042)	1.547*** (0.052)
Country-level variables								
Cumulative COVID-19 deaths per 100 million people								
Stringency of national measures to suppress COVID-19								
GDP growth rate for 2020								

(Continued)

TABLE 1 | Continued

	Model 5		Model 6		Model 7		Model 8	
	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination
Quality of education system	−0.730 (0.377)	−0.869 (0.511)						
General trust in government			−0.018* (0.007)	−0.024** (0.009)				
Satisfaction with democracy					−0.015* (0.006)	−0.020** (0.008)		
Distrust in science							0.270* (0.124)	0.326* (0.167)
Proneness to conspiracy theories								
Political orientation								
Religiosity								
Social cohesion								
σ^2	0.229*** (0.066)	0.427*** (0.120)	0.207*** (0.059)	0.366*** (0.104)	0.208*** (0.060)	0.373*** (0.106)	0.222*** (0.064)	0.412*** (0.116)
Variance partition coefficient (VPC)	0.0651	0.1149	0.0592	0.1001	0.0594	0.1018	0.0632	0.1112
Covariance	0.304*** (0.086)		0.267*** (0.075)		0.270*** (0.076)		0.393*** (0.083)	

	Model 9		Model 10		Model 11		Model 12	
	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination
Intercept	1.536*** (0.154)	−1.291*** (0.180)	1.532*** (0.156)	−1.283*** (0.183)	1.540*** (0.161)	−1.282*** (0.191)	1.540*** (0.161)	−1.291*** (0.191)
Gender (RC: Male)	0.255*** (0.038)	0.186*** (0.042)	0.255*** (0.038)	0.186*** (0.042)	0.257*** (0.038)	0.186*** (0.042)	0.256*** (0.038)	0.186*** (0.042)
Age (group centered)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)	−0.022*** (0.001)	−0.015*** (0.001)
Age when finalizing education (RC: <16)								
16–19	−0.099 (0.112)	−0.196 (0.118)	−0.098 (0.112)	−0.192 (0.118)	−0.098 (0.112)	−0.197 (0.118)	−0.099 (0.112)	−0.198 (0.118)
20+	−0.301** (0.112)	−0.447*** (0.118)	−0.301** (0.112)	−0.443*** (0.118)	−0.301** (0.112)	−0.450*** (0.118)	−0.305** (0.112)	−0.450*** (0.118)
Still studying	−0.415*** (0.121)	−0.678*** (0.131)	−0.416*** (0.122)	−0.675*** (0.131)	−0.419*** (0.122)	−0.679*** (0.131)	−0.419*** (0.122)	−0.682*** (0.131)
Never had formal education	−0.003 (0.153)	−0.127 (0.169)	−0.005 (0.153)	−0.125 (0.169)	−0.008 (0.153)	−0.126 (0.169)	−0.009 (0.153)	−0.126 (0.169)
Number of adults in the household (group centered)	−0.007 (0.015)	0.032* (0.016)	−0.006 (0.015)	0.033* (0.016)	−0.005 (0.015)	0.031 (0.016)	−0.006 (0.015)	0.032* (0.016)
Place of residence (RC: Rural area)								
Small or middle–sized town	0.020 (0.048)	−0.254*** (0.051)	0.021 (0.048)	−0.253*** (0.052)	0.023 (0.048)	−0.255*** (0.052)	0.019 (0.048)	−0.253*** (0.052)
Large town	−0.166** (0.051)	−0.417*** (0.055)	−0.166** (0.051)	−0.415*** (0.055)	−0.163** (0.051)	−0.419*** (0.055)	−0.170** (0.051)	−0.415*** (0.055)
Living abroad	0.362*** (0.100)	0.182 (0.121)	0.366*** (0.101)	0.182 (0.121)	0.360*** (0.100)	0.179 (0.121)	0.365*** (0.100)	0.177 (0.121)
Vaccinated in adult age	−0.508*** (0.040)	−0.717*** (0.044)	−0.507*** (0.040)	−0.717*** (0.044)	−0.515*** (0.040)	−0.717*** (0.044)	−0.511*** (0.040)	−0.722*** (0.044)
Seriously ill because of COVID-19	0.276 ***(0.054)	0.224*** (0.062)	0.276 ***(0.054)	0.225*** (0.062)	0.277 ***(0.054)	0.226*** (0.062)	0.277 ***(0.054)	0.224*** (0.062)
Knowing people who were seriously ill because of COVID-19	−0.412*** (0.046)	−0.701*** (0.048)	−0.410*** (0.045)	−0.700*** (0.048)	−0.408*** (0.045)	−0.704*** (0.048)	−0.411*** (0.045)	−0.703*** (0.048)

(Continued)

TABLE 1 | Continued

	Model 9		Model 10		Model 11		Model 12	
	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination	Indecisive	Refuse vaccination
Satisfaction with the way government has handled the vaccination strategy	−0.745*** (0.040)	−1.499*** (0.050)	−0.743*** (0.040)	−1.497*** (0.050)	−0.744*** (0.040)	−1.502*** (0.050)	−0.749*** (0.040)	−1.502*** (0.050)
Public authorities not sufficiently transparent about COVID-19 vaccines	0.346*** (0.044)	0.412*** (0.051)	0.348*** (0.044)	0.413*** (0.051)	0.352*** (0.044)	0.412*** (0.051)	0.349*** (0.044)	0.415*** (0.051)
Websites provide reliable information on COVID-19 vaccines	0.029 (0.068)	0.194** (0.072)	0.029 (0.068)	0.194** (0.072)	0.031 (0.068)	0.193** (0.072)	0.031 (0.068)	0.193** (0.072)
Online social networks provide reliable information on COVID-19 vaccines	0.052 (0.077)	0.392*** (0.078)	0.052 (0.077)	0.392*** (0.079)	0.054 (0.077)	0.392*** (0.079)	0.052 (0.077)	0.395*** (0.079)
Colleagues, friends and family provide reliable information on COVID-19 vaccines	0.127** (0.048)	−0.249*** (0.056)	0.126** (0.048)	−0.251*** (0.056)	0.126** (0.048)	−0.250*** (0.056)	0.127** (0.048)	−0.250*** (0.056)
Can avoid COVID-19 infection without being vaccinated	0.968*** (0.042)	1.548*** (0.052)	0.967*** (0.042)	1.547*** (0.052)	0.969*** (0.042)	1.550*** (0.052)	0.969*** (0.042)	1.545*** (0.052)
Country-level variables								
Cumulative COVID-19 deaths per 100 million people								
Stringency of national measures to suppress COVID-19								
GDP growth rate for 2020								
Quality of education system								
General trust in government								
Satisfaction with democracy								
Distrust in science								
Proneness to conspiracy theories	0.016** (0.006)	0.021** (0.008)						
Political orientation			0.534* (0.222)	0.675* (0.298)				
Religiosity					−0.009 (0.007)	−0.008 (0.010)		
Social cohesion							0.010 (0.009)	0.010 (0.012)
σ^2	0.197*** (0.057)	0.358*** (0.102)	0.213*** (0.061)	0.390*** (0.110)	0.251*** (0.072)	0.466*** (0.131)	0.256*** (0.073)	0.471*** (0.132)
Variance partition coefficient (VPC)	0.0565	0.0981	0.0608	0.1060	0.0709	0.1241	0.0722	0.1252
Covariance	0.257*** (0.073)		0.279*** (0.079)		0.335*** (0.094)		0.338*** (0.095)	

*p < 0.05; **p < 0.01; ***p < 0.001.

Estimates based on the multiple imputation technique with 10 imputed values.

RC stands for "reference category."

Source: Author's own calculations based on Flash Eurobarometer 494.

science, coupled with specific views on the way the authorities have handled the current pandemic are the key determinants of attitudes toward vaccination against COVID-19 in the EU. All coefficients have the expected signs, namely higher trust implies higher readiness to get vaccinated and vice versa.

As already mentioned, there is a large body of literature identifying a weak psychological contract between the state and citizens as the key force behind the rising occurrence of informal practices in post-socialist countries (27, 34). While less harmful forms of noncompliance commonly arise from formal institutions failing to deliver goods and services on time and/or under satisfactory quality, more serious offenses (e.g. undeclared work and akin tax evasion activities) are increasingly the result of rebellion against massive, ineffective, and over-intrusive state apparatus (26–30, 35). Our findings suggest that similar mechanisms are probably in place when it comes to COVID-19 vaccination, meaning that many people in transition societies probably refuse it simply to defy the authorities.

In this respect, one should not neglect the ongoing rise of antiestablishment parties (mostly right-wing ones), which commonly target masses disappointed with the way political leaders sort out current social and economic issues. Indeed, our analysis showed that countries with larger populations of right-oriented citizens face larger resistance to vaccination (**Table 1**). This endorses the first part of Hypothesis 5. On the other hand, contrary to studies from the rest of the world (21, 22), religious views seem not to represent significant impediments to vaccination in the EU.

To get a more tangible insight into the relevance of individual factors, **Figure 3** shows predicted probabilities by five key criteria for each of the three analyzed groups of citizens. The comparison of results straightforwardly highlights the satisfaction with the authorities as by far the most important determinant of vaccination uptake in the EU. As can be seen, individuals dissatisfied with the way the government has handled vaccination strategy are 3.5 times more likely to reject vaccination and 1.7 times more likely to delay it compared to those who are confident about the work of the institutions in charge. The second most important discriminatory factor is trust in information from online social networks, which increases the probability to reject vaccination by almost 50%.

Although individual effects of the remaining covariates are somewhat less salient, each of them represents an important piece of the complex puzzle explaining discrepancies in vaccination rates across the EU. To exemplify this, the last panel of **Figure 3** shows the predicted probabilities for three extreme individuals. As illustrated, low-educated persons displeased with the government's strategy against COVID-19, who seek reliable information online and firmly believe they can avoid future infection have a 54.4% chance to be totally against vaccination. This probability reduces to only 0.8% in situations when a person is fully content with the work of the authorities, does not rely on informal sources of information, and has not suffered from severe infection so far (but does know people who did so).

DISCUSSION

The issue of COVID-19 vaccine hesitancy has so far been approached primarily from the medical perspective. Reflecting knowledge about the factors that led to a reduced interest in vaccination against other diseases, most public discussions and academic studies in the EU and beyond thus paid due attention to a short period within which COVID-19 vaccines were developed and the accompanying lack of reliable safety information (8, 9, 12). However, 1 year into the campaign, it has become clear that safety concerns cannot fully explain strong resistance to COVID-19 vaccination in many EU member states. To explore why this is so, and in particular why the anti-vaccination movement has been more ingrained in post-socialist societies, this paper took a novel approach by scrutinizing the matter through the lens of economic, political, and cultural challenges EU countries are facing at the moment.

For this purpose, data from Flash Eurobarometer 494 on vaccination attitudes in the EU were analyzed. According to the survey, 13.4% of Europeans planned to delay vaccination against COVID-19, while 11.2% did not have any intention to get vaccinated. A deeper insight into the resulting dataset revealed that 15.1% of the variation related to anti-vaccination views and 9.3% of the variation concerning indecisiveness at the EU level go beyond the personal characteristics of survey respondents.

Although the multilevel multinomial logit exposed a range of socio-economic and political factors explaining these variations, the lack of confidence in the state institutions appears to be by far the most important driver of the anti-vaccination movement in many countries. The problem goes beyond the current pandemic and its consequences, given that the conducted analysis highlighted low general trust in government (not necessarily related to the strategies to combat the virus) and dissatisfaction with democracy as key determinants of anti-vaccinationism in the EU. Not only did inconsistencies of the authorities during the pandemic pave the way for the rapid spread of conspiracy theories but they hence most likely further fueled the existing culture of deliberate opposition to formal rules and recommendations (26, 35).

The situation is particularly worrying in post-socialist countries, which are currently witnessing historically low levels of both vertical trust (i.e. trust in the authorities) and horizontal trust (trust in fellow citizens) (36). Previous studies have shown that nepotism, string-pulling, bribery and akin practices inherited from the socialist period still represent a substantial impediment to economic and social development in these "newer democracies" (26, 27, 34). Besides forcing many people to build their own informal networks of trust, weak rule of law has also nurtured the culture of obstruction of the ruling elites. Judging from the results of our analysis, this devastating war is being fought on all possible battlefields, irrespective of the accompanying costs.

The issue of COVID-19 vaccination thus clearly illustrates how the long-lasting structural problems can manifest in unforeseen circumstances if left unaddressed. The combination of defiant behavior and disproportionate reliance on unverified sources of information has undermined the efforts of scientists,

FIGURE 3 | Predicted probabilities by different criteria, %. (1) Panels 1–5 illustrate how the change in the observed variable affects the predicted probabilities for an average EU citizen. (2) Panel 6 shows the predicted probabilities in the extreme scenarios. Citizen 1—was not ill because of COVID-19, but knows people who were seriously ill; satisfied with the way government has handled the vaccination strategy (including the transparency issues); does not rely on friends, relatives, media, or online social networks when seeking information on COVID-19; does not think she/he can avoid infection without vaccination; still studying. Citizen 2 —was ill because of COVID-19, but does not know people who were seriously ill; dissatisfied with the way government has handled the vaccination strategy; relies on media and online social networks when seeking information on COVID-19; thinks she/he can avoid infection without vaccination; finished education by the age of 15. Citizen 3—was ill because of COVID-19, but does not know people who were seriously ill; dissatisfied with the way government has handled the vaccination strategy; relies only on friends and relatives when seeking information on COVID-19; thinks she/he can avoid infection without vaccination; never had formal education. Source: Author's own calculations based on Flash Eurobarometer 494.

healthcare workers, politicians, and compliant citizens to defeat the virus. Consequently, all plans to attain the so-desired herd immunity *via* vaccination have fallen into the water.

However, there are other battles to come, so it is essential to learn the lesson and prevent future escalations of the problem. In line with the findings presented in this paper, as well as from other studies on the misalignment between formal and informal institutions (27, 34, 36), the key emphasis must be on improving the integrity of public institutions. Among other things, this would require increased transparency, improved efficiency of administration, a decisive fight against corruption, and promotion of meritocracy in the public sector. Reforms of education systems also ought to be high on the agenda, whereby the accent should be on the development of critical thinking rather than on a mere task-solving. Finally, endeavors are required to ensure the credibility of information posted online. This primarily applies to online social networks, which are currently the main channel through which conspiracy theories are spread (14, 20, 37).

Although focused on a present-day health issue, this paper is expected to have a wider impact in a variety of scientific fields. Above all, it is envisaged that academics from the fields of political science, economics, psychology, and sociology will find the results presented here interesting and inspiring. Accordingly, if this study encourages other interdisciplinary researchers to further explore this important topic, then it will have fulfilled one of its broader aims.

There are, however, certain limitations of the conducted analysis, which ought to be mentioned. First of all, data utilized in this study were collected during the early phase of vaccination and thus do not necessarily represent the up-to-date state of affairs. The emergence of new variants of the virus on the one hand and perceptible economic consequences of the pandemic on the other (i.e. inflation of consumer prices, shortages of goods and services, new travel restrictions, etc.) have certainly changed the way many people look at the vaccination. In addition, individual-level variables used in the analysis were limited only to those available as part of the Eurobarometer survey, meaning that not all essential covariates were included. Ethnicity, race, marital status, income, and the existence of comorbidities are just the most noteworthy examples of omitted variables. These issues have to be resolved in future studies on the matter, which this paper will hopefully motivate.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found at: https://search.gesis.org/research_data/ZA7771.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and approved it for publication.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.858265/full#supplementary-material

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Environmental Pollution Liability Insurance of Health Risk and Corporate Environmental Performance: Evidence From China

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Environmental pollution liability insurance (EPLI) is a type of insurance purchased by an enterprise to compensate the loss of the victims in the event of an environmental pollution incident. Although EPLI can realize the post-treatment of environmental pollution to a certain extent, there is still less understanding of whether EPLI can improve the environmental performance of enterprises. This study takes A-share listed companies in heavily polluting industries as the research object, determines the treatment group samples according to the Insurance coverage list published by the Ministry of Environmental Protection in 2014 and 2015, and then constructs the empirical test model. In order to ensure that there is no sample selection bias, the PSM method is used to preprocess the samples in this study to ensure the robustness of the conclusions. The empirical tests show that EPLI can significantly improve corporate environmental performance. Further analysis showed that higher public visibility is conducive to the positive environmental effects of EPLI. Compared with state-owned enterprises, non-state-owned enterprises have more significant implementation effects after introducing EPLI. On further examination, the result indicates that environmental pollution liability insurance can improve environmental performance by alleviating corporate financing constraints. The findings of this paper enrich the theory of the economic impact of environmental pollution liability insurance, which has some meaningful theoretical guidance for enterprises and policy makers.

Keywords: environmental pollution liability insurance, health risk, environmental performance, public visibility, ownership structure

INTRODUCTION

The massive urbanization in mainland China has raised issues related to industrial pollution affecting population health (1, 2). This is increasingly becoming one of the top priorities in governing authority's agendas (3, 4). It is clearly documented with a bold rise in Chinese domestic health and pharmaceutical spending in medium-term forecasted projections up to 2025 (5) and 2030 (6). The responsibility frontier in policy makers' mindset is now shifting from the public sector toward the private-owned manufacturing industry (7).

The significance of corporate environmental performance in improving corporate value and corporate image has become increasingly important with the increasing concern of lawmakers and the public on environmental issues. Scholars began to pay more attention to what factors affect the environmental performance of enterprises. The existing literature mainly includes three aspects.First is the influence of internal factors of a company on its environmental performance, such as governance structure and CEO characteristics. For instance, Walls et al. (8) studied the influence of governance structure, including ownership, board size and managerial incentives, on corporate environmental performance. Elmagrhi et al. (9) found that with the increase in the proportion and age of female directors, a company's environmental performance would also increase. Slater and Dixon-Fowler (10) found that CEOs with MBA degrees bring a higher level of environmental performance to their companies. Second is the impact of external pressure on the company's environmental performance, such as regulation and social license. For instance, Kagan et al. (11) studied to what extent and how external factors such as regulation, market, and social pressure affect the environmental performance of corporates; Graafland and Smid (12) used SMEs as a research sample to explore how social licensing affects environmental performance. Third, the impact of policy tools on environmental performance, such as environmental management systems (EMS) and ISO 14001. For instance, Zobel (13) found that some certifications, such as EMS and ISO14001 certification, can effectively improve the environmental performance of enterprises. Environmental Pollution Liability Insurance (EPLI) not only has the function of post-compensation as a kind of insurance, but also shows its attribute as a system in the actual implementation. However, the existing research focuses more on the insurance nature of EPLI and ignores its institutional nature. There is a question worth discussing, that is, whether EPLI can effectively play the role of institutional norms to improve enterprises' environmental performance grade, and literature research on this aspect is still lacking.

Environmental pollution events often bring huge losses, both economically and environmentally. In recent years, the scope of responsibility of the principal responsible for pollution incidents has been expanding from international practice, which means that once the environmental pollution happens to the enterprise, the enterprise often has to face the huge capital repayment pressure. EPLI is a type of insurance used to compensate for injuries and deaths caused by pollution and related restoration and clean-up costs toward the third party. Therefore, EPLI can play a role in dispersing enterprise environmental risks. Scholars have conducted research on the effects of EPLI from different perspectives. On the one hand, some scholars compared the effects of EPLI in different implementation modes. Feng et al. (14) used a case study method to compare the effects of implementing compulsory and voluntary environmental pollution liability insurance, corresponding to Wuxi and Chongqing (China). The results showed that the local government could establish a relatively mature pollution insurance system more quickly with the implementation of compulsory insurance. On the other hand, some scholars have studied the role of EPLI. Staccione et al.

(15) conducted interviews with experts and waste treatment and disposal plants (WTPs) operators to investigate their attitudes and perceived efficiency toward environmental insurance. The results showed that environmental insurance is a good financial tool for managing environmental risks. Yang et al. (16) took the enterprises in chemical industrial parks as an example to evaluate the implementation effect of EPLI to improve environmental risk management and made policy recommendations. In general, previous studies on the implementation effects of EPLI have focused less on enterprises and more on the insurance nature of EPLI. From the perspective of stakeholder theory, corporates should not merely focus on the interest of their shareholders, but also have to do their best to meet the expectation of other stakeholders. In the EPLI model, stakeholder relationships are formed between multiple roles, including governments, consulting teams, insurance companies, third party services and companies (17). Consulting teams will be responsible for designing the EPLI's operational mechanism; Governments will provide financial support and supervision for the operation of insurance; Insurance companies will collect premiums and make compensations when environmental pollution accidents occur; Third parties will provide on-site inspection and other environmental services. Under this system design, the common need of these external stakeholders for the company is to reduce the occurrence and loss of pollution incidents. Therefore, we believe that coverage of EPLI will help companies improve their environmental performance levels by increasing stakeholder pressure on companies. Previous literature did not examine the implementation effect of EPLI as a system. Given this research gap, we designed an empirical test in this paper to explore whether EPLI will have an impact on the environmental performance of companies.

Public visibility refers to the degree to which a company receives attention from the public (18). According to the stakeholder-agency theory, the problem of information asymmetry is widespread between management and stakeholders. This is because management can use their facilities to whitewash or selectively disclose internal information, which will increase costs for stakeholders to distinguish whether management decisions are in their favor. During the operation of the EPLI system, the acquisition of environmental information by stakeholders is an important link to ensure the implementation of environmental pressure on enterprises. Higher public visibility can assist stakeholders in determining whether a company's behavior is in line with their expectations (19). Combined with the above, the probability of corporate managers acting in the interests of their stakeholders' increases as their visibility increases. Therefore, we believe that a moderating role of public visibility is reflected in the moderating relationship between EPLI and corporate environmental performance.

Another influence of corporate environmental performance is corporate governance structure, such as ownership structure. The environmental performance of state-owned firms tends to be higher than that of non-state-owned enterprises because the goal of state-owned firms is to maximize economic welfare (20). EPLI improves corporate environmental performance by introducing stakeholder groups to exert environmental pressure

on companies. According to resource dependence theory, the pressure exerted by stakeholders on a firm depends on the importance of the resources they control to the firm. State-owned enterprises can obtain external resources more easily by virtue of their political connections. Malatesta and Dewenter (21) found it easier for politically connected companies to obtain debt financing. Therefore, we believe that non-state-owned firms are more sensitive to environmental pressures from EPLI and have more incentive to improve environmental performance than state-owned enterprises.

As the largest developing country, the Chinese government has paid particular attention to environmental issues in recent years (22). The government has also supported EPLI. China's EPLI was officially introduced in 2007. The Guidance on Environmental Protection and the Insurance Regulation Commission clarified the objective orientation, development principle, division of responsibilities and specific work content arrangement of EPLI in China. To address the above research gaps, we examine the institutional effects of EPLI and focus on whether EPLI can positively affect firms' environmental performance by combining stakeholder theory, agency theory, and resource dependence theory. In addition, we further investigate the moderating effect of public visibility and ownership structure from the perspective of stakeholder pressure. Moreover, this paper takes 2014–2015 insured companies published by the Ministry of Environmental Protection as data collection objects and conducts an empirical study on listed companies in heavy pollution industries in China to test our theoretical hypothesis. Our research objectives include (a) identifying the impact and mechanism of EPLI on corporate environmental performance, (b) examining the moderating effect of firm visibility on the relationship between EPLI and corporate environmental performance, and (c) examining the moderating effect of ownership structure on the relationship between EPLI and corporate environmental performance.

The contributions of this study are: First, this paper enriches the literature on the microeconomic effects of EPLI and uses empirical methods to explore the impact of EPLI on corporate environmental performance. Second, this study focuses on the institutional effects of EPLI, which enriches the theoretical research on the effects of EPLI's implementation. Third, this paper uses stakeholder theory as the main theoretical support, combined with agency theory and resource dependence theory, to construct a theoretical framework to explain the effect of EPLI on corporate environmental performance, enriching the connotation of existing theories.

The remainder part of this paper is structured as follows. The following section will introduce the relevant research on EPLI and environmental performance, theoretical background and hypothesis derivation. In the following chapters, we will report the design and the findings of our empirical research. The last part will summarize the whole study and put forward optimization suggestions.

THEORETICAL BACKGROUND AND HYPOTHESIS

It can be found from the dimension of stakeholder theory that since the needs of stakeholders are different and sometimes contradictory, managers will respond to the needs of stakeholders according to certain priorities, which are determined by stakeholder salience. Stakeholder salience can be described as the degree of pressure imposed by stakeholders on management, which is the function of power, legitimacy and urgency (23). The central stakeholders in China's EPLI system are insurance companies and the government (17). On the one hand, a contractual relationship is formed between enterprises and the insurance companies, and the circumstances that trigger a change in the interests of both parties are pollution accidents because they will lead directly to insurance claims. On the other hand, the roles of government for enterprises are administrative support and supervision. With the introduction of the enactment in China linking the performance evaluation of local officials to environmental issues in 2006, environmental accidents will directly affect the promotion benefits of officials. Therefore, both insurance companies and the government have a power-basis, legitimate and urgent needs to improve corporate environmental performance. Further, the insurance companies and the government will be classified as definitive stakeholders because they meet all three attributes according to the stakeholder salience theory, whose demands will put more pressure on managers than other stakeholders' demands (23). Studies have found that high pressure from stakeholders can promote the growth of corporate environmental performance (24).

Furthermore, according to stakeholder-agency theory, adequate disclosure of internal information will increase the pressure on managers to act in line with stakeholders' interests. EPLI can alleviate the degree of information asymmetry by introducing external supervision. On the one hand, the governance structure of China's EPLI system is generally dominated by the government (25), and the government will supervise and evaluate the effect of the implementation of the EPLI. On the other hand, third-party service agencies will also provide on-site inspection and other services to supervise the effectiveness of the system (17). In the process of supervising the enterprise, stakeholders in the EPLI system will make the information on the firm's environmental performance more widely spread among them (14), which will increase the environmental pressure on the firm.

In summary, EPLI can alleviate the problem of information asymmetry between major stakeholders in the EPLI system and enterprises to a certain extent and thus increase the pressure on managers to improve environmental performance. Based on the above discussion, we propose our first hypothesis:

Hypothesis 1. EPLI has a positive impact on corporate environmental performance.

According to stakeholder-agency theory, even though enterprises are faced with pressure from stakeholders, the management still tends to engage in opportunistic behaviors that

are inconsistent with the expectations of stakeholders. However, more visible companies will face more burdensome external constraints and higher public demands for corporate citizenship, which will set a higher threshold for managers' opportunistic behavior (18).

On the one hand, widespread public attention can help stakeholders in the EPLI system determine whether a company's activities meet green standards (19). Companies with high public visibility will attract more public attention, which means that when companies purchase EPLI, there will be more third-party organizations such as media and securities analysts to report and evaluate this event (26). In other words, the attention of public institutions has broadened the channels for stakeholders to access information related to the company's purchase of EPLI. Therefore, public visibility will help stakeholders judge whether the actions of managers are in their interests and thus further increase the environmental pressure of stakeholders on the company.

On the other hand, with the increase in visibility, the company is faced with pressure from the public, a potential stakeholder, which urges the company to participate more in social responsibility activities (27). Flammer (28) also found that external green pressure from public concern will lead to the formation of green social responsibility norms. This means that stakeholders in the EPLI system will put more environmental pressure on the company when the company's public visibility is higher, thus making the contribution of EPLI to the company's environmental performance stronger. In summary, greater public visibility will curb the opportunistic behavior of managers, thus increasing the pressure of stakeholders in the EPLI system on companies to improve their environmental performance. Based on the above discussion, we propose our second hypothesis:

Hypothesis 2. Public visibility plays a positive role in moderating the relationship between EPLI and corporate environmental performance.

Existing research provides evidence for the relationship between ownership structure and environmental performance (29). State-owned enterprises (SOEs) have more political ties than non-SOEs, and the influence of such ties is stronger than in other countries due to the particularities of China's market economy development (30). For non-SOEs, environmental pressure exerted by stakeholders has a more significant impact on its environmental performance. On the one hand, Chinese SOEs have better access to external debt financing and government subsidies (31). According to resource dependence theory, when the resources held by stakeholders cannot pose a threat to the company, the power of stakeholders on managers will also be weakened. Therefore, the stakeholder pressure brought by EPLI will not significantly affect the company's willingness to improve its environmental performance in the context of relatively loose external restrictions of SOEs.

On the other hand, SOEs face more political intervention to engage in more socially beneficial activities (32, 33). This makes SOEs pay more attention to avoiding adverse social impacts, which means that as SOEs face more significant political pressure to improve their environmental performance,

the positive role of EPLI will become less significant. Therefore, compared with non-SOEs, EPLI has no significant effect on the environmental performance improvement of SOEs. Based on the above discussion, we propose our third hypothesis:

Hypothesis 3. Compared with SOEs, EPLI has a more significant positive effect on corporate environmental performance in non-SOEs.

MATERIALS AND METHODS

This study selected heavily polluting industry companies in the A-share market listed on the Shanghai and Shenzhen exchanges as our sample. The reason for selecting companies in heavily polluting industries as samples is that most companies in the insurance coverage list are from heavily polluting industries. Focusing on heavily polluting industries can eliminate the problem of sample selection bias to a certain extent.

According to 2003, 2008, and 2012 classification standards of heavily polluting industries announced by the Ministry of Environmental Protection and the listed company classification guidelines announced by the China Securities Regulatory Commission in 2012, we selected a total of 44 industries, including the metal products industry, pharmaceutical manufacturing industry, chemical raw materials and chemical products manufacturing industry as our target industries. We screened the listed companies in these industries according to the following criteria: 1. Exclude listed companies that regulators give special treatment (ST) because of questions about the authenticity of their financial data. 2. Eliminate the missing company samples of key variables. We ended up with a total of 912 company-year observations, of which EPLI covered 116 samples. The EPLI coverage data is manually collected according to the Insurance coverage list announced by the Ministry of Environmental Protection in 2014 and 2015 and the iFind database. The company's financial data comes from the China Stock Market and Accounting Research (CSMAR) financial database. The environmental performance data comes from Rankins CSR rating database. Statistics software is Stata 15.0.

Variables
Dependent Variable
Corporate Environmental Performance (CEP)
There are two options for measuring environmental performance in the existing literature: The first one is taking the company's pollutant emission level as the measurement standard. For example, Quying (34) adopted the ratio of expense on pollutant emission to operating revenue as a proxy variable for environmental performance. Ren et al. (35) measured the environmental performance based on changes in emissions of waste gas, wastewater and solid waste. Similarly, some other literature has also adopted quantitative indicators to measure CEP (36, 37). The advantage of using quantitative data to measure environmental performance is that the data is more reliable, but the limitation is that it only focuses on the dimension of corporate emissions and ignores the importance of environmental strategy. The second one is using qualitative indicators such as scoring to measure CEP. Klassen

and McLaughlin (38) applied positive environmental events to represent good environmental performance and negative events to represent poor environmental performance. Griffin et al. (39) constructed environmental performance indicators based on corporate environmental strength and concern levels in data sets such as MSCI, ESG, KLD, and STATS. In the study of Wang et al. (40), the "green watch" project supported by the World Bank was introduced, which applies to China's corporate environmental performance rating. The rating system covers emission standards, whether it has passed ISO14000 or not, and divides CEP into five grades. This indicator has also been applied in the empirical study of Duanmu et al. (41). However, the implementation degree of the "green watch" project varies in different provinces, so it is not a suitable choice when testing with A-share listed companies as the sample.

In this paper, we chose the RKS ratings to measure the company's environmental performance from the RKS dataset because we believe it can reflect a company's environmental performance more comprehensively (9). RKS is currently the only third-party rating indicator in China. It is based on the KLD framework and GRI 3.0 global reporting standards, and uses 70 indicators to analyze and score the content of various social responsibility reports issued by listed companies in China. The ratings range from 0 to 100 and are evaluated from the dimensions of social responsibility strategy and innovation, disclosure content, and technical sufficiency.

Independent Variable

Environmental Pollution Liability Insurance (EPLI)

Since the firm's decision to purchase Environmental Pollution Liability Insurance for the Group and its subsidiaries does not require the consent of the board of directors, it is not feasible to obtain insurance coverage data totally from public information disclosed by listed companies. We finally selected the insurance coverage list announced by the Ministry of Environmental Protection (only published in 2014 and 2015) as the primary data source and supplemented by the public information disclosure of listed companies in the iFind database. We adopted a dummy variable (Ins) to measure EPLI, which equals 1 if the company is insured that year; otherwise, 0.

Public Visibility

We measured public visibility (Vis) by the percentage of revenue a company spent on advertising (42). The company's investment in advertising is conducive for consumers and investors to understand the company's brand and products better so that the company will be able to attract wider public attention (43). Therefore, we consider the size of advertising spending to be an intuitive measure of a company's public visibility. Specifically, we use the ratio of advertising expenses (e.g., advertising, exhibition, publicity, etc.) included in sales expense to sales revenue as a proxy variable for public visibility.

Control Variables

Previous studies on environmental performance examined the role of some company characteristics. To avoid interference of other factors in our observed relationship between EPLI and CEP, we controlled for the following factors in our model. Specifically, we selected firm size, leverage, return on asset (ROA), management expense ratio, firm age and property nature as our control variables. Each variable is explained as follows:

Firm size (*Size*): According to stakeholder theory, larger companies often face greater stakeholder pressure. They also control more resources to ensure they can engage in activities that improve environmental performance (44). Therefore, we assume that firm size will be related to environmental performance. Referring to the relevant empirical literature, we used the natural logarithm of the total assets of the company as the proxy variable of company size (45).

Leverage (*Lev*): The asset-liability ratio reflects a company's capital structure and financial condition. The existing empirical studies show that the leverage ratio reflects the pressure of the company to bear from the creditors and thus positively affects the company's environmental performance. However, Cormier and Magnan (46) found that the leverage negatively affected corporate environmental information disclosure. Considering the above empirical results, we included leverage as a control variable.

Return on asset (*ROA*): ROA measures a company's financial performance. The company's profitability will affect the resources that the company can invest to improve the environmental performance and thus have an influence on the environmental performance. We used the net profit ratio to weighted average total assets to calculate ROA in this article.

Management expense ratio (*GA*): The ratio of administrative expenses to operating income. The management expense ratio is also an indicator of the company's financial performance. We take this index as the control variable in this paper.

Firm age (*Age*): Referring to the empirical study of Cole et al. (47), we chose company age as the control variable. We assume that younger companies are more environmentally conscious and more willing to use cleaning equipment. We define this variable as the natural logarithm of the number of years since the company was founded.

Ownership nature (*SOE*): China's state-owned enterprises often face stronger institutional pressure to improve

TABLE 1 | Measurement items for EID.

Item	Content
I_1	Enterprise environmental protection investment and environmental technology development
I_2	Government grants, financial subsidies and tax breaks related to environmental protection
I_3	Discharge of pollutants from enterprises and emission reduction
I_4	ISO environmental system certification information
I_5	Measures to improve the ecological environment
I_6	The impact of government environmental policy on enterprises
I_7	Loans for environmental protection
I_8	Litigation, compensation, fines and awards related to environmental protection
I_9	The concept and goal of enterprise environmental protection
I_{10}	Other income and expenditure items related to the environment

their environmental performance (9, 48). The empirical study of Earnhart and Lizal (49) also showed that the increase in state-owned ownership has a positive impact on environmental performance. Specifically, we assigned a value of 1 to the state-owned enterprises and a value of 0 to the non-state-owned enterprises in our sample.

Corporate transparency (*EID*): Corporate transparency can be defined as the extent to which a corporate discloses important management and operation information to the outside world. Greater firm transparency means that companies are devoting more resources to addressing information asymmetry with their stakeholders (18). We believe that corporate transparency reflects the extent to which companies take proactive steps to reduce information asymmetry, while EPLI reduces information asymmetry through the active behaviors of stakeholders. Therefore, we apply corporate transparency as the control variable. We referred to Xia et al. (50) and adopted the level of Environmental Information Disclosure (EID) to measure corporate transparency. EID is the method of project scoring. The specific scoring items are shown in **Table 1**. Each item is granted 3, 2, 1, or 0 points depending on the disclosure of financial information, specific non-monetary information, and general non-monetary information. The final score of EID is the sum of the scores of 10 items.

Models

The basic hypothesis required for testing is that the EPLI has a positive effect on the CEP. The basic model applied is:

$$CEP_{i,t} = \beta_0 + \beta_1 \, Ins_{i,t} + \beta_2 \, Control \, Variables_{i,t}$$
$$+ \sum Year + \sum Industry$$
$$+ \sum Region + \varepsilon_{it} \tag{1}$$

Where i is for individual corporate and t for the year, *CEP* is the corporate's environmental performance; *Ins* is a dummy variable representing whether the company is insured for EPLI. If the company insured EPLI in the current year, the value of *Ins* is equal to 1; otherwise is equal to 0. *Control Variables* include *Size*, *Lev*, *ROA*, *GA*, *Age*, and *SOE*; β_i is the model regression coefficient; ε_{it} is the residual term. Furthermore, we added annual, regional, and industry dummy variables to the model to control for fixed effects.

In order to test the moderating effect on public visibility to the relation between EPLI and CEP, we adopted the following model for verification.

TABLE 2 | Descriptive statistics of variables.

Variable	Obs.	Mean	Median	Std. Dev.	Min.	Max.
CEP	912	40.664	38.256	10.940	18.272	87.948
Ins	912	0.127	0	0.333	0	1
Size	912	22.980	22.889	1.758	12.746	28.509
Lev	912	0.488	0.497	0.207	0.009	1.037
ROA	912	0.040	0.034	0.059	−0.645	0.265
GA	912	0.086	0.071	0.082	0.002	1.178
Age	912	2.816	2.833	0.389	1.609	7.608
SOE	912	0.593	1	0.492	0	1
EID	912	4.162	3	4.054	0	20
Vis	479	0.752	0.008	4.999	−0.037	79.683

TABLE 3 | Correlation coefficient matrix.

Variables	CEP	Ins	Size	Lev	ROA	GA	Age	SOE	EID	Vis
CEP	1									
Ins	0.144***	1								
Size	0.358***	0.123***	1							
Lev	0.117***	0.049	0.471***	1						
ROA	0.024	−0.014	−0.061*	−0.408***	1					
GA	−0.097***	−0.049	−0.273***	−0.375***	−0.023	1				
Age	−0.035	0.007	0.056*	0.125***	−0.067**	−0.095***	1			
SOE	0.181***	0.035	0.230***	0.259***	−0.213***	−0.181***	0.159***	1		
EID	0.072**	0.154***	0.116***	0.054*	−0.150***	−0.103***	−0.013	0.126***	1	
Vis	0.169***	0.152***	0.113**	0.078*	0.006	−0.017	0.185***	−0.077*	−0.005	1

$$CEP_{i,t} = \beta_0 + \beta_1 \, Ins_{i,t} + \beta_2 \, Vis_{i,t} +$$

$$\beta_3 Ins^* Vis + \beta_4 Control \, variables + \sum Year +$$

$$\sum Industry + \sum Region + \varepsilon_{it} \qquad (2)$$

Model 2 adds public visibility variables (*Vis*) and the interaction term of EPLI and public visibility (*Ins*Vis*) based on Model 1. *Ins* is a categorizing variable, and *Vis* is a continuous variable. We can judge the moderating effect of public visibility when the company is insured EPLI (the value of *Ins* is equal to 1) by testing the significance of the interaction term coefficient. Regarding the moderating effect of the ownership structure, this paper tests it through group regression.

RESULTS

Descriptive Analysis

Statistics for critical variables of the model are reported in **Table 2**, including the number of observations, mean, median, standard deviation, maximum and minimum. The mean value of *Ins* is 0.127, which means that 12.7% of the sample observations were insured against EPLI. It can be seen that the EPLI coverage rate of listed companies is generally low. The mean value of variable *CEP* is 40.664, and the median value is 38.256, indicating that the environmental performance of sample companies is generally higher than the average level. In addition, the standard deviation of the variable *CEP* is 10.94, which is significantly higher than other variables, showing the strong heterogeneity of the environmental performance of sample companies. The mean value of *SOE* is 0.593, indicating that state-owned enterprises in the sample account for the majority. The standard deviations of the variables that reflect a company's financial performance (*ROA, GA*) are 0.082 and 0.492, respectively. It indicates that the volatility of variable ROA is stronger than that of GA.

Correlation Analysis

The correlation coefficient matrix reflecting the correlation between variables is reported in **Table 3**. We can see that the variables *CEP* and *Ins* show a positive correlation at the level of 0.01, which preliminarily confirms hypothesis 1, assuming that EPLI has a promoting role on CEP. The correlation coefficient between the variables *CEP* and *SOE* is significantly positive, which also reflects that the environmental performance of state-owned enterprises is better.

Regression Analysis Results

The regression results of Models 1 and 2 are reported in **Table 4**. The values in parentheses represent the t value of the coefficient of the variables. Hypothesis 1 proposed that the environmental performance of corporates will be significantly enhanced under the influence of EPLI. We regressed the corporate's environmental performance to the EPLI and control variables with robust standard errors clustered at the corporate level in Model 1. The results showed that EPLI is positively

TABLE 4 | Model regression results (1).

Variables	Model 1 CEP	Model 2 CEP
EPLI	2.920**	0.863
	(1.423)	(1.430)
Lev	3.695	−3.448
	(3.183)	(5.219)
EID	−0.142	−0.024
	(0.109)	(0.176)
ROA	6.029	3.421
	(6.989)	(8.973)
SOE	2.500**	3.442**
	(1.038)	(1.415)
GA	−3.834	−5.800
	(5.671)	(9.814)
Age	−2.088**	−1.797
	(0.932)	(1.100)
Size	1.605***	2.405***
	(0.379)	(0.663)
Vis		−0.058
		(0.092)
Ins*Vis		0.560***
		(0.151)
Industry FE	Control	Control
Year FE	Control	Control
Region FE	Control	Control
Constant	13.260	−5.414
	(9.039)	(16.000)
Observations	912	479
R-squared	0.373	0.450
F	6.270	4.530

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

correlated with a corporate environmental performance at the significance level of 5%, suggesting that the company's environmental performance can be improved by insuring EPLI.

The regression results of model 2 show that the interaction term coefficients of Ins and Vis are positive and significant at the 1% level. As described in the previous model setting section, if the interaction term coefficient is significantly positive, we can reasonably assume that public visibility can expand the impact of EPLI on corporate environmental performance. In other words, the higher the public visibility of the company, the deeper the impact of EPLI on the company's environmental performance.

We divided the samples into groups of SOEs and groups of non-SOEs and conducted regression, respectively, to test the moderating effect of the company's ownership structure. The regression results are reported in **Table 5**. The *p*-value of the coefficient test of variable *Ins* of the non-state-owned enterprises' group is 0.051, while the *p*-value of the state-owned enterprise group is 0.147. This result indicates that EPLI has little effect

	Non-state-owned enterprises	State-owned enterprises
Variables	**CEP**	**CEP**
EPLI	5.072*	2.408
	(2.579)	(1.654)
Lev	3.409	6.883
	(4.667)	(4.596)
Size	1.274***	1.717***
	(0.469)	(0.595)
ROA	16.970*	9.323
	(8.637)	(10.600)
GA	−2.511	8.434
	(6.822)	(13.450)
EID	0.040	−0.212
	(0.162)	(0.146)
Age	−2.700	−2.336**
	(2.020)	(1.016)
Constant	18.950*	14.410
	(11.020)	(14.330)
Industry FE	Control	Control
Year FE	Control	Control
Region FE	Control	Control
Observations	371	541
R-squared	0.441	0.403
F	3.500	4.520

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

on the improvement of the environmental performance of state-owned enterprises. In contrast, for non-state-owned enterprises, EPLI is an effective means to improve their environmental performance, which supports hypothesis 3.

Robustness Checks

Due to the low coverage rate of EPLI (12.7%) in the samples we used, the empirical test with such samples may lead to the problem of sample self-selection. We adopted the propensity score matching (PSM) procedure to process the samples. The aim is to match a group of samples with the most similar propensity score for those who purchase EPLI. Specifically, we matched the samples based on three key variables: company size, ROA and the number of years of company listing (1:2 matching). The differences in critical variables between the control and treatment groups before and after matching are shown in **Table 6**. It can be seen that except for *EID*, other variables are not significant in the *t*-test after matching, indicating that the matching effect is good. We used the matched samples for the model test, and the results were reported in **Table 7**. The results were consistent with the conclusions of our empirical test before. Therefore, we believe that our conclusions in the empirical test section are robust.

Considering that the possible inverse causality between environmental performance and EPLI may bring about the problem of endogeneity in the model, we construct the model

using the explained variables 1 year in advance for regression. The reason for choosing the explained variable 1 year in advance is that our explanatory variable has only two data periods. The model used for the robustness test is shown as follows:

$$CEP_{i,t+1} = \beta_0 + \beta_1 Ins_{i,t} + \beta_2 Control\ Variables_{i,t} + \sum Year + \sum Industry + \sum Region + \varepsilon_{it} \quad (3)$$

$$CEP_{i,t+1} = \beta_0 + \beta_1 Ins_{i,t} + \beta_2 Vis_{i,t} + \beta_3 Ins^* Vis + \beta_4 Control\ variables + \sum Year + \sum Industry + \sum Region + \varepsilon_{it} \quad (4)$$

We controlled the models' fixed effects of industry, year and region, effectively avoiding the endogenous problem caused by missing variables. The test results of Models 3 and 4 are reported in **Table 8**. There is no material difference between our results and the above. Therefore, we believe that our conclusions obtained in the empirical test are robust.

DISCUSSION

In view of the widespread concern about the green issue, the environmental responsibility of enterprises, especially the heavily polluting ones, is becoming increasingly important (51, 52). In practice, terrible performance on green social responsibility will hurt the corporate reputation and core competitiveness, thus undermining the value of a company (53, 54). In previous literature studies, EPLI has been studied more as a tool for environmental compensation. In fact, EPLI shows its institutional nature in the actual design and operation process, which means that EPLI is likely to play a further role in improving the environmental performance of enterprises; however, the research on this aspect is still lacking. The current study aimed to fill in the gaps in the existing literature on the effect, mechanism and influencing factors of EPLI on corporate environmental performance (55).

Using panel data from listed companies in China's heavily polluting industries from 2014 to 2015, we examined whether and how EPLI affects companies' environmental performance. Our empirical results showed the following findings. First, our results indicated that EPLI has a positive impact on corporate environmental performance. This discovery extended the research conclusions of Yang et al. (17) and provided empirical evidence of the effectiveness of EPLI operation in China. From the perspective of stakeholder theory, the formation of the new stakeholder relationship will lead to changes in the pressure exerted by stakeholders on the company, thus changing the company's environment, practices and strategic choices. After the company purchases EPLI, it forms a new interest relationship among enterprises, government and insurance companies (17).

TABLE 6 | Sample balance test.

Variable	Unmatched Matched	Mean Treated	Control	*t*-test % bias	*t*	*p* >	*t*	
Lev	U	0.515	0.484	15.700	1.480	0.140
	M	0.517	0.536	−9.800	−0.720	0.469
Size	U	23.547	22.897	34.400	3.750	0.000
	M	23.640	23.643	−0.200	−0.020	0.987
ROA	U	0.038	0.040	−4.500	−0.420	0.678
	M	0.036	0.044	−13.000	−1.050	0.293
EID	U	5.802	3.923	46.200	4.720	0.000
	M	5.704	4.091	39.700	2.950	0.003
SOE	U	0.638	0.587	10.500	1.050	0.294
	M	0.643	0.591	10.700	0.810	0.418
GA	U	0.075	0.087	−17.500	−1.480	0.139
	M	0.075	0.073	2.500	0.240	0.809
Age	U	2.823	2.815	2.200	0.210	0.837
	M	2.829	2.862	−9.400	−0.560	0.577

Through the risk transfer mechanism of EPLI products, the losses caused by pollution events will be directly related to the stakeholders in this system. Therefore, EPLI will increase the urgent pressure of stakeholders' environmental demands on company managers, thus prompting managers to adopt green measures to improve the company's environmental performance.

Second, we found that public visibility positively moderates the relationship between EPLI and corporate environmental performance. This finding revealed that EPLI is more effective in improving the environmental performance of companies with higher public visibility, which is in line with the findings of Wu et al. (56). As Dou et al. (18) indicated, the public concern has raised higher requirements for the legitimacy and citizenship of enterprises. Therefore, in a more visible corporate environment, managers' opportunistic behavior will be severely constrained, leading them to act in accordance with stakeholder expectations. Moreover, the widespread public attention will broaden the channels for stakeholders to obtain relevant information about the company and help stakeholders judge whether the company's actions truly serve their interests, which also negatively affects managers' opportunistic behavior.

Third, we found that EPLI has a significant impact on the environmental performance of non-SOEs but has no significant impact on SOEs. Our findings further provide empirical evidence for the study of ownership structure on enterprise environmental performance (57). Compared with non-SOEs, SOEs are more politically connected (30). For example, Chinese SOEs have easier access to bank credit facilities and government subsidies. However, while enjoying the benefits, state-owned enterprises also need to make concessions and shoulder more social responsibilities (31). Therefore, the environmental performance pressure of SOEs mainly comes from the government, and due to the resource advantages of SOEs, external stakeholders are less able to exert pressure on them, according to resource dependence theory. Accordingly, EPLI has no apparent effect on the environmental performance of SOE. While the environmental performance pressure of non-SOEs comes from different stakeholders, the stakeholder pressure brought by EPLI will significantly improve the corporate environmental performance.

CONCLUSION

Theoretical Contributions

Scholars have paid much attention to the research on corporate environmental performance in recent years (12). The influence of factors such as corporate governance structure, external pressure and policy tools on environmental performance has been discussed in the existing literature (9, 12, 13). However, as an innovative financial product related to environmental protection, EPLI's impact on corporate environmental performance has received little attention, especially with little literature providing evidence from an empirical perspective. We systematically analyze the relationship changes between corporates and external stakeholders after the purchase of EPLI and further analyze the impact of relationship changes on enterprise environmental performance. In addition, we found the moderating effect of public visibility and ownership structure. Therefore, our findings provide a new perspective to studying the mechanisms that influence corporate environmental performance.

First, this study promotes the research on environmental performance and expands the application connotation of stakeholder theory by identifying the impact of EPLI on environmental performance and its mechanism. Previous studies have examined the impact of measures taken by companies such as ISO 14001 certification and environmental management systems (EMS) on environmental performance (13, 58). However, scholars' research on EPLI mainly focuses on its insurance attribute, and most studies on the environmental effects of EPLI are currently focused on qualitative case studies (16, 25). The influence of EPLI on environmental performance

TABLE 7 | Robustness test (1).

Variables	Model 1 CEP	Model 2 CEP
EPLI	3.132*	0.659
	(1.701)	(1.886)
Lev	1.854	11.720*
	(5.471)	(6.838)
EID	−0.027	0.482
	(0.213)	(0.314)
ROA	7.500	18.030
	(14.800)	(22.690)
SOE	3.719**	3.647
	(1.649)	(2.315)
GA	22.960*	7.667
	(12.780)	(12.310)
Age	−3.495**	−3.296**
	(1.356)	(1.478)
Size	2.575***	−0.406
	(0.768)	(1.092)
Vis		−0.023
		(0.129)
Ins*Vis		0.361**
		(0.149)
Constant	−8.510	56.920**
	(17.300)	(23.920)
Industry FE	Control	Control
Year FE	Control	Control
Region FE	Control	Control
Observations	297	143
R-squared	0.550	0.793
F	3.94	5.40

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

TABLE 8 | Robustness test (2).

Variables	Model 5 CEP	Model 6 CEP
EPLI	2.490*	1.596
	(1.463)	(1.640)
Lev	4.189	−4.576
	(3.441)	(5.097)
EID	−0.154	−0.059
	(0.108)	(0.174)
ROA	7.482	5.635
	(7.397)	(10.700)
SOE	1.896*	2.439
	(1.093)	(1.510)
GA	−7.328	−7.150
	(6.077)	(11.430)
Age	−0.898	−0.267
	(1.058)	(1.032)
Size	1.691***	2.814***
	(0.446)	(0.638)
Vis		0.043
		(0.092)
Ins*Vis		0.367***
		(0.139)
Constant	12.540	−13.510
	(10.190)	(15.030)
Industry FE	Control	Control
Year FE	Control	Control
Region FE	Control	Control
Observations	875	457
R-squared	0.392	0.485
F	6.490	4.930

Robust standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

from the perspective of the institutional attribute is worth exploring. Our research attempted to explain the relationship between EPLI and corporate environmental performance with reference to stakeholder theory. Specifically, we first identify the stakeholder relationship between corporates and other external entities in the EPLI system and then further analyze the role of the stakeholder relationship in improving corporates' environmental performance. Based on stakeholder theory, the existing literature often analyzed the environmental pressure of stakeholders from the perspective of stakeholder salience (59), while the analysis of stakeholder salience in the EPLI system is theoretically lacking. This study discussed the stakeholder salience of two key stakeholders, the government and insurance companies, and confirmed their positive effect on environmental performance through empirical methods. Furthermore, this study also combined with the stakeholder-agency theory to explore how EPLI can increase the environmental pressure of stakeholders on the enterprise and further expand the connotation of EPLI institutional effect. Overall, this study fills in the research

gap of factors influencing environmental performance from the perspective of EPLI and expands the application scope of stakeholder theory.

Second, the influence of public visibility on the environmental performance of corporates is considered in this study, which enriches the research on public visibility. As an important concept in stakeholder theory, previous literature has examined the effect of public visibility on corporate social responsibility (56, 60). However, no studies have focused on the factors that may affect the environmental effects of EPLI. From the perspective of agency theory, the opportunism behavior of the management will weaken the actual influence of stakeholder pressure on the enterprise. Social stakeholders will maintain a strong interest in companies with higher visibility, thus inhibiting managers' opportunistic tendencies. In this situation, the environmental pressure exerted by the EPLI system on the enterprise will be better translated into a higher level of environmental performance. Our findings revealed the significant positive impact of EPLI on environmental performance in companies with higher

public visibility, providing a new insight for the study of public visibility.

Third, we contribute to the resource dependence theory by dividing the sample into state-owned and non-state-owned enterprise groups and examining the effect of EPLI on their environmental performance separately. Compared with the situation in other countries, the differences in political connections between China's SOEs and non-SOEs are greater (30). We analyzed the heterogeneity of environmental performance between SOEs and non-SOEs, and the results showed that EPLI was only effective in promoting corporate environmental performance in non-SOEs with weak political constraints. Therefore, the results of this study can provide evidence for corporate environmental performance under different resource constraints.

Managerial Implications

Under the background that enterprises pay more and more attention to environmental social responsibility (61), the conclusions obtained in this paper can effectively and practically guide decision-makers to take green measures. This study revealed that EPLI could not only transfer the risk of environmentally responsible accidents (17), but also have a positive impact on a company's daily environmental performance. Specifically, the practical significance of this paper includes the following points.

First, the company can actively purchase EPLI for senior executives to encourage them to improve the environmental performance. EPLI is an effective way to motivate companies to improve their environmental performance for companies in heavily polluting industries. The company's decision-makers should realize that it is necessary to introduce external environmental pressure to improve the environmental performance of the company in the context of China's inadequate environmental laws and regulatory systems, and EPLI has the effect of increasing environmental pressure on company. In particular, under the modern corporate governance structure with the separation of ownership and management, EPLI introduces a multi-subject system, which, to a certain extent, intensifies the environmental pressure of stakeholder groups on the corporate, thus playing a role in regulating corporate behavior.

Second, the government can take administrative measures to force SOEs to implement EPLI, so as to enhance SOEs to actively fulfill their environmental responsibilities. Although the environmental effect of EPLI is satisfactory, the low insurance rate of enterprises is still a serious problem due to the imperfect environmental laws and regulations in China (25). Therefore, government enforcement measures can be adopted at the present stage for enterprises with serious environmental pollution. Because SOEs are facing more political pressure than non-SOEs, more attention can be paid to non-SOEs in the case of enforcement.

Third, environmental policy makers can adopt the strategy of forcing enterprises to disclose EPLI information to improve the environmental performance of enterprises. At present, the company's purchase of EPLI is not included in the scope of compulsory information disclosure for listed companies in China. However, the compulsory disclosure of this information may help EPLI to play its role in easing financing constraints. Furthermore, perfecting the information communication channels between companies and stakeholders is conducive to improving the companies' public visibility, which can promote a more significant improvement in environmental performance.

Limitations and Future Directions

This study explains the relationship between EPLI and environmental performance from both theoretical and empirical perspectives. However, our study still has several limitations that need to be discussed. First, we used data from listed companies in heavily polluting industries for empirical testing, so the applicability of our results is limited to specific countries and industries. We have tried to obtain the company's insurance information from the public information disclosure (such as a financial report or social responsibility report). However, since the EPLI is not a compulsory disclosure of the listed company, the samples obtained by this method are generally inefficient. We believe that with the improvement of the information disclosure system of listed companies, follow-up research can be carried out based on larger sample size.

Second, our study only focused on the impact of whether a company has EPLI on environmental performance. For future research, more potential factors such as CEO characteristics (10, 62) need to be explored to influence the relationship between EPLI and environmental performance. In conclusion, it is hoped that this study can provide ideas for other studies and further discuss the microeconomic effects of EPLI. Future research can explore how EPLI and other measures to promote environmental performance, such as environmental regulation, can work together.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://www.gtarsc.com/.

ETHICS STATEMENT

Ethics approval for this research was not required as per institutional and national guidelines. Consent from all research participants was obtained by virtue of survey completion.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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The quality of Syrian healthcare services during COVID-19: A HEALTHQUAL approach

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Syria is a developing country that face enormous healthcare challenges
that aggravated with the outbreak of COVID-19. In the study, we evaluate
the perceived healthcare service quality based on hospital type, public and
private, using five HEALTHQUAL dimensions. We find that service quality in
Syrian private hospitals is perceived better that in public hospitals. However,
neither type of hospitals scores exceptionally high in any of the examined
HEALTHQUAL dimensions. On the contrary, both hospitals score extremely
low in the Improvement dimension. We argue that crowdedness environment,
medical staff availability and their low salaries, pricing policies as well as the
health insurance system, are to blame for such low perceived quality.

KEYWORDS

healthcare service quality, public hospitals, private hospitals, COVID-19,
HEALTHQUAL, Syria

Introduction

The Syrian healthcare system has a complex nature and has long been subject to
changes amid political and economic conditions. Public hospitals were the backbone
of the Syrian healthcare system pre-war and largely belong to the Ministry of Health,
Ministry of Higher Education and Scientific Research and Ministry of Defense. The
combined impact of wartime destruction, healthcare worker migration, poor working
conditions, and severe budgetary shortfalls led to the deterioration of public hospitals'
services and allowed private hospitals to increasingly compensated for poorly public
services (1). However, public hospitals remain the main provider of free or cheap
medications for chronic diseases (2).

The Syrian economic regime has adopted socialism since 1963. However, the Syrian
government started to open the economy since 1980s and encouraged the participation of
private sector. However, it was until 2005 when the 10th national conference of Al-Baath
party officially announced the move to social market economy. Such move reduced the
government intervention in economic activities and opened the door for private sector
to participate in economic activities and healthcare is no exception. Expectedly, the
government expenditure on health as percentage of GDP declined from 4.9 percent in
2005 to 3.4 percent in 2010 (3). Such decline was enormous if we consider the increase

in prices and population and it leads to increase out-of-pocket spending on healthcare to compensate for the declining role of public healthcare services. In addition, some public hospitals started to offer paid services for those who are better off with noticeable differences in service quality between both types of patients (4).

Further reductions in government spending on health are recorder since 2010. According to recent projected budgetary figures, the Syrian government expenditure on health has declined in 2020, in real terms, to reach less than half of 2011 figures (5). This situation represents a decline in health expenditure per capita from $9.72 in 2011 to $4.49 in 2020 (5). In 2020, there was 507 hospitals, disproportionally distributed between cities and among public and private hospitals, with 114 public and 393 private hospitals and an average number of persons per bed of 706 (5) which is lower than the average number of persons per bed in 2011 of 734 (6).

The Syrian healthcare system has long been based on out-of-pocket payments, which represents 53.69 percent of health expenditure in 2012 (7). Health insurance has gained grounds among public workers after a national legislation that made health insurance as compulsory for all public workers. The majority of workers in the private sector are health insured as part of their salary package. However, self-employed workers, such as farmers, remain out of the health insurance coverage. The percentage of health insured persons is < 5 percent of the whole population in 2020 (8). Yet, this health insurance is far from being universal and is poorly administrated which force well-off patients to give up the service and pay for their own treatment. Uncovered patients still prefer to visit public hospitals which are always open to all.

Private hospitals have been considered as logical alternatives to public hospitals and are expected to relieve some burden from public hospitals. However, the underregulated and profit-driven incentives private hospitals diminished the utility of private services in responding to COVID-19 (1). In addition, private hospitals suffered from similar shortages and problems as government hospitals (9).

Syria has witnessed a significant daily increase in the number of COVID-19 cases and an increase in mortality rates among patients, medical and nursing staff (10). In addition, it faced a shortage of many basic tools and equipment to treat patients, the most important of which are oxygen tubes. Many non-government initiatives were launched to support the government efforts and overcome these challenges.

Overcrowding in Syrian public hospitals is not a recent result of the pandemic. During the Syrian war, many areas were destroyed, and the migration of large numbers of people to safer areas increases, including the capital, Damascus. This displacement led to an increase in patient's volume in public hospitals. Private hospitals, motivated by the aim of continuing their usual surgeries, refrained from accommodating COVID-19 positive patients. These patients were prescribed medications and sent home quickly with all necessary instructions.

This gloomy image of the Syrian healthcare means that COVID-19 pandemic comes to Syria in a very difficult time to add insult to injury. Despite the strict measures imposed by the Syrian government in the form of distancing and precautionary measures, the lack of ventilators and personal protective equipment (PPE), in public and private hospitals, are thought to have resulted in a troubling number of deaths among patients and healthcare worker alike (1). Patients become more reluctant to visit hospitals during the pandemic. Public hospitals were viewed as "less as treatment centers and more as potential sites of transmission" (1). Moreover, insurance companies claimed that health insurance policies do not cover COVID-19 treatment. Furthermore, private hospitals refused to admit COVID-19 patients, and the cost of treatment in hospitals that admit COVID-19 patients was prohibitively high for the average Syrian. The end result of this situation is that Covid-19 patients had to choose home treatment and the quality of care and patient safety, whether of COVID-19 patients or others, were extremely questionable.

Importance of research

The focus of policymakers usually shifts during pandemics from the quality of care and safety of patients *per se* to the management of the pandemic itself. However, providing quality care and making things safe for patients will be more challenging during pandemics. Out of fear, lockdown restrictions, or insufficient availability of staff and resources at health facilities, many Syrian patients, including COVID-19 positive cases, refrained from visiting emergency departments, delayed operations, or missed their scheduled check-up. While healthcare systems in many countries have prioritized COVID-19 patients, the opposite was true in Syria and COVID-19 patients have failed to receive the appropriate care.

The low quality of health services has severe direct and indirect consequences. In addition to the loss of an organization's customers, if the organization's services are not of good quality, poor healthcare services will have a tremendous impact on the spread of the virus (11). Yet, public hospitals are unconcerned with such customer loss given that they are centrally funded and not profit-driven. A systematic analysis concluded that poor healthcare quality was the primary factor contributing to an increase in fatalities from cardiovascular disease, newborn traumas, and communicable diseases (12). Patients are not the only victims of low healthcare quality, but also the worsening quality of healthcare provided makes doctors more prone to workplace violence. Mohamad et al. (13) reported that 84.74 percent of resident doctors at public hospitals exposed to verbal violence while 19.08 percent exposed to physical violence.

COVID-19 related research in Syria is relatively rare and focused on Syrians' knowledge of the disease. Al Ahdab (9) found that Syrian residents demonstrated modest knowledge, attitudes and practices toward COVID-19 during the pandemic. Shibani et al. (14) confirmed the knowledge gap regarding many aspects of the disease and the hesitancy of Syrians toward taking the COVID-19 vaccines. This research endeavors to test the quality of Syrian healthcare system in the very difficult time of COVID-19 pandemic outbreak using HEALTHQUAL scale. It will also compare the quality of healthcare services between public and private hospitals according to the five dimensions of HEALTHQUAL scale.

Literature review

The attempts to evaluate the service quality in the healthcare sector were old and enormous and can be traced to Donabedian (15), who discussed the pros and cons of a number of methods and approaches used to evaluate the medical care quality. Myers (16) considered accessibility, effectiveness, efficiency, and improvement of care quality and continuity as items for healthcare safety. Donabedian (17) added equity and efficiency as additional items to quality measurement that are related to patient care experience. Grönroos (18) developed the first service quality model to measure service quality based on qualitative methods. Then, Parasuraman et al. (19) developed the second service quality model (SERVQUAL) on the basis of exploratory research, in which service quality is seen as a function of the differences between customer expectations and service performance. SERVQUAL was based on five dimensions: tangibles, reliability, responsiveness, assurance, and empathy. Cronin and Taylor (20) proposed the weighed service performance (SERVPERF) model. SERVPERF was based on the five dimensions of SERVQUAL and 22 items to measure service quality but did not use the gap between expectations and service performance. Jain and Gupta (21) argued that SERVPERF framework was mythologically an improvement over SERVQUAL.

A number of studies attempted to add, reduce or change the SERVQUAL dimensions to accommodate different settings such as Carmen (22), Bowers et al. (23), Jun et al. (24), Shelton (25), Doran and Smith (26), Mostafa (27), Scobie et al. (28), Evans and Lindsay (29), Yesilada and Direktor (30). Rahim et al. (31) used machine learning to build a sentiment analyzer and service quality classifier, instead of questionnaire, to automatically classifies the sentiment and SERVQUAL dimensions using comments from 48 official public hospitals' Facebook pages.

Lee (32) proposed HEALTHQUAL as a measurement of healthcare service quality on the basis of tangibility, efficiency, safety, empathy, and improvements of care services. HEALTHQUAL is a multidimensional scale that combines patient's view with hospital view while considering the

perspective of accreditation institutions. Such patient-centered perspective is largely influenced by a cultural milleu and has some common shared features across vast geography of Arabic League or MENA countries (33).

There have been several attempts to compare service quality in public vs. private hospitals before the spread of COVID-19. Andaleeb (34) argue that private hospitals were more motivated than public hospitals to offer higher service quality since these hospitals depend on income from patients. Many researchers supported this view in their findings regarding patients' perceptions of private and public hospitals' service quality (35–42). However, other studies argued that the reverse is true (39, 43, 44). Rahim et al. (31) founnd that patients in Malaysia were generally satisfied with the services provided by public hospitals though they did not compare with private hospitals.

Studies on the quality of healthcare in Syria is sporadic. Alfarraj (45) and Mahmoud (46) examined the quality of the healthcare merely in public hospitals, i.e., in the Ministry of Higher Education and the Ministry of Health, respectively. Such examinations were carried out in war-free, pandemic-free periods and did not compare healthcare quality between public and private hospitals. In addition, both studies considered limited dimensions of healthcare quality and concluded that patients positively perceived the quality of healthcare service at public hospitals. Despite the frequent adaptations of the HEALTHQUAL survey to measure perceived satisfaction, to date, no studies have been conducted using the HEALTHQUAL scale in Syria.

Methods

In this study, we analyze the quality of healthcare service using five dimensions HEALTHQUAL adapted from and Kim (47). Thus, our HEALTHQUAL scale compromises of five constructs and a total of 27 items: (1) satisfaction with facilities and equipment (6 items); (2) satisfaction with safety (5 items); (3) perceived empathy (7 items); (4) perceived efficiency (5 items); (5) perceived improvements of care service (4 items).

A descriptive, exploratory, cross-sectional study was carried out during 2021. An internet-based questionnaire on the basis of the above-described HEALTHQUAL scale was applied to a sample of 220 visitors to public and private hospitals during the COVID-19 pandemic outbreak. All items were measured on a 5-point Likert scale, where five was "strongly agree" and one was "strongly disagree." Respondents to the questionnaire were informed that the data collection was anonymous and the purpose of this research is only of scientific objectives.

Table 1 illustrates the demographic characteristics of the respondents according to hospital type, public or private. It shows that there were 152 respondents that have visited private

TABLE 1 Distribution of the surveyed visitors according to age, gender, and hospital type.

Age	Public hospital		Private hospital		Total
	Male	**Female**	**Male**	**Female**	
18–34	31	14	19	51	115
35–54	7	11	16	25	59
+55	2	3	15	26	46
Total	40	28	50	102	220

hospitals compared to only 68 who went to public hospitals. In addition, the main age group in our sample is the smallest one (the age range of 18 to 34 years) with 115 respondents. It also shows that females dominate our sample with 130 respondents.

Results

Table 2 shows the results from the combined sample of visitors to both public and private hospitals. The means of respondents' scores on Readiness, Safety, Empathy, and Efficiency range between 2.56 and 3.36. However, there is a serious issue regarding the mean scores of improvement items: appropriateness of care service provided (1.13), degree of improved patient condition after using this hospital care (1.26) and complete and comprehensive health services in the hospital (and is referred to other specialists if necessary) (1.27). These scores indicate that the Syrian healthcare services has serious problems with the improvement dimension of HELATHQUAL.

Table 3 presents the five constructs of HEALTHQUAL together with their 27 items. To illustrate the individual viability of each item, the factor loadings and composite reliability for each construct are also reported. As can be seen, the factor loadings obtained from Principal Component Analysis in most of the indicators were > 0.70, demonstrating that the proposed indicators are suitable for the constructs. Eigen values for Readiness, Safety, Improvement, Efficiency, and Empathy are 4.279, 3.930, 2.868, 3.110, and 5.468, respectively. The percentage of variance explained are Readiness (71.31), Safety (78.594), Improvement (67.162), Efficiency (62.196), and Empathy (78.11).

Reliability was tested on the basis of Cronbach's alpha values (Table 3). All of the coefficients of reliability for the constructs exceeded the threshold value of 0.70 for exploratory constructs. In the reliability test, the Cronbach's alpha value for empathy was the highest with 0.953 and improvement was the lowest, 0.818.

Table 4 illustrates the descriptive statistics of HEALTHQUAL dimensions according to hospital type. Private hospitals scored higher than public hospitals at all dimensions which indicates better service quality at private hospitals in comparison to public hospitals during COVID-19 spread, which is consistent with (48). The t-test for the

equality of means suggests that private hospitals superiority is significant at five percent level of significance. Surprisingly, both hospitals score low at improvement dimension but private hospitals still outperforming public hospitals in this regard. In general, the results show that private hospitals surpassed public hospitals by achieving high rates in all dimensions of HEALTHQUAL.

Regarding readiness, we found a statistically significant difference in respondents' evaluation of readiness between public and private hospitals in favor of the private hospitals. The mean of perceived readiness for private hospitals is (3.35 ± 0.997) is higher the mean of responses regarding the readiness of public hospitals (2.42 ± 0.952). Moreover, the difference in perceived readiness is in favor of private hospitals and is statistically significant with t-statistics of −6.485. This result can be explained by funding shortages due to war conditions that reduced the availability of necessary facilities and hygiene issues. In addition, personnel at public hospitals did not pay enough attention to hygiene issues due to the low self-awareness toward sterilization and personal hygiene guidelines (9, 49, 50).

Private hospitals have modernly designed buildings and attractive rooms, in addition of equipment and medical tools that surpass public hospitals. Private hospitals can easily adjust their prices to provide the necessary facilities and to cover the purchase of necessary hygiene equipment and to hire skilled staff. These results are attributed to several reasons, the most important of which is that private hospitals have modernly designed buildings and attractive rooms, in addition to medical equipment, tools and equipment that exceed public hospitals, whose buildings are old and neglected and in need of modification. Hospitals must provide a sophisticated and safe treatment environment for patients and staff that enhances a sense of comfort and safety.

The results from the Safety dimension illustrate a mean of (3.29 ± 0.1.06) against the mean of responses in public sector (2.65 ± 1.108) and the difference is statistically significant at five percent level of significance. Syrian patients feel more comfortable and safer while treated at private hospitals compared to public hospitals possibly because they are less-crowded than public hospitals. Crowded environment stands as a major obstacle in improving the service quality in public

TABLE 2 Measurement items of HEALTHQUAL.

Construct/Indicator	Code	Mean	SD
Readiness (Tangibles)			
- Degree of securing advanced medical equipment	R1	2.97	1.251
- Degree of securing medical staff with advanced skills and knowledge	R2	3.20	1.203
- Degree of convenient facilities	R3	2.69	1.313
- Degree of continuous hygiene and sterilization	R4	3.10	1.299
- Degree of cleanliness of employee uniforms	R5	3.18	1.269
- Overall cleanliness of the hospital	R6	3.28	1.283
Safety			
- Degree of a comfortable and safe environment for receiving treatment	S1	3.17	1.187
- Degree of the feeling that doctors would not make misdiagnoses	S2	3.11	1.307
- Degree of the feeling that nurses would not make mistakes	S3	3.01	1.253
- Degree of confidence about the medical proficiency of this hospital	S4	3.14	1.218
- Degree of a hospital environment that is safe from infection	S5	2.90	1.407
Improvement			
- Appropriateness of care service provided	Q1	1.13	0.729
- Recognition and efforts for the best treatment by the medical staff	Q2	3.07	1.152
-Degree of improved patient condition after using this hospital care	Q3	1.26	0.656
-Complete and comprehensive health services in the hospital (and is referred to other specialists if necessary)	Q4	1.27	0.744
Efficiency			
- Attitudes about not using unnecessary medication	F1	3.07	1.383
-Providing patient the side effects of medication	F2	2.56	1.318
- Degree of efforts for providing appropriate treatment methods	F3	3.23	1.196
- Degree of convenience for treatment procedures	F4	3.09	1.226
- Degree of efforts for reducing unnecessary procedures	F5	3.04	1.267
Empathy			
-Polite attitudes of employees	E1	3.24	1.162
-Explaining the details	E2	3.24	1.213
-Listen to the patient	E3	3.20	1.183
-Understand and consider the patient's situation	E4	3.36	1.273
-A sense of closeness and friendliness	E5	3.10	1.242
-Hospital knows what the patient wants (meet their needs).	E6	2.99	1.235
-Hospital understands the patient's problems as empathy	E7	3.00	1.259

hospitals. Another reason for these differences is related to the pricing policies where public hospitals treatment costs are free or symbolic and the income of medical staff at public hospitals is low and makes them careless in terms of diagnosis and follow up. Previous studies show that patients with high income receive better healthcare service (35, 51–53).

The main purpose of improvement dimension is to measure whether the medical services meet the needs of patients and whether the patient feels satisfied during and after providing the services. Sharifi (54) called this dimension "effectiveness" which is related to patient's goals in receiving the appropriate and complete treatment from the hospital. The results in Table 4 above show the dissatisfaction of respondents from this dimension from both hospitals with a mean of (1.81 ± 0.65)

for the private hospitals in comparison to (1.37 ± 0.63) for the public hospitals. We conclude that the services provided in both public and private hospitals during the pandemic were unable to meet the requirements and needs of patients and that they did not feel that their health conditions improved after using the healthcare service. This is despite that private hospitals scored significantly higher than public hospitals on this dimension.

In terms of efficiency, private hospitals score higher than public hospitals in this dimension with an averages of (3.11 ± 1.016) and (2.74 ± 0.94), respectively. Moreover, this difference is statistically significant at five percent level of significance. However, this dimension has the lowest difference between public and private sector. This can be partially explained by the fact that public hospitals still attract expert medical staff who are

TABLE 3 Factor loadings and composite reliability of HEALTHQUAL.

Construct/ Indicator	PCA			Composite reliability: Chronbach's alpha
	Factor loadings	Total eigen values	% of variance explained	
Readiness (Tangibles)		4.279	71.310	0.919
R1	0.826			
R2	0.761			
R3	0.85			
R4	0.872			
R5	0.868			
R6	0.884			
Safety		3.930	78.594	0.930
S1	0.876			
S2	0.893			
S3	0.891			
S4	0.931			
S5	0.839			
Improvement		2.686	67.162	0.818
Q1	0.853			
Q2	0.855			
Q3	0.792			
Q4	0.775			
Efficiency		3.110	62.196	0.846
F1	0.832			
F2	0.792			
F3	0.846			
F4	0.712			
F5	0.754			
Empathy		5.468	78.110	0.953
E1	0.861			
E2	0.831			
E3	0.907			
E4	0.87			
E5	0.905			
E6	0.906			
E7	0.904			

highly experienced doctors. Those medical staff are still working in the public sector despite their low salaries either because they have contractual obligations or because they use their positions at public hospitals as tool to provide their private patients easy access to cheap public healthcare services.

The results from the empathy dimension confirms previous dimension results. That is, private hospitals outperform public hospitals in terms of perceived empathy with averages of (3.36 ± 1.04) and (2.705 ± 1.02) for private and public hospitals,

respectively. Again, the difference between averages is in favor of private hospitals and is statistically significant at the five percent level of significance. The overcrowded environment at public hospitals and shortages in medical staff do not permit medical staff spend enough time with patients and develop the sense of closeness and friendship. That is medical staff are forced, sometimes, to work beyond their knowledge and expertise to fill the shortage of services gap (55), and have less time to build rapport with patients, deteriorating the doctor–patient relationship. On the contrary, medical staff at private hospitals are in a better position to listen to patients and explain every detail of their treatment. In addition, they are well-paid and care about patients' feedback and satisfaction from their services.

In order to investigate which of the examined variables affect the improvement dimension, we run the following linear regression for each type of hospitals separately,

$$\text{Improvement}_i = \alpha + \beta_1 \text{Readiness}_i + \beta_2 \text{Safety}_i + \beta_3 \text{Efficiency}_i + \beta_4 \text{Empathy}_i + \varepsilon_i$$

The results from estimating the above equation can be seen in Table 5 below. It can be seen that readiness is a significant determinant of public hospitals improvement dimension with a coefficient of 0.206 that is significant at one percent level of significance. Readiness is the most important factor in this analysis with a standardized coefficient of 0.311. Safety and Empathy are only significant at 10 percent level of significance while efficiency is insignificant at all levels. The insignificant impact of efficiency on Improvement is due to the fact that public hospitals have well trained medical staff. Yet, these hospitals failed to meet patients' needs and ambitious as patients did not feel better after using their healthcare service due to overcrowding and resource shortages.

When estimating the same equation on private hospitals, we also find that readiness is a significant determinant of improvement at one percent level of significance and efficiency is also significant and has the highest standardized coefficients with 0.349. This suggests that patients give more importance to efficiency than readiness as determinant factor of improvement. Empathy has also a positive and significant impact on improvement with a coefficient of 0.101. In addition, Safety has a positive and significant impact on improvement but only at 10 percent level of significance.

To address the problem of endogeneity and as part of the robustness tests, we investigate if the variable Efficiency plays a mediator role in the relationship between the other three variables, Readiness, Safety, and Empathy, and Improvement. Thus, we construct a variable (RSE) as the average of these three variables and disentangle the direct and indirect effects of these variables on Improvement. The results from the public hospitals analysis in Table 6 indicate that the effect of the above-mentioned three variables on Improvement is predominantly direct with a coefficient of 0.164 of the total effect of 0.184.

TABLE 4 Descriptive Statistics of HEALTHQUAL dimensions according to the type of hospital (public vs. private).

Hospital type		N	Mean	Std. deviation	Std. error mean	t-test for equality of means
Readiness	Public	68	2.4265	0.95260	0.11552	−6.485
	Private	152	3.3575	0.99768	0.08092	
Safety	Public	68	2.5618	1.10859	0.13444	−4.641
	Private	152	3.2921	1.06501	0.08638	
Improvement	Public	68	1.3750	0.63113	0.07654	−4.703
	Private	152	1.8191	0.65433	0.05307	
Efficiency	Public	68	2.7412	0.94383	0.11446	−2.554
	Private	152	3.1118	1.01635	0.08244	
Empathy	Public	68	2.7059	1.02270	0.12402	−4.356
	Private	152	3.3637	1.04071	0.08441	

TABLE 5 The Regression of improvement on independent variables.

Variable	Public hospitals		Private hospitals	
	β	Standardized coefficients	β	Standardized coefficients
α	−0.112		−0.127	
Readiness	0.206***	0.311	0.169***	0.257
Safety	0.152*	0.268	0.104*	0.169
Efficiency	0.083	0.124	0.225**	0.349
Empathy	0.136*	0.221	0.101**	0.161
Adj-R^2	0.681		0.689	
F-Statistic	36.777		84.747	
P-value	0.000		0.000	

***,**,* represent significance at 1, 5, and 10 percent, respectively.

The results from private hospitals' analysis confirms previous results of direct effect of Readiness, Safety, and Empathy on improvement. The coefficient of direct effect is 0.127 of the total effect of 0.186. Hence, the indirect effect is represented by a coefficient of 0.059 which is larger than that for public hospitals of 0.02. This indicates that Efficiency only plays a partial role as a mediator in the relationship of these variables on improvement in the case of private hospitals.

Discussion

Syria is a developing country that face enormous challenges. Suffering from low resources, low service quality, shortage in protective equipment for the medical and nursing staff (Derida,20) due to war conditions. The outbreak of COVID-19 aggravated the already difficult situation and show the fragility of the healthcare system.

In the study, we evaluate the perceived service quality based on hospital type, public and private, using five HEALTHQUAL dimensions. We find that service quality in private hospitals is perceived better that in public hospitals. However, neither type

of hospitals scores exceptionally high in any of the examined HEALTHQUAL dimensions. We argue that crowdedness environment, medical staff availability and their salaries, pricing policies as well as the health insurance system, are to blame for such low perceived quality.

The investigation of the impact of the examined four dimensions of HEALTHQUAL on improvement suggests that all these variables load significantly on improvement and contribute toward the perceived improvement of private hospitals' healthcare services. We also find that Efficiency plays a mediator role in the relationship between Improvement and Readiness, Safety, and Empathy. However, Efficiency fails to affect Improvement at Syrian public hospitals.

The results of this study provide valuable insights to researchers, policymakers, managers, and patients. The novelty of this study lies in that it compares the quality of healthcare services between public and private hospitals in the special context of COVID-19 outbreak period and in a healthcare system that was on the edge of collapse due to war conditions. Policymakers and managers are increasingly interested in measuring and improving the service quality since healthcare service quality is one of the main factors that affect hospital

TABLE 6 The mediation role analysis.

Independent variable	Dep. variable	Public hospitals		Private hospitals	
		β	t-statistics	β	t-statistics
Efficiency	α	0.881***	3.874	0.314*	1.658
(Mediator)	RSE	0.242***	8.719	0.279***	15.331
	R^2	0.610			
	F-Statistic	235.027			
	P-value	0.000			
Improvement					
(Direct Effect)	α	−0.113	−0.823	−0.111	−1.014
	RSE	0.164***	7.407	0.127***	7.598
	Efficiency	0.084	1.253	0.213***	4.560
	R^2	0.699		0.696	
	F-Statistic	75.338		170.272	
	P-value	0.000		0.000	
Improvement					
(total effect)	α	−0.039	−0.313	−0.044	
	RSE	0.184***	12.159	0.186***	
	R^2	0.691		0.653	
	F-Statistic	147.829		282.467	
	P-value	0.000		0.000	

***,**,* represent significance at 1, 5, and 10 percent, respectively.

choice. It is also of great importance for patients who select the hospital they visit on the basis of fellow recommendations. Hence, we present some practical implications for improving service quality for both private and public hospitals. Many of these prominent bottleneck inefficiencies of response to Pandemics challenge were also noted in an array of comparable health systems sharing some historical legacy with Syria's one in medical care provision and financing (56, 57).

This study rings the alarm bell that patients are unsatisfied with healthcare services provided by public hospitals. Surprisingly, public hospitals failed at all HEALTHQUAL dimensions. Policymakers should address patients concerns regarding service quality at public hospitals. It is suggested that the almost free-of-charge policy applicable at public policy, with its negative consequences such as crowdedness, is the one to blame for the perceived low service quality. We recommend that policymakers consider introduce changes in pricing policies at public hospitals to allow reasonable fees. The fees collected should provide improvements in closing the gap between public and private hospitals' service quality levels. In addition, public hospital patients, who have longer waiting times than a pre-determined threshold, should be directed to private hospitals where their fees for hospital services should be covered by government. Following such suggestions, if the crowdedness of public hospitals decreases,

it is believed that medical staff at public hospitals will provide more patient-centered care interventions, develop a consistent positive patient safety culture across the hospital. Furthermore, policymakers and managers of public hospitals should develop a performance evaluation system that encourage receiving feedbacks for patients. These may lead to an improvement in the service quality of public hospitals (35). In the long-term perspective quality of large public hospitals affects the entire fiscal sustainability of the health system (58, 59).

Surprisingly and despite that private hospitals outperformed their public counterparts, private hospital performance at all dimensions as far below expectations. It is unexplained that private hospitals, while charging high fees for treatment, are not scoring quite high on all HEALTHQUAL dimensions. Private hospitals should pay more attention to HEALTHQUAL dimensions and particularly to improvement dimension by providing follow-up service to patients and provide patients with the best possible treatment.

The health insurance system is one of the main causes of such low perceived healthcare quality. The refusal of insurance companies to cover COVID-19 treatment meant that those who are diagnosed with the disease do not receive full treatment and they are discharged before their full recovery and before they feel their health conditions are improved. The expected result is that they are dissatisfied with this service quality. Such findings

indicate lack of adaptive capability by the health system affected with a large-scale epidemic which has been documented in other Mediterranean and Asian health systems (60).

Finally, healthcare authorities should recognize that increase the awareness of public of COVID-19 and other pandemics is a priority that will have many advantages. On the one hand, it will reduce the transmission of disease and consequently the number of patients and deaths. On the other hand, such awareness will make hospitals care more about hygiene issues and consequently increase the perceived healthcare quality.

Study limitations

There were a number of limitations in the study. First, the research is expected to have the majority of respondents from Damascus, the capital of Syria. We fear that our results may not reflect the service quality perceptions in hospitals from all around Syria. Even though the results confirmed the results of previous studies conducted in other countries, future research that includes country-specific hospitals or healthcare service quality models should also be conducted. Second, the study implemented an e-questionnaire, which definitely bias our sample toward young and internet users. In future research, it is advised to increase higher age representation through manual distribution of questionnaires to enable researchers to generalize their results. Third, other healthcare quality dimensions could be used in order to double check the results obtained from HEALTHQUAL measure.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

LA designed the questionnaire and wrote the literature review. SM wrote the conclusion and limitations. MJ revised the draft and developed the discussion. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Health workforce policy in the Russian Federation: How to overcome a shortage of physicians?

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Russia looks for ways to overcome a shortage of physicians. Health workforce policy is focused on training an additional number of physicians. The current efforts have reduced some areas of the shortage but failed to solve the problem due to many factors that reproduce the deficit. A distorted structure of service delivery with weak primary care generates demand for outpatient specialists and hospital doctors and requires a perpetual increase in their number. The lack of long-term labor planning results in the oversupply of some specialties and the shortage of others. The regulation of post-graduate training is not enough to improve the allocation of physicians across specialties and health system sectors. We argue that an extensive increase in the number of physicians without changing their composition will hardly change the situation. A more active structural policy is required with a focus on strengthening primary care and improving planning and regulation of health workforce structure.

KEYWORDS

workforce, physician shortage, workforce planning, primary health care, post-graduate training, Russian Federation

Introduction

The ability of health systems to respond to new challenges is heavily dependent on the deployment of an adequate supply of health professionals in sufficient numbers, operating in the right areas of service delivery, and with appropriate scope for professional development. This is particularly true for many post-Soviet countries that face inadequate health funding and the legacy of the "Semashko" model. Russia is among the world leaders in the physicians-population ratio: 4.2 physicians per 1,000 population vs. the average of 3.6 for OECD countries [1]. However, the country now faces a serious problem of physician shortage, particularly in primary care. The Federal Ministry of Health (MoH) reports that around 20% of physicians' positions in polyclinics were unfilled in 2019 [2].

The coexistence of a relatively high number of physicians and their shortage is a phenomenon that can be accounted to many factors. Partly, this is the result

of special health care needs due to country-specific factors such as harsh climate in many regions, low density of large rural population, and high incidence of cardiovascular diseases and accidents (3). The major causes for the Russian health worker supply imbalance, however, are evident in our former research (4) that indicates the important contribution of a deficit of primary healthcare physicians, unequal income opportunities for certain physician specialties, physicians are not adequately supported by nurses, and allied health personnel. The paradoxical situation of "too many too few" requires a special set of workforce policy interventions. Their analysis is relevant for countries that face similar problems.

Following the break-up of the Soviet Union in 1991, the Russian health system has undergone a significant transition to mandatory health insurance (MHI) but has retained its chronic underfunding. Public health expenditures have not exceeded 3.5% of GDP over the last decades (5). The institutional structure of service delivery has not changed much. Most of the facilities are state-owned. Primary health care (PHC) in urban areas is provided by multispecialty polyclinics—separate clinics for adults and children; each has a catchment area and a patient list managed by district therapists, district pediatricians, and general practitioners (GPs)—all of which are collectively referred to as 'district physicians' (DPs). The catchment population of urban polyclinics ranges from 30,000 to 120,000 people. Big entities employ 15–20 categories of specialists. According to the legislation, PHC is practically the equivalent of outpatient care. Hospitals vary in size, the structure of specialties, and the number of patients (6).

To cope with the problem of physician shortage, the government has started a number of policy activities. The presidential decree of May 2012 set the task to increase the salary of physicians to the level of 200% of the average remuneration in the economy of the corresponding regions, and the salary of nurses to 100%. These targets have been reached in most of 85 regions of the country (7). But this important measure was not enough to eliminate the shortage. Additional measures have been taken, of which the most important is a national program "Providing medical organizations with qualified personnel" (further program) for 2018–2024 (2).

The objective of this paper is to explore the activities and outcomes of this program and some other policy activities. The major research questions: What are the major policy interventions? What are the factors driving the health labor imbalances? What should be done to solve this problem? We analyze the main developments over the last 10 years with a focus on the period of the program implementation.

The analysis is based on a review of the Russian and international literature, as well as materials of the federal and regional health authorities. The official statistical data are supplemented by our estimates and comparisons with OECD countries.

Policy options and implications

The program major activities

The major objective of the program is to reduce the shortage of physicians and nurses with focus on primary care. While the government recognizes the existence of a critical imbalance in the health workforce, there is an inadequate study and debate on how best to improve the scope and impact of the program's interventions and investments.

The program is focused on increasing the number of physicians. The admission of students to medical universities increased from 2018/2019 to 2020/2021 by 20% in general medicine specialties [(8), p. 117]. It is expected to raise the number of physicians in state medical organizations from 37.4 per 10,000 population in 2017 to 40.7 by 2024 (Table 1).

To achieve these indicators, a so-called "target enrollment" of students is expanding. It provides for the involvement of regional governments in the admission of students to medical universities, including post-graduate training. Regional policymakers are supposed to assess the demand for specific medical specialists in their regions, contract universities, and make commitments to financial subsidies for the education of students and the employment of graduates. The share of such targeted enrollments in the total number of admissions to medical universities is to increase from 57% in 2018 to 62% by 2024 (9).

Policies to facilitate health worker employment are being implemented with regional health employment centers established. These centers are to search for medical personnel in the labor market, attract physicians from other regions, and collect information on job vacancies for public distribution. The centers are also to promote the development of a so-called "shift method", that is the employment of health workers for temporary work in local areas with an acute shortage of medical personnel (10).

To attract medical professionals, some financial benefits have been introduced, including a partial compensation of utilities. Since 2012, a special program has been implemented in rural areas and small towns. Physicians who choose the work in rural settings are provided with a lump sum to buy a house or an apartment.

To improve the quality of medical personnel qualifications, new professional standards and accreditation procedures are being introduced. They are to cover all medical workers in 2022. On contrary to this objective, the so-called "simplified accreditation" of medical university graduates was introduced in 2016. They are allowed to work as district therapists and pediatricians without passing post-graduate training—an approach unknown internationally (6).

TABLE 1 Indicators and targets of the federal program "Providing medical organizations with qualified personnel" in Russia, 2017–2024.

	2017	2019	2020	2021	2022	2023	2024
Physicians working in state medical organizations (persons per 10,000 population)	37.4	37.9	38.4	38.9	39.5	40.1	40.7
Medical nurses working in state medical organizations (persons per 10,000 population)	86.2	86.8	87.8	89.1	90.4	92.3	95.1
Outpatient care physicians working in state medical organizations (persons per 10,000 population)	20.7	20.9	21.1	21.4	21.7	22.9	22.5
Per cent of filled physicians positions in units providing outpatient care (individuals with a multiple job-holding coefficient of 1.2)	79.7	81.0	83.0	86.0	89.0	92.0	95.0
Per cent of filled nurses positions in units providing outpatient care (individuals with a multiple job-holding coefficient of 1.2)	88.8	90.0	91.0	92.0	93.0	94.0	95.0
The share of outpatient care physicians in the total number of physicians, %*	55.3	55.2	55.0	55.0	55.1	55.2	55.3
Medical nurses-physicians ratio*	2.3	2.3	2.3	2.3	2.3	2.3	2.3

*The author's calculation based on the first lines of this table.
Source: (2).

TABLE 2 Physicians and nurses in Russia, 2010–2020.

	2010	2015	2018	2019	2020
Physicians, thousands	716	673	704	715	737
Physicians per 10,000 of population	50.1	45.9	47.9	48.7	50.4
Nurses, thousands	1,509	1,550	1,491	1,491	1,490
Nurses per 10,000 of population	105.6	105.8	101.6	101.6	102.0

Source: [(8), p. 114, 116].

Some outcomes indicators

These several policy interventions yield some important progress, but much more is to be accomplished. The number of physicians fell in 2010–2017 and then increased by 4.6% in 2018–2020. Physician–population ratio had the same trend. The increase in the last years was the result of additional enrollment of medical students. However, the supply of nurses had a downward tendency—both in absolute and relative terms (Table 2).

To assess the shortage, the program established an indicator of staffing full-time positions of physicians and nurses. It is planned to increase the share of filled outpatient physician positions from 79.7% in 2017 to 95% by 2024. Nearly the same progress is planned for nurses (Table 1).

Using this indicator, the MoH estimates a 39% decrease in the total shortage of physicians and a 37% decrease in the shortage of outpatient physicians over 2016–2019. The size of the latter in 2019 (before the start of the pandemic) was estimated at the level of 8.4%. Among the most wanted outpatient specialties are dentists, radiologists, orthopedic dentists, dermatologists, neurologists, surgeons, and ophthalmologists (2).

The declared strategy of PHC priority is not being realized. The total number of district physicians fell in the period 2010–2017 but then increased only by 1.1% in the period 2018–2021 (Table 3)—partly due to the influx of graduates from medical universities without post-graduate training. As a result, their capacity for high-quality health outcomes is constrained.

The COVID-19 pandemic has aggravated the shortage of PHC physicians and limited their accessibility. The number of vacant doctor positions doubled in 2021 (11). According to a national population survey in October 2021, 70.1% of respondents reported "the inability to make an appointment with the doctor at first attempt" (12). The pandemic has revealed additional labor shortages, including the lack of infectious disease specialists, rehabilitators, nurses, and social workers. The qualification of many DPs was not enough to manage new cases. The government has mobilized hospital doctors. They took on the major burden of the pandemic.

In the hospital care sector, there is an oversupply of physicians. According to the official estimate, this surplus increased by 21% in the period 2016–2019. The oversupplied specialties include gynecologists, psychiatrists, surgeons, therapists, pediatricians, and radiologists. But at the same time, there is a deficit of hospital resuscitators, ophthalmologists, ultrasound specialists, and psychotherapists (10).

The special program for rural areas has started successfully. In 2012, 7,713 physicians and paramedics settled in rural areas as beneficiaries of the program. However, their influx has slowed down to the level of 5,338 physicians in 2018 (10). Financial benefits work relatively well but their funding is insufficient. The share of recipients of housing and utility allowances in the total number of physicians is only 5.8% (10). An additional limitation is the lack of rural physicians' professional communication with urban medical centers.

TABLE 3 District physicians in Russia, 2010−2021.

		2010	2015	2018	2020	2021
1	District therapists, thousands	37,835	35,442	36,215	37,380	38,406
2	District pediatricians, thousands	26,723	25,932	28,161	28,722	28,416
3	General practitioners, thousands	8,983	9,520	11,358	10,505	9,839
4	Total number of district physicians, thousands. (1+2+3)	73,541	70,894	75,734	76,607	76,661
5	Total number of physicians in the system managed by the MoH, thousands	625,671	543,604	551,502	557,303	563,608
6	Share of district physicians in total number of physicians,% (4:5)	11.7	13.0	13.7	13.7	13.6
7	Share of GPs in total number of district physicians, % (3:4)	12.2	13.4	14.9	13.7	12.8

Sources: Author's estimates based on (8).

The results of the workforce policy, however, are highly dependent on the methodology of the shortage estimates. The official indicator of the occupied positions does not account for multiple job-holding by professionals. This is particularly true for primary care physicians. With a federal norm of 1,700 residents served by each district therapist, the actual average catchment area in 2019 was 2,690 residents, in some regions-—3,000–4,000 (13). According to the survey of physicians, 67% of Russian physicians occupy 1.5 or more positions (14). This phenomenon of multiple job-holding contributes to a substantial gap between the official estimates of the share of occupied positions and the estimates of the actual number of physicians. For example, in Karelia region, the former is 92.8% (nearly all positions are filled), while the latter is only 64.8% (15).

Our estimate of the actual shortage of district therapists, based on the norm of 1,700 adults per physician, is 32%, much higher than the official estimate (13).

While modest gains in reducing the supply shortages of certain types of physicians, the situation of "too many too few" has not changed much. The factors that create structural imbalances in the Russian health workforce are still in place.

Why is the physician shortage reproduced?

Service delivery disproportions

They cause the imbalances in the health workforce in the following directions. First, primary care is still the weakest sector of the health system. The task profile of district therapists and pediatricians is limited, they manage only the easiest cases and refer nearly half of patients to outpatient specialists, while their European counterparts manage from 80 to 95% of cases without referrals to specialists (13, 16). The institute of general practitioners with wide clinical and coordinating functions is poorly developed: the share of GPs in the total number of district physicians is only 12.8% and falling (Table 3). This acts as the major driver generating demand for specialists. Meeting this

demand is not easy; therefore, the shortage of some specialists is as acute as the deficit of generalists.

Second, a traditional hospital-centered model of service delivery remains in its major features. The number of bed-days per capita is still 70–75% higher than in the EU (6). The work in a hospital is very attractive for the graduates, and their annual influx has generated an oversupply of some hospital doctors. The MoH recognizes this oversupply, but the program does not provide for the redistribution of physicians to polyclinics: the share of outpatient care physicians in the total number of physicians in 2024 will be the same as in 2018, i.e., 55% (Table 1).

Third, the level of physicians' specialization in Russia is very high: there are 92 specialties and subspecialties. Many routine diagnostic tests are performed by specific categories of specialists. Specialization of primary care has reached the point when specialists in polyclinics account for two-thirds of physician positions, while district physicians have lost their primary role. Specialists of polyclinics are usually not involved in inpatient care; therefore, the country needs two categories of specialists—for inpatient and outpatient care. For example, outpatient urologists do not do any surgery. This process of excessive specialization creates demand for an additional number of physicians and increases the number of unfilled positions.

Fourth, the physician shortage is reproduced by a deeply rooted division of labor between physicians and other medical personnel. The nurse-physician ratio in Russia is 2.3 to 1 and is not planned to increase by 2024 (Table 1), while in the USA, Japan, and EU countries, 2.8–4.7 nurses to one physician (1). Nurses' clinical functions are traditionally low in Russia (6). No serious attempts have been made to reduce the demand for physicians by extending the functions of nurses.

Health labor planning patterns

Labor imbalances begin with a reliance on weak labor forecasting and planning systems at the regional and federal levels. A long-term vision of the structure of physicians' specialties is needed. In Western countries, in the early 2010s,

there were long-term plans for the demand and supply of physicians and nurses in 2030 and even later. These plans were based on the assessment of epidemiological, socio-demographic, and technological factors (17). In Russia, such plans are unavailable. Post-graduate students' enrollment is based on the current assessment of the unfilled positions with a high probability of the graduates' supply not matching demand for specific specialties in the period of 8–10 years.

Regional target enrollment increases the responsibility of regional governments for the employment of graduates but does not reduce the probability of future disproportions across physician specialties. Contracting with medical universities is based on the estimate of current needs, rather than a strategic understanding of future demand and supply for the coming decades. Our analysis of the websites of several regional health authorities shows that not a single region posted estimates of the long-range need for personnel, broken down by individual medical specialties.

The federal MoH has developed a planning methodology, which is based on health care utilization and the number of physicians and nurses per unit of the volume of care (8). But this methodology also suffers from its focus only on current supply and distribution needs. Furthermore, the focus on utilization often provides distorted estimates. For example, a decreasing number of visits to PHC physicians per resident (the recent trend in Russia) results in a decreasing need for the number of primary care physicians. This is contrary to the current objective to strengthen primary care. Other supply factors not addressed include patterns in demographic, trends in disease incidence, and general labor conditions for housing, income, and lifestyle.

Inadequate regulation of physicians post-graduate training

The federal MoH develops quotas for the annual admission to post-graduate training in individual specialties, which are then distributed among medical universities based on their applications. The biggest quotas are for the specialties in short supply. However, there is a gap between quotas and the actual applications of medical universities (18). The latter are interested in increasing the number of students who pay for their training. These are the students in the most popular specialties of gynecologists, urologists, and dentists who provide services mostly for out-of-pocket payments. A chronic underfunding of medical universities from public sources aggravates the structure of training: it is shifting to specialties with a high "financial return". Also, medical universities are slow to adjust their capacity to new needs. Only 3 % of them have units for training GPs (19).

Actionable recommendations

An extensive increase in the number of physicians does not solve the problem of their shortage. It is necessary for federal and regional policymakers *to strengthen the policy focus on the structural parameters of human resources and the elimination of their imbalances*. The experience of many OECD countries provides good examples of such policies. A range of levers is used, including providing incentives to encourage more doctors to choose a general practice and to foster the take-up of certain specialties that are expected to be in short supply in the future; to expand the roles of nurses and other non-physician providers to reduce pressures on physicians. In post-graduate training, there is a search for a new balance between general practitioners and specialists. For example, in France, 48% of medical graduates go to residency in general practice (20). These trends are very relevant to Russia.

Also, the mechanisms to overcome the hospital-centered model of service delivery are needed. We can suggest (a) strengthening control over opening new positions of hospital doctors, (b) increasing the capacity of outpatient departments in hospitals and staffing them with oversupplied doctors, and (c) retraining some specialists to general practitioners.

Strengthening health labor planning. First, to develop middle- and long-term plans for 2030 and 2035, respectively. Second, to account for a complex of factors (future morbidity and mortality, changes in medical technology, possible reconfiguration of physicians' and nurses' roles, and shifts in service delivery structure). Third, to use the indicators of shortage that take into account the multiple job-holding and plan its reduction.

Strengthening regulation of postgraduate training structure. To overcome the orientation of medical universities to expand training in oversupplied, well-paying "commercial" specialties, it is necessary to increase public funding for medical education. The quotas for post-graduate training should be developed not 1.5 years before the start of admission (as it is now), but 3–4 years before. Universities should have time to change their structure to accommodate the growing number of highly wanted professionals. These quotas should be based on the indicators of strategic forecasts and recruitment plans that may extend up to 10 and 20 years in the future.

Increasing the share of GPs in the total number of physicians from the current 13% to the average for the "new" EU countries −29% (19) by 2030. Use financial and nonfinancial incentives for doctors who choose general practice. Cancel the current practice of "simplified accreditation" of primary care physicians and take a course on modern postgraduate training of GPs. This will strengthen the capacity of PHC and decrease the demand for specialists.

Conclusion

The health workforce policy in Russia has recently been activated to overcome the shortage of physicians in the situation of serious labor imbalances. Physicians training is expanding, the regions of the country are increasingly contracting medical universities for post-graduate training of specific specialists, and some financial incentives are used. However, the severity of the problem remains high, mostly in primary care. The main reasons for the reproduction of physicians' deficit are the following: a distorted structure of service provision, the lack of medium- and long-term labor planning, the insufficient regulation of post-graduate training structure across specialties, and the underestimate of the general practitioner's role in reducing demand for outpatient specialists. The major lesson learned is that an extensive increase in the number of physicians without changing their composition does not solve the problem. A structural policy is needed to ensure that the workforce structure is in line with the needs of the health system for the coming decade.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Budget cap and pay-back model to control spending on medicines: A case study of Bulgaria

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Central and Eastern European countries (CEEC) have among the highest rates of increase in healthcare expenditure. External reference pricing, generics and biologics price capping, regressive scale for price setting, health technology assessment (HTA), and positive drug lists for reimbursed medicines are among the variety of implemented cost-containment measures aimed at reducing and controlling the rising cost for pharmaceuticals. The aim of our study was to analyze the influence of a recently introduced measure in Bulgaria—budget capping in terms of overall budget expenditure. A secondary goal was to analyze current and extrapolate future trends in the healthcare and pharmaceutical budget based on data from 2016 to 2021. The study is a retrospective, observational and prognostic, macroeconomic analysis of the National Health Insurance Fund's (NHIF) budget before (2016−2018) and after (2019−2021) the introduction of the new budget cap model. Subgroups analysis for each of the three new budget groups of medicines (group A: medicines for outpatient treatment, prescribed after approval by a committee of 3 specialists; group B: all other medicines out of group A; and group C: oncology and life-saving medicines out of group A) was also performed, and the data were extrapolated for the next 3 years. The Kruskal−Wallis test was applied to establish statistically significant differences between the groups. During 2016−2021, healthcare services and pharmaceutical spending increased permanently, observing a growth of 82 and 80%, respectively. The overall healthcare budget increased from European €1.8 billion to 3.3 billion. The subgroup analysis showed a similar trend for all three groups, with similar growth between them. The highest spending was observed in group C, which outpaced the others mainly due to the particular antineoplastic (chemotherapy) medicines included in it. The rising overall healthcare cost in Bulgaria (from European €1.8 billion to 3.3 billion) reveals that implementation of a mechanism for budget predictability and sustainability is needed. The introduced budget cap is a relatively effective measure, but the high level of overspending and pay-back amount (from European €34 billion to 59 billion

during 2019–2021) reveals that the market environmental risk factors are not well foreseen and practically implemented.

Introduction

In 1998, the World Health Organization (WHO) raised awareness of the fact that the growth of expenditure for medicines had outpaced the growth in the gross domestic product (GDP) of the world economy by four times (1). Subsequent research showed that per-person healthcare costs had grown by 2.3%, whereas GDP per person had increased by only 1.5% for the period 2000–2018 (2). The same report outlined that only eleven out of 52 countries had reported that GDP growth was higher than the growth in healthcare costs, whereas, in 31, the share of public expenditure had risen more than twice the GDP. The direct costs associated with non-communicable diseases (NCDs) are expected to grow by 0.8% per year in EU countries between 2014 and 2020, with the main factors leading to this being the aging EU population, as well as the introduction of new health technologies (3).

Post-soviet Central and Eastern European Countries (CEEC) have seen some of the highest rates of increases in healthcare expenditure. A possible reason for this could be the transition from planned to market economies, with the implementation of many new regulations leading to gaps between regulatory and control measures. Furthermore, the influx of new medicines could have introduced the need for faster endorsement of control measures pertaining to the pharmaceutical area, in order to control prices and reimbursement, as well as pharmaceutical spending (4).

Over the years, a variety of cost-containment approaches, aimed at controlling the rising cost of pharmaceuticals, have been employed; implementation of positive drug lists of all reimbursed medicines, establishment of regulatory bodies on prices and reimbursement, external reference pricing for manufacturer price setting, regressive scale for price setting, generics and biologics price capping, health technology assessment (HTA) for new medicines before inclusion in the positive drug list (PDL), discounts of medicinal products, and other financial-based managed entry agreements negotiated with marketing authorization holders (MAH) have continuously been introduced in the regulation of CEEC (5–7). Most of these measures are also introduced in Bulgaria (8) where they aim to control prescribers, producers, or the whole market, but their impact on the overall budget has not been defined.

In addition to the measures aimed at controlling the rising cost of medicines, other financial budget models were developed

such as annuity (9), Netflix model (10), and a variety of forecasting models such as Andersen's behavior model (11, 12), micro-, component-based, and macro-models (13)to reduce and manage budget growth or help consumers (14).

In 2018, the Bulgarian National Health Insurance Fund (NHIF) (15) introduced a budget cap model for pharmaceuticals in order to control the growth of expenditure for pharmaceuticals by separating all reimbursed medicines into three groups, according to their contribution to the budget (group A: medicines for outpatient treatment, prescribed after approval by a committee of three specialists; group B: all other medicines out of group A; and group C: oncology and life-saving medicines out of group A). The maximum reimbursed budget for each group is negotiated with the marketing authorization holders four times annually. If the reimbursed budget in the group exceeds the negotiated cost, pharmaceutical companies return revenue respective to the proportion of their market share and budget increase above the negotiated value. The effectiveness of this measure has not been studied until now and that provoked our interest in the topic.

The aim of this study is to analyze the trends in the healthcare and pharmaceutical budget for the period 2016–2021 and to forecast future tendencies. In addition, we also performed a subgroup analysis of the three budget groups of medicines for the period 2019–2021, after the introduction of the new model.

The main question we wanted to answer was whether the rate of growth of the budget decreased after the introduction of the new model.

Methods

Design of the study

The study is a retrospective, observational and prognostic, macroeconomic analysis of the NHIF budget for healthcare services and medicines during 2016–2021. The spending information for healthcare services and medicines was extracted from official sources and compared for both periods. The first period encompasses the time before the introduction of the new budget cap model (2016–2018) and the second one, after that (2019–2021).

The data included in the analysis were selected from different sections of the NHIF webpage. As the officially

FIGURE 1
National Health Insurance Fund (NHIF) budget for healthcare services and medicines (Euro, mln).
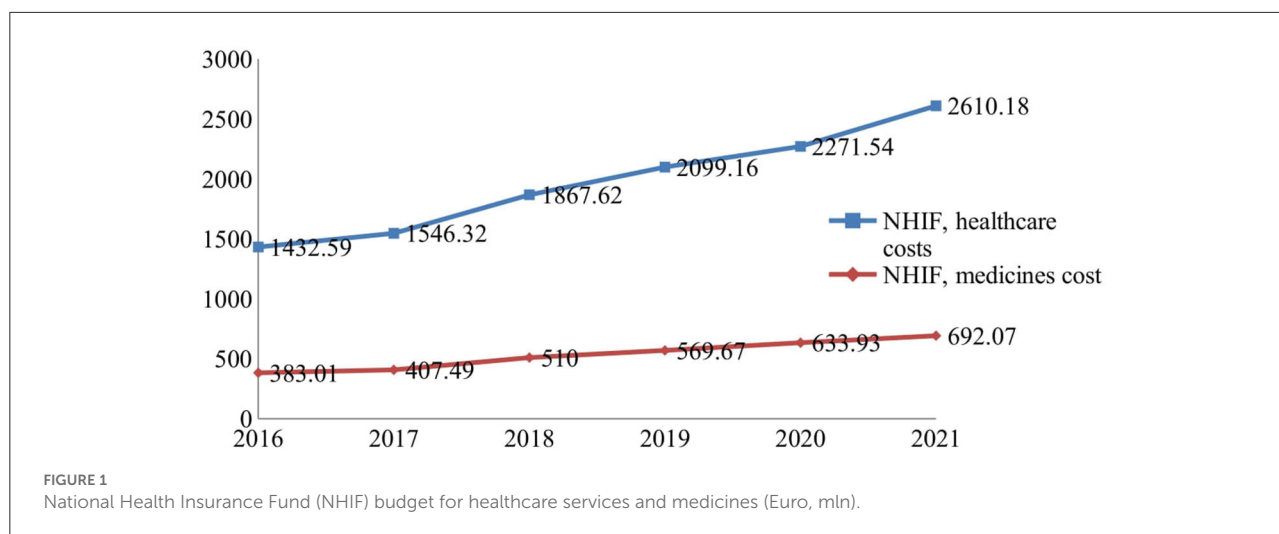
published information was unstructured, we used a four-step approach to systematize it. First, we identified NHIF codes of medicines considering each individual trademark and respective reimbursed expenditure. Second, all trademarks were systematized according to the International Nonproprietary Names (INNs) of medicines and arranged into the main financial groups (A, B, and C), according to NHIF requirements for budget predictability. Third, we calculated the reimbursed expenditure and annual reimbursed spending for each year of consideration and time period for every INN. Fourth, we extracted the information for the overspending of the medicines per budget cap groups (A, B, and C) and summarized it for each year.

Subgroup analysis was also conducted for each of the new budget groups of medicines (A, B, and C) by pharmaco-therapeutic and ATC groups in order to explore which medicines have the highest contribution to the budget growth. We extrapolated the budget data for the next 3 years for every subgroup, calculated the share of the budget increase, and compared those shares.

Data sources

Healthcare and pharmaceutical spending data during 2016–2021 were collected from the official government newspapers approved by the parliament.

Information about the real pharmaceuticals' expenditure and the pay-back sums was collected from the NHIF database for every subgroup of medicines. For the subgroup analysis, the officially published information covers several packages and reimbursed amounts for each budget group of medicines (groups A, B, and C) including pharmaco-therapeutic groups (16).

All costs are presented in Euro at the fixed exchange rate of 1 Euro = 0.51 BGN.

Quantitative analyses

For data analysis, we employed the following quantitative and statistical methods: an index analysis, extrapolation based on time series analysis, and Kruskal–Wallis test.

Indexes of budget change were calculated using two approaches. The first one is as a chain index where the spending each year is divided by the previous year's spending (2017/2016 year; 2018/2019 year; 2020/2019 year; 2021/2020 year). The second is as a basic index where the first year in the observed period, namely 2016, is taken as a base and each year is divided by the base year (17, 18). The chain and basic indexes illustrate two different points of view—the rate of difference each year compared to the previous one, and the rate of change in each year compared with the first year of observation. In this way, differences by period can be examined over a wide range, and the most significant changes can be assessed.

The Kruskal–Wallis test was applied to establish statistically significant differences between public spending during the observed period and to compare proportions (19). It is a non-parametric method used for the comparison of independent samples. We consider it the most appropriate test to assess reimbursed spending and potential statistically significant differences between applied chain and basic indexes because they are not normally distributed. Med Calc vers.16.4.3 (Ostend, Belgium; 2016) software was applied.

The final calculative method was an extrapolation based on the principles of time series analysis (20). We used it to determine the probable values of the future reimbursed sales based on the time trends. We apply the extrapolation of sales data for the next 3 years (2022–2024) based on data for the

previous 3 years to be more precise and match the same time period of observation and future reimbursed sales. This way we can illustrate the current and expected trend of reimbursed amounts considering the main group of medicines (groups A, B, and C).

Results

Budget analysis

During 2016–2021, healthcare services and pharmaceutical spending increased permanently, observing a growth of 82 and 80%, respectively, at the end of the period (Figure 1).

The total healthcare budget rose from European €1.8 billion to 3.3 billion, and the relative contribution of pharmaceuticals was on average 21.25 ± 0.36%. The average index of budget increase for medicines is 1.126 ± 0.73 vs. 1.128 ± 0.054 for healthcare costs. The indexes vary from 1.06 to 1.25 (Table 1). Comparing the indexes during the first 3 years (2016–2018) with that of the second 3-year period (2019–2021), we observe a decrease in the values of these indexes and their growth despite the permanent increase in the budget for medicines.

On average, the budget growth for healthcare services cost and medicine are 3865.16 ± 875.23 and 1044.5 ± 241.13, respectively. The Kruskal–Wallis test revealed statistically significant differences between all compared indexes ($p < 0.0001$).

Subgroup cost analysis for medicines after budget cap introduction

After extracting the costs from the real expenditure for medicines, we can see that there is budget overspending and the expenditure is higher than the projected cost (Tables 2, 3).

There is a budget growth for the whole period as it is most evident in group C with declining indexes. Therefore, group C has the highest contributing rate to expenditure increase.

The new budget model is based on negotiation with the companies for the cap value of the expenditure and, in case of budget drilling, the companies pay back the exceeded sum. The accepted model has led to the overall payback into the budget of European €34 million in 2019 to European €59 million in 2021. Group C is once again with the highest payback amount, but in 2021, the sum that was returned had decreased. It is also evident that the payback is lower than the overspending. The negotiated payback is not publicly revealed, and we cannot discuss who covers the rest of the expenditure but it is highly likely that it is the NHIF (Table 3).

The subgroup analysis shows that antineoplastic medicines contribute with the highest rate toward the expenditure; nevertheless, they are distributed in two budget groups, followed by antidiabetic medicines (Table 4). The latter corresponds with the morbidity patterns in the country and areas of the faster introduction of new technologies.

No statistically significant differences were found comparing reimbursed spending paid by the NHIF for the latest 3 years *via* Kruskal–Wallis test ($p = 0.886$).

Expenditures forecast

Based on the current rising levels, we extrapolated the public expenditure for medicines for the next 3 years, in order to check whether the budget cap model will continue to control the budget growth (Figure 2).

Logically, the expenditure for medicines is expected to increase, based on the extrapolation of the current trend, eventually reaching around European €480 million by the end of 2024. Group C will continue to be the main cost driver, followed by group A, while group B is expected to stay at a constant value.

Discussion

Bulgaria currently has the lowest per capita expenditure for healthcare out of all EU countries, both in absolute terms and as a share of GDP (21). Previous comparisons of macroeconomic and healthcare spending between Balkan and Eastern European countries from 1995 to 2014 revealed the biggest growth in Bulgaria, Serbia, and Slovenia. The largest median spending on health as a percentage of GDP was found in Bosnia and Herzegovina and Greece, and the smallest one was found in Turkey and Romania (22). A previous study confirmed that the main factor, among others, leading to increased healthcare costs in Bulgaria was the increase in GDP (23).

The budget cap and co-payment policies can reduce the utilization of medicines and create some savings in the short-term period. At the same time, decreasing the consumption of the life-saving group of medicinal products and those used for chronic diseases could impact negatively patients and healthcare costs, resulting in increasing payment for hospital treatment (24). The assessment of budget cap policy impact on healthcare spending in the long-term period depends on a variety of factors as well as the design and methodology. Budget cap design requires considering disease prevalence and rate of inflation. The active monitoring of new technologies and their high costs could be incorporated into budget planning as some specific conditions may require additional costs (25). Italy has a similar model of managed entry agreements (MEAs), an analysis of which also revealed a discrepancy between expected payback and collected payback. The calculated total theoretical payback was estimated at €46.3 mln in 2013, but

TABLE 1 Healthcare services and pharmaceuticals budget growth (mln Euro).

Exploring parameter	2016	index	2017	Index	2018	Index	2019	Index	2020	Index	2021
NHIF, healthcare services costs—chain index*	1432.59	1.08	1546.32	1.21	1867.62	1.12	2099	1.08	2271.54	1.15	2610.18
NHIF, medicines cost chain index*	383.01	1.06	407.49	1.25	510	1.12	570	1.11	633.93	1.09	692.07
NHIF, medicines cost basic index**		1.06		1.33		1.48		1.65		1.81	
Total healthcare costs and basic indexes**	1815.60	1.07	1953.81	1.31	2377.62	1.47	2669	1.60	2905.47	1.82	3302.25
Medicines as part of total budget (%)	21.10		20.86		21.45		21.35		21.82		20.96

*chain indexes calculated between each two subsequent years.
**fixed base indexes calculated by dividing each year to 2016.

TABLE 2 Annual NHIF spending and rate of index of change during 2019−2021 (Euro).

	Expenditure 2019	Index 2020 vs. 2019	Expenditure 2020	Index 2021 vs. 2020	Expenditure 2021
Group A	222,755,603	1.12	250,547,170	1.06	266,210,908
Group B	151,593,119	1.04	157,993,953	1.01	159,448,726
Group C	234,275,772	1.26	294,042,467	1.13	331,015,921
Total expenditure, Euro	608,624,495	1.15	702,583,589	1.08	756,675,555

only 31.3 mln was collected. It is worth noting that the Italian system of pharmaceutical expenditure control is based on two main categories of medicines [essential drugs and drugs for chronic diseases (class A) and medicines for hospital utilization (H)] limited to various ceilings which are paybacks in case of overspending (26, 27). Other implemented price-volume schemes, volume of sales related to a target population, confidential discounts, and payback schemes are commented on in Poland and Hungary. According to the authors, this policy tool allows rational spending, while ensuring patient access to new medicines (28).

To the best of our knowledge, this is the first national study exploring budget tendencies after the budget cap with the pay-back model was introduced. The study findings illustrated rising reimbursed spending for medicines in Bulgaria after 2018. The time series analysis is applied as a forecasting approach for price impact examination, results of new regulation, and medicines utilization analysis. It allows discussion on prognostic data in short- and long-term periods (19, 29). The inclusion of new medicines in the PDL, large chronic disease spread, rate of inflation, and rising GDP altogether affect public expenditure for medicines in Bulgaria. At the same time, we found that budget capping has nonetheless introduced a measure of control over the growth of the budget, illustrated by the calculated indexes and their different rates of increase pre- and post-2018. The high value of revenue paid back by MAH indicates that not all factors contributing to the budget increase are incorporated in the annual budget planning. In this respect, the COVID-19 pandemic led to increased public spending on healthcare resources

and pharmaceuticals and could be considered an important cost driver.

A recently introduced budget cap model in Spain links pharmaceutical spending to GDP. A report indicated that pharmaceutical cost control through that methodology is not effective, and it is inadequate when considering entry and diffusion of innovation (30).

When the medicine, spending ceiling is exceeded in Greece, the companies return revenue above that as a direct cash return to National Organisation for Health Services (EOPYY, Εθνικός Οργανισμός Παροχνς Υπηρεσιων Υγείας). The Greek budget cap was introduced as a temporary measure and was linked to real GDP growth and implemented as a claw-back mechanism. It resulted in lower medical service and pharmaceutical expenditures but also some delay due to the complexity associated when expenditures exceed the ceiling (31). The introduction of budgetary targets improves cost allocation and cost-benefit considerations. Participation of all stakeholders along with analysis of age-related morbidity and medical progress spending prediction could minimize the overall risk and support the implementation of effective measures (32).

Conclusion

Our study shows that the introduction of the budget cap model by separating the medicines into three main groups allows for budget predictability in the face of continuously rising expenditures. The main pharmaco-therapeutic groups with the highest contribution to the

TABLE 3 Paid-back expenditure by Marketing Authorisation Holder (MAH).

Budget group of medicines	2019	2020	2021
	Exceeding amount, Euro	Exceeding amount, Euro	Exceeding amount, Euro
Group A	902,627.07	22,559,466.48	15,800,907.72
Group B	1,131,246.30	4,245,937.68	3,482,188.2
Group C	32,188,504.7	46,829,660.64	39,805,921.26

TABLE 4 Pharmaco-therapeutic groups with the highest reimbursed spending during 2019−2021.

	Pharmaco- therapeutic groups (ATC code)	Reimbursed spending paid by NHIF, Euro		
		2019	2020	2021
Group A	Antineoplastic and immune modulating agents *(ATC L01, L02, L03, L04)*	92,618,969.22	100,352,463.87	105,163,926.78
	Medicines used in diabetes *(ATC A10)*	52,561,598.07	60,354,025.26	62,061,145.20
	Anti-infective for systemic use *(ATC J01)*	34,473,807.51	-	
	Nervous system *(ATC N03, N04, N05, N06,N07)*		31,718,183.67	33,065,438.43
Group B	Respiratory system *(ATC R03, R05)*	38,670,312.42	39,505,463.43	38,492,289.27
	Cardiovascular system *(ATC C01, C02, C03, C04, C07, C08, C09, C10)*	36,646,981.26	54,430,917.39	35,725,513.26
	Antithrombotic agents *(ATC B01)*	29,984,085.24	33,962,781.90	37,680,754.32
Group C	Antineoplastic agents *(ATC L01, L02)*	247,092,784.05	312,641,611.68	352,789,198.26
	Blood and blood forming organs*(ATC B02, B03)*	6,365,626.20	7,029,557.46	8,200,311.42
	Drugs affecting bone structure and mineralization *(ATC M05)*	5,839,378.62	6,793,392.27	7,714,503.78

costs are those with the most expensive new technologies (antineoplastic and immunomodulatory agents, drugs affecting bone structure and mineralization) and those covering diseases with the largest prevalence in Bulgaria (nervous system, respiratory disease, diabetes, and cardiovascular diseases).

The limitation of our study is the lack of officially published data for the real sums returned by the industry. The other limitation is the fact that healthcare spending due to SARS-COVID-19 is not selected and categorized as a part of overall expenditure, despite this, spending indexes remained similar throughout the years. The inflation rate in healthcare is between 0.2 and 1.3% within the study period which could also be the reason for rising healthcare services expenditure (33). We do not explore the consumer price indexes and inflation rate due to the following reasons. First, our analysis focuses

on the whole budget and not on individual items. Second, during the observed period, inflation was relatively stable due to the fixed exchange rate of the currencies. Further studies are needed to explore the trends in healthcare costs in a long-term period after the budget cap and pay-back model implementation as well as price index changes due to the inflation rate.

The rising overall healthcare cost in Bulgaria (from European €1.8 billion to 3.3 billion) reveals that implementation of a mechanism for budget predictability and sustainability was needed. Moreover, the extrapolation of reimbursed spending suggests that an increase for the next 3-year period is expected, thus reaching European €985 million in 2024. The introduced budget cap is a relatively effective measure, but the high level of overspending and pay-back amount (from European €34 billion to
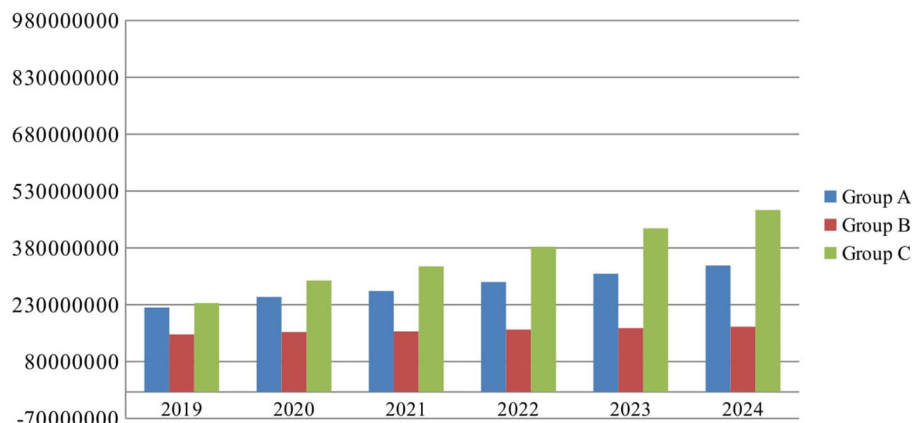
FIGURE 2
Expenditures forecast for 2022–2024.

59 billion during 2019–2021) reveals that the market environmental risk factors are not well foreseen and practically implemented.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

GP conceived and designed the investigation. ZM collected the data and performed the results section. MDi and MK wrote the introduction and conclusion. KT and NG wrote the discussion. KT and MDo prepared the statistical analysis. DT and LM wrote the methodology, result draft, and validated statistics. All authors wrote and revised the manuscript and approved its submission for publication, confirming that the study is original.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Evaluating computing students' digital skills and health literacy: A case from Bulgaria

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The main purpose of this article is to describe the importance and the challenges of digital health literacy as recognized during the COVID-19 pandemic. First, basic definitions of health literacy and digital health literacy are provided, followed by, and matched against digital competence frameworks, and health literacy skills content and scales. Based on that, a compatibility analysis is provided, against the expectations for satisfactory levels definition for the respective competences and skills. For the approbation of the approach, results received from the participation of computing students at the Sofia University St. Kliment Ohridski in the COVID-19 Health Literacy Survey are used.

1. Introduction

The concept of literacy has changed significantly in recent years, and today, it is increasingly associated with the acquisition of specific skills in certain areas. Literacy has an impact not only on the professional career but also on the overall lifestyle of people, especially when it comes to health literacy. On the contrary, the evolution in the way information is presented and perceived today, related to its storage and processing in electronic form, brings to the forefront the need for solid digital skills.

These trends were reinforced during the COVID crisis when the need to access reliable information was vital, and most of this information was only available digitally.

1.1. Digital literacy

The demand for digital skills for life and work today is greater than ever. Broadly considered as skills needed to effectively operate in an increasingly digital world, digital skills are analyzed at different levels, and many frameworks discuss their evaluation.

First, several industry-based competence frameworks were explored in the IT area. Between them, the Skills Framework for the Information Age (SFIA) and the European e-Competence Framework (e-CF) are the most widely used.

SFIA addresses the Professional Skills, Behaviors, Knowledge, Qualifications, and Certifications of the employees. Seven generic "Levels of Responsibility"—Follow, Assist, Apply, Enable, Ensure/advise, Initiate/influence, and Set strategy/inspire/mobilize, are defined to measure them, and specific skills are defined for each of the seven levels (1).

The European e-Competence Framework (e-CF), a reference framework of information and communication technology (ICT) competences, structures the required competences in this field into five e-Competence areas, namely, Plan, Build, Run, Enable, and Manage, following the classical IT lifecycle view. This is the first (Dimension 1) of the four dimensions proposed by the framework. Dimension 2 gives a general description of the competences, while Dimension 3 describes five e-CF proficiency levels for each competence. Finally, Dimension 4 presents knowledge and skills examples, which are related to those described in Dimension 2 competences (2).

As most jobs (not only in IT) require digital skills today, in 2013 the European Commission (EC) launched a common framework, The Digital Competence Framework (DigComp), to assist in the evaluation of these skills among European citizens. The DigComp Conceptual Reference model differentiates digital competences into five competence areas as follows (3).

1. Information and data literacy.
2. Communication and collaboration.
3. Digital content creation.
4. Safety.
5. Problem-solving.

For all twenty-one competences in the five competency areas (CA), proficiency levels are described in categories as *Foundation, Intermediate, Advanced,* and *Highly professional.*

The most recent version, DigComp 2.2, complements the previous ones with connections to emerging technologies, as well as to other organizations. In addition, it provides more guidelines and examples (4).

1.2. COVID-19 as a pandemic

COVID-19 is an infectious disease caused by the SARS-CoV-2 virus (5). In March 2020, the World Health Organization (WHO) described the spread of COVID-19 as a pandemic (6). One of the first things that were explained in order to slow down the transmission and prevent ourselves was for people to be very well-informed about the disease symptoms and how the virus spreads. Now, in the third year of the COVID-19 pandemic, information about the virus spreads on the Internet. Meanwhile, misinformation is still a problem that we have to deal with.

According to the WHO, nowadays societies confront a health decision-making paradox (7). The paradox is the necessity for people to make healthy lifestyle choices for themselves and their families, while being neither prepared nor supported in their efforts to make the right choices. The result is that today's advanced societies are still unprepared to equip people with the required skills in order to find, understand, assess, and use the provided information to improve their health.

It was this paradox that played a crucial role during the COVID-19 pandemic. It was then realized that the weaker the health literacy skills, the less healthy the choices people make.

1.3. Health and digital health literacy

There are many definitions for health literacy (HL). One of the first definitions, well-accepted, is the one proposed in 2012 by the European Health Literacy Consortium: "Health literacy is linked to literacy and entails people's knowledge, motivation and competences to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning health care, disease prevention, and health promotion to maintain or improve quality of life during the life course" (8).

Different studies have been conducted analyzing the importance of HL, exploring different geographies, and covering various population samples and student groups (9, 10). Some studies focus on and further evaluate the impact of the COVID-19 pandemic on students' behavior and health promotion (11, 12).

Many tools are developed that measure health literacy. According to the latest health literacy research and practices described and developed by the Ophelia (OPtimising HEalth LIteracy and Access) process (13), we have now several tools that allow us to identify and respond to health literacy needs (14).

- Health Education Impact Questionnaire (heiQ) (15): It is used to evaluate health education and self-management programs.
- Information and Support for Health Actions Questionnaire (ISHA-Q) (16): It is used to identify specific health literacy strengths and limitations, it can be used for individuals and communities, and it was designed for cultures that often make decisions as a group;
- eHealth Literacy Questionnaire (eHLQ) (17): It provides insight into users' perceptions and experiences of digital health solutions, and it helps understand why implementations work or fail.

One of the most popular tools used in health literacy measures in the world is the Health Literacy Questionnaire (HLQ), which enables needs assessment, evaluation, and quality improvement (18, 19). The major characteristic of HLQ is that it helps to determine a person's ability to obtain, read, understand, remember, and act on healthcare information. It gives insight into health literacy strengths and limitations and helps us to develop suitable interventions. It assesses nine literacy areas and can be used for individuals and communities.

In practice, HLQ is a multidimensional tool for measuring health literacy, and this makes it convenient for the purpose of our study. It has nine scales, and each scale measures an aspect of health literacy as follows.

#1. Feeling understood and supported by healthcare providers.
#2. Having sufficient information to manage my health.
#3. Actively managing my health.
#4. Social support for health.
#5. Appraisal of health information.
#6. Ability to actively engage with healthcare providers.
#7. Navigating the healthcare system.
#8. Ability to find good health information.
#9. Understand health information well-enough to know what to do.

1.4. Purpose of the study

Achieving a good level of health literacy, more specifically e-health literacy, is an important factor for young people's prosperity in the modern world. The investigation of the current state in this new field requires purposeful efforts of both components, namely, digital competences and health literacy skills. This process should start at the universities and find its initial reflection in their curricula.

Many internationally respected and reputable organizations, including the Organization for Economic Co-operation and Development (OECD), have underlined the role and importance of HL. Addressing HL barriers will help health systems become more people-centered. Now health literate individuals are able to seek ways to understand their health options and take more control over their health decisions (20).

In this study, the following new questions arise:

- What are the digital competences required for the students studying medicine and vice versa?
- What are the health literacy skills of computing students?
- What needs to be improved, to make them work better together in the field of eHealth in their further professional realization?

Despite intensive research in this area during the last few years, as described above, there are still not enough specific tools to perform this assessment effectively. Another possible approach is to analyze results from already done research, where other goals and scope are set, and to look for elements that allow assessment of certain aspects of digital competences and health literacy skills and their matching.

Such a possibility was provided by the research done on the COVID-19 Health Literacy Survey: University Students (COVID-HL Survey) where an assessment of "digital health literacy of university students during the COVID-19 pandemic" is included (21). We explored such results from a COVID-HL Survey, provided among computing students in Bulgaria—namely, students in the Faculty of Mathematics and Informatics (FMI) at Sofia University St. Kliment Ohridski. The purpose of our analysis was to make an initial assessment of the level of health literacy of students in Bulgarian universities based on COVID-HL Survey results that include items related to students' health literacy and digital skills.

2. Materials and methods

In this study, we use the results received from the COVID-19 Health Literacy Survey on the digital health literacy of university students during the COVID-19 pandemic, conducted with the participation of students at the Faculty of Mathematics and Informatics at Sofia University. We match those results against the Digital Competence Framework (DigComp 2.2) and the health literacy measurement tool Health Literacy Questionnaire (HLQ). Our primary objective is to provide an analysis of compatibility, against the expectations for satisfactory levels definition for the respective competences and skills.

2.1. The survey

The COVID-19 Health Literacy Survey was developed as a tool to assess some aspects of the "digital health literacy of university students during the COVID-19 pandemic" (21). The tool was developed by both the Public Health Center Fulda (PHZF) at the Fulda University of Applied Sciences and the Interdisciplinary Center for Health Literacy Research at Bielefeld University. The questionnaire has been used for exploring the behavior of students in many countries during information seeking and has been proven to be a reliable tool (22, 23).

Twenty-eight questions in the following four groups were included in the survey.

- Sociodemographic information (Q1–Q10);
- Current life situation and future (Q11–Q12);
- Health literacy and information-seeking behavior (Q13–Q23);
- Personal health situation (Q24–Q28).

Each investigated element had several sub-components and a relevant scale for assessment.

The survey was translated into Bulgarian, and some details, concerning Bulgarian websites and Bulgarian institutions, were adjusted. The study was conducted at Sofia University St. Kliment Ohridski, the biggest and the oldest university in Bulgaria (24, 25). The Faculty of Mathematics and Informatics (FMI) at Sofia University has strong traditions in conducting high-level education in the fields of Mathematics, Informatics, and Computer Science. More than 80% of undergraduate students at the faculty are educated in Computer Science, Information Systems, and Software Engineering programs based on the latest ACM curricula recommendations (26).

In total, 1,690 computing students from the Faculty of Mathematics and Informatics were asked to take part in the survey, and 221 students participated in the study. The students were informed that although some personal data were collected, it could not be assigned to a specific person. Furthermore, the information was collected solely for scientific purposes, with the aim of additionally developing support services. The survey had the approval of the ethics committee of Sofia University St. Kliment Ohridski. All answers were collected electronically *via* a digital platform ensuring the anonymity of the participants. Of all respondents, 84% were undergraduate students in Computer Science, Software Engineering, and Information Systems programs at FMI; 15% were graduate students; and 1% were Ph.D. students. In the biggest group of undergraduate students, 32.62% were from the first academic year, 22.99% were from the second academic year, 24.60% were from the third academic year, and 19.79% were from the fourth academic year.

The study explores the HL of a relatively homogeneous group of computing students. Some limitations of the data collected are also done by the use of the predefined COVID-19 Health Literacy Survey. Additionally, compliance with the frameworks chosen for the study imposes limitations on the volume of data used. On the contrary, it makes the research more focused and provides insights, which we hope can further help in better understanding students' HL and finding ways of improving in the field.

2.2. Digital competences scale: DigComp 2.2

Different frameworks discuss among others digital competences and e-competences. We decided to use DigComp 2.2 because it provides the latest and more integrated view of the topic. Considering

TABLE 1 DigComp 2.2, HLQ, and COVID-HL-Survey cross-reference.

DigComp 2.2 competence area	DigComp 2.2 competence description	COVID-19 health survey questions	HLQ scales
1. Information and data literacy	1.1 Browsing, searching and filtering data, information, and digital content	Q14	#8. Ability to find good health information
	1.2 Evaluating data, information, and digital content	Q16, Q22, Q23	#5. Appraisal of health information
	1.3 Managing data, information, and digital content	Q19, Q20	#7. Navigating the healthcare system
4. Safety	4.3 Protecting health and wellbeing	Q11, Q12	#9. Understanding health information well-enough to know what to do

the digital literacy aspects in our study, we focus on the first competence area in the framework: 1. Information and data literacy. Three competences are presented as follows.

1.1 Browsing, searching, and filtering data, information, and digital content.
1.2 Evaluating data, information, and digital content.
1.3 Managing data, information, and digital content.

All these three competences are connected to the ability to search, navigate, and access data, and to evaluate the reliability of data sources and the information provided by them. The same skills are the focus of one of the main goals of the COVID-HL Survey questionnaire—"assess digital health literacy of university students during the COVID-19 pandemic" (21), and several questions from the questionnaire address the topic.

The other competence area where we find a match within the terms of the discussed frameworks is the fourth competence area in the DigComp 2.2 list: 4. Safety (4). The competence area 4.3. Protecting health and wellbeing concerns the ability of people to avoid health-related risks and threats to their physical and psychological wellbeing while they use digital technologies.

2.3. Health literacy scale: HLQ

The HLQ provides nine independent scale scores, focusing on the strengths and limitations of the respondent and providing insight into those scales. Populations' health literacy strengths and limitations can be evaluated by average scale scores for groups of respondents (along with standard deviations). The effect sizes before and after a concrete intervention can be evaluated through the differences in the mean scores either before or after the intervention of different groups. Finally, similar health literacy profiles of groups of individuals can be evaluated by using cluster analysis. As "HLQ was grounded in citizens' lived experience" (19), it is expected to be useful in the assessment of citizens' needs, which corresponds to the DigComp 2.2 framework.

In our case, we selected four out of the nine scales: #5. Appraisal of health information, #7. Navigating the healthcare system, #8. Ability to find good health information, and #9. Understanding health information well-enough to know what to do. Based on them, we conducted a compatibility analysis of the received COVID-HL Survey questionnaire results, by an evaluation regarding the low and high levels of the implied attributes defined in HLQ.

The selection of four out of nine HLQ scales was done on the basis of the similarity of the scales in all the HL survey (21) data, the HLQ (19), and the DigComp 2.2 framework (4). Further data should be collected to cover the rest of the HLQ scales and develop a complete tool.

2.4. Frameworks matching and cross-reference

Having the above-discussed frameworks and scales, we analyzed the content of all items and selected the questions from the COVID-19 Health Literacy Survey that most closely correspond to both frameworks (DigComp 2.2 and HLQ). We focused our conceptual analysis on:

- identifying common elements in both frameworks—DigComp 2.2 and HLQ and their recommendations and questionnaire questions that address them; and
- analyzing the available responses against the framework of the digital competences and addressing the health literacy scales.

The result of the matching is presented in Table 1.

We concentrated our survey on items directly covered by corresponding questions from the COVID-19 Health Literacy Survey and as such do not use all items from both frameworks (DigComp 2.2 and HLQ).

In the next sections, we present the selected questions, discuss the received responses, and analyze them in accordance with the above guidelines.

3. Results

For the purpose of this study, we reviewed the available questions from the COVID-19 Health Literacy Questionnaire and their responses. According to DigComp 2.2, Dimension 1 defines several competence areas, and Dimension 2 defines the competences for each area. We match the respective competence area and the competences listed within it to a question or multiple questions from the COVID-19 Health Literacy Survey as well as to the HLQ health literacy areas whenever we find a correspondence between the three components, as stated in Table 1.

FIGURE 1
Evaluation of students' ability easily to find good health information.
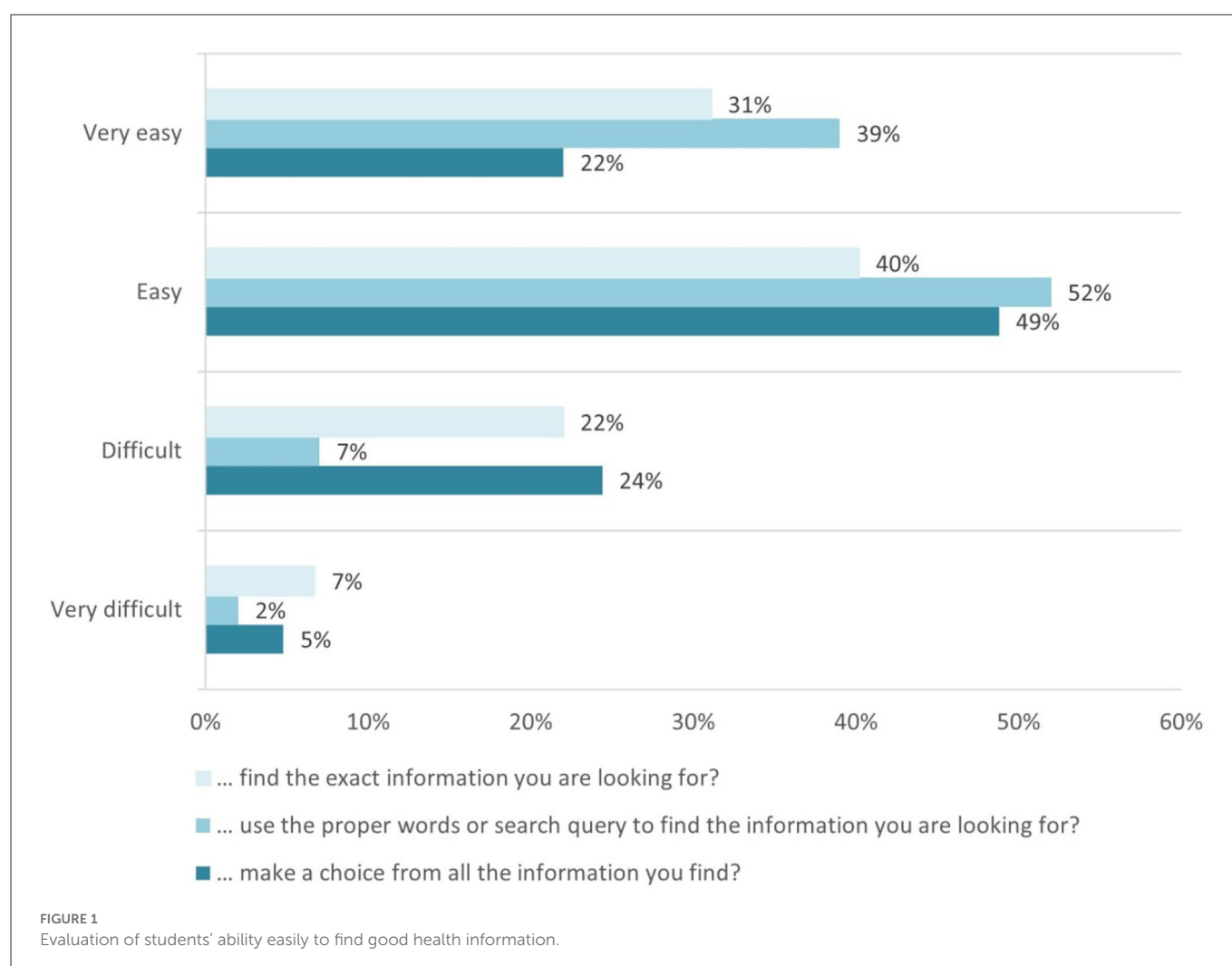
3.1. Information browsing, searching, and filtering as an ability to find good health information

Under the scale of *(1) Very easy, (2) Easy, (3) Difficult*, and *(4) Very difficult*, three sub-questions.

Q14-op.1… make a choice from all the information you find?
Q14-op.2… use the proper words or search query to find the information you are looking for?
Q14-op.3… find the exact information you are looking for?

were provided for question Q14 "When you search the Internet for information on the coronavirus or related topics, how easy or difficult is it for you to…"

In total, 71% of students reported *Easy* and *Very easy* they find the information they are looking for, and 91% of students consider it *Easy* and *Very easy* to use the proper words for a focused search. Also, most of the students find it *Easy* and *Very easy* to make a choice from the information they find (see Figure 1).

This declares skills covered in the competence area 1. Information and data literacy, more particularly for the competence 1.1 Browsing, searching and filtering data, information, and digital content, aiming

"To articulate information needs, to search for data, information, and content in digital environments, to access them and to navigate between them" (4).

From the health literacy side, such skills are outlined in scale #8. Ability to find good health information on HLQ health literacy areas. The low level of the construct is described as "Cannot access health information when required. Is dependent on others to offer information," while the high descriptor of the construct is defined as "Is an information explorer. Actively uses a diverse range of sources to find information and is up to date." According to the definitive answers to question Q14, we can conclude that the highest indicator has been achieved.

3.2. Evaluation of data, information, and digital content as an appraisal of health information

To evaluate competence 1.2. Evaluating data, information, and digital content of competence area 1. Information and data literacy, we use three questions from the COVID-19 Health Literacy Survey— Q16, Q22, and Q23. We match the results to the HLQ scale #5. Appraisal of health information.

FIGURE 2
Means the students used to appraise health information.
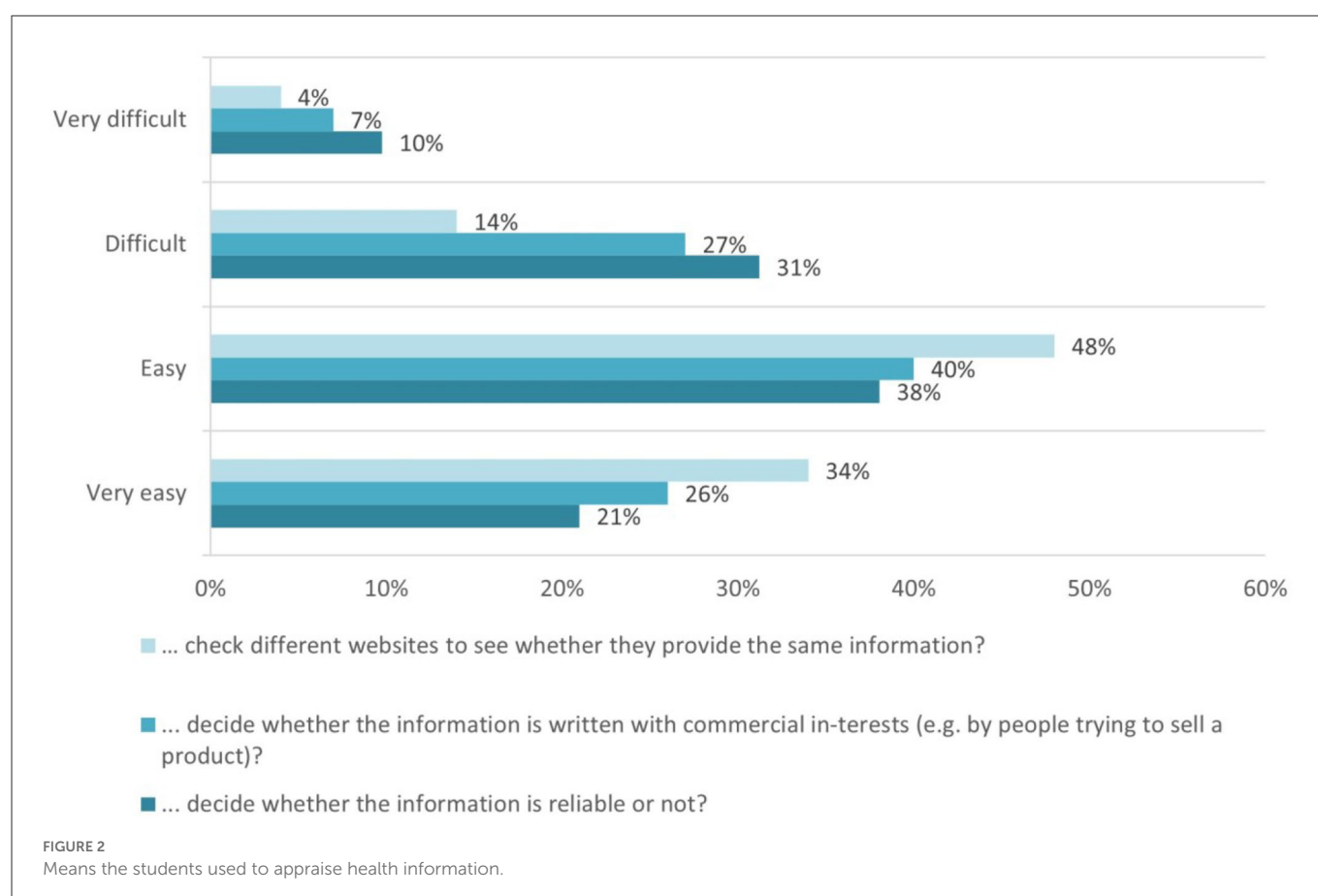
We started the analysis with the question Q16 "When you search the Internet for information on the coronavirus or related topics, how easy or difficult is it for you to…" with the following three sub-questions.

Q16-op.1… decide whether the information is reliable or not?
Q16-op.2… decide whether the information is written with commercial interests (e.g., by people trying to sell a product)?
Q16-op.3… check different websites to see whether they provide the same information?

The results present relatively lower levels for appraising the reliability of the information: 31% of respondents find it *Difficult*, 10% of respondents find it *Very difficult* to decide whether the information is reliable, and 59% of respondents find it *Easy* or *Very easy* to apply their critical thinking skills and to make this decision. It is not quite easy for the students to evaluate whether the information is written with commercial interests-—34% of respondents consider it Difficult and *Very difficult* (Figure 2).

As for the option of checking different sources, the results show that 48% of the students find it *Easy*, and another 34% of the students find it *Very easy*, to check different websites and compare whether they provide the same information.

Computing students' digital competences are also achieved by analyzing their answers to questions related to the evaluation of the reached information (Q22) and the satisfaction level achieved (Q23).

In the first question, Q22 "Now it's about how important various things are to you when you search the Internet for coronavirus and related topics. How important is it to you that…," six sub-questions are provided as follows.

Q22-op.1 … the information is up to date?
Q22-op.2 … the information is verified?
Q22-op.3 … you quickly learn the most important things?
Q22-op.4 … the information comes from official sources?
Q22-op.5 … different opinions are represented?
Q22-op.6 … the subject is dealt with comprehensively?

The majority of the responses relay the importance of information being verified, secure (coming from official sources), and up-to-date for students. Such responses indicate that there are objective criteria for the health-specific information evaluation, and the computing students fully comply with this (Figure 3).

The last question relevant to data, information, and digital content evaluation—Q23 "How satisfied are you with the information you find on the Internet about coronavirus?"— measures students' satisfaction with the obtained information. The answers are provided under the scale of (1) *Very satisfied,* (2) *Satisfied,* (3) *Partly satisfied,* (4) *Dissatisfied*, and (5) *Very dissatisfied*.

Generally, the answers report students successfully find the information they are looking for while critically evaluating the

obtained information (Figure 4). This fully corresponds to the *Advanced* proficiency level of 1.2. Evaluating data, information, and digital content competence.

The overall results show that computing students reach also the upper levels of the high descriptor of the HLQ construct for area #5 defined as "Able to identify good information and reliable sources of
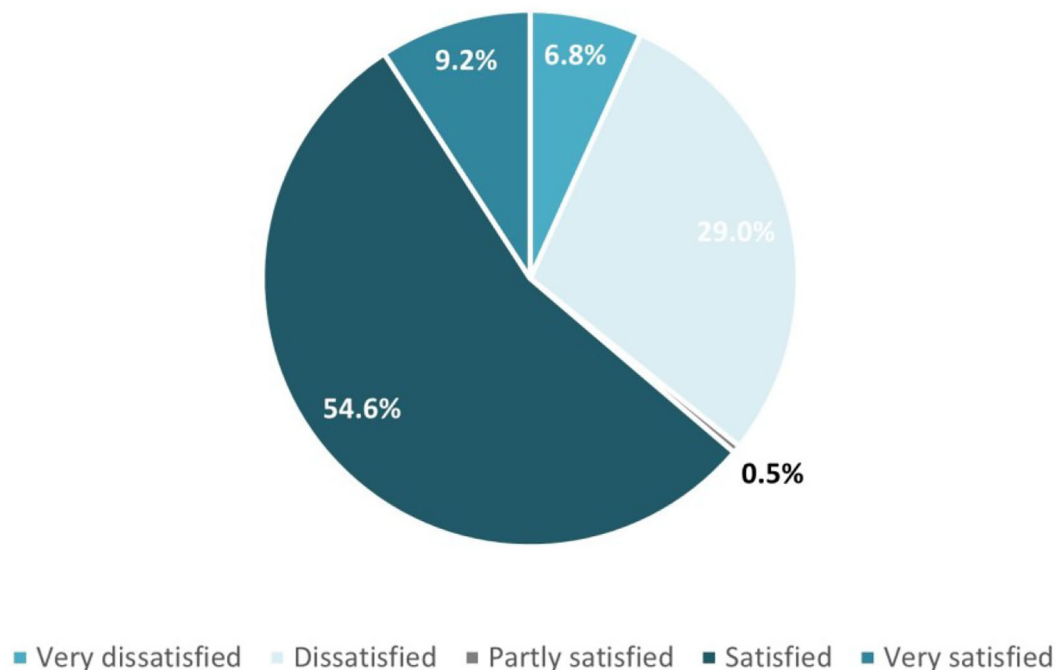
FIGURE 4
Reached information satisfaction levels achieved.

information. They can resolve conflicting information by themselves or with help from others."

3.3. Managing data, information, and digital content for navigating the healthcare system

Explored are the results from answers to the next two questions Q19 and Q20, in relation to competence 1.3. Managing data, information, and digital content (under the same first DigComp 2.2 competence area) and corresponding to area #7 of the HLQ— Navigating the healthcare system.

In question Q19, various possibilities are mentioned on how to get information about the coronavirus and related topics on the Internet.

Q19-op.1–Search engines (e.g., Google, Bing, Yahoo!).
Q19-op.2–Websites of public bodies (for example, the Bulgarian national unified information portal, the current news provided by the Ministry of Health, RHI—the Bulgarian Regional Health Inspectorate).
Q19-op.3–Wikipedia and other online encyclopedias.
Q19-op.4–Social media (e.g., Facebook, Instagram, and Twitter).
Q19-op.5–YouTube.
Q19-op.6–Blogs on health topics.
Q19-op.7–Guidebook-communities (e.g., zdrave.net).
Q19-op.8–Health portals (e.g., credoweb.bg).
Q19-op.9–Websites of doctors or health insurance companies.
Q19-op.10–News portals (e.g., of newspapers and TV stations).

The results received for Q19 are interesting. The students need to indicate how often they use different sources to get information about the coronavirus. The list includes the most used search engines (like Google, Bing, and Yahoo) and specific sources of health information like websites of public bodies. Furthermore, specific Bulgarian websites, which provide up-to-day coronavirus information, were included in our adapted questionnaire (Figure 5).

There is a prominent trend showing that computing students trust reliable public sources and have reservations when it comes to trusting individual entities working or having paid interests in the field.

For question Q20 "What language do the sources have that you use for searching information on coronavirus and related health topics?" we see English language preference strongly expressed, as 77% of respondents use it (Figure 6).

We believe that the provided results for Q19 and Q20 put the computing students to the upper level of the HLQ area #7 "Navigating the healthcare system," taking into consideration the high-level construct for this area is defined as "Able to find out about services and supports so they get all their needs met. Able to advocate on their own behalf at the system and service level" (15).

3.4. Safety and protection of health and wellbeing as a measure for understanding health information well-enough to know what to do

Finally, for the evaluation of competence area 4. Safety, and particularly competence 4.3. Protecting health and wellbeing, we analyzed both questions Q11 and Q12 of the COVID-19 Health Literacy Survey.

Question Q11 "How do you personally find your current life situation in general?" explores students' perception of eight options:
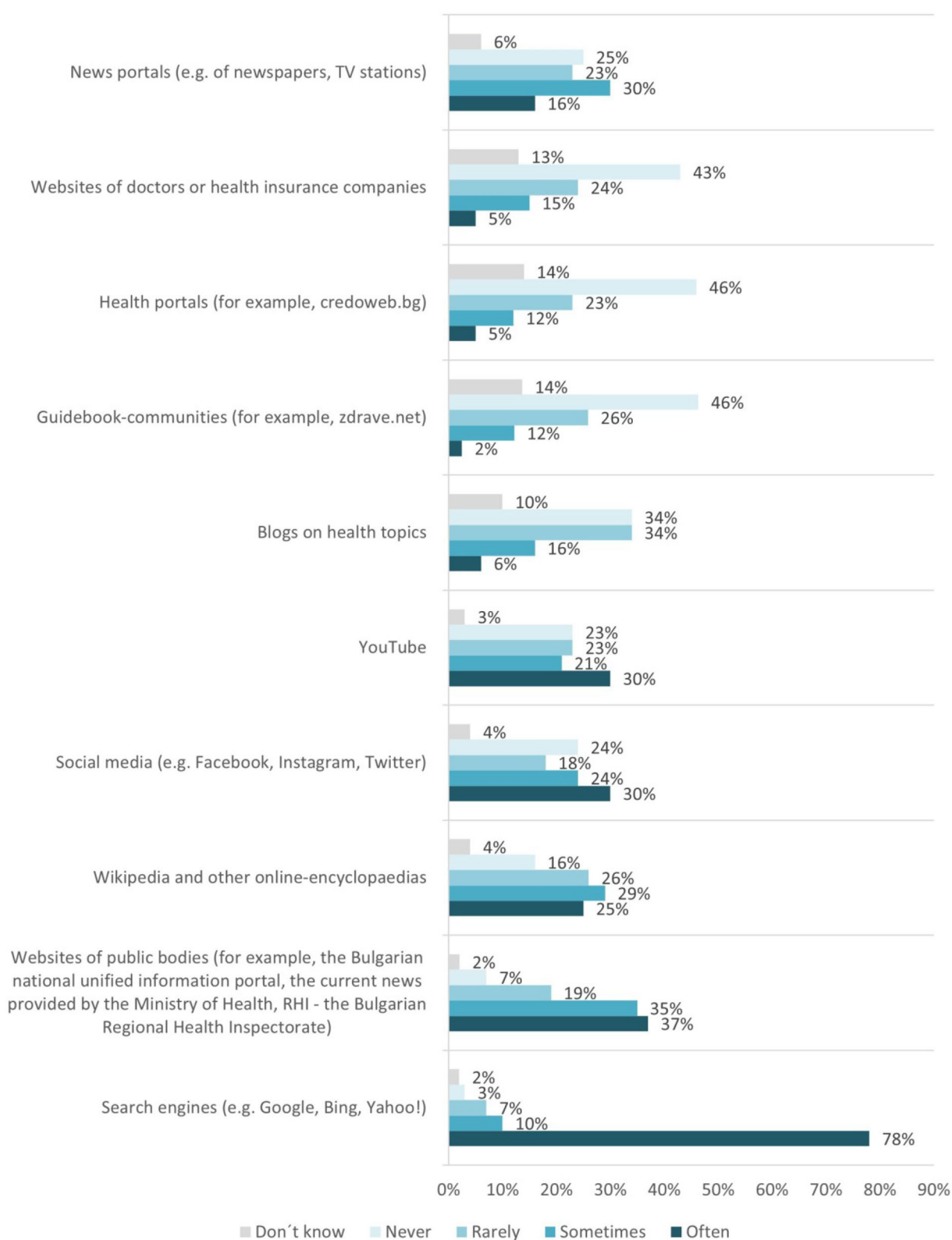
FIGURE 5
Sources used by the students to get information about the coronavirus and related topics on the Internet.

(op.1) manageable–unmanageable, (op.2) meaningless–meaningful, (op.3) structured–unstructured, (op.4) easy to influence–impossible to influence, (op.5) insignificant–significant, (op.6) clear–unclear, (op.7) controllable–uncontrollable, (op.8) predictable–unpredictable, and (op.9) rewarding–unrewarding. A 7-level scale evaluates the nuances between the two opposite values (Figure 7).

The question focus is on measuring the sense of coherence mainly on the work context. This can be interpreted as a wellbeing evaluation criteria presence. This is the first component of the HLQ area #9 "Understanding health information well-enough to know what to do." Three directions can be identified in these evaluations as follows: comprehensibility (options 1, 3, 6, and 9), manageability (options 4 and 7), and meaningfulness (options 2, 5, and 8). The overall results indicate that our students, having in mind the difficulties faced around the COVID-19 pandemic, are normally conservative against the whole situation.
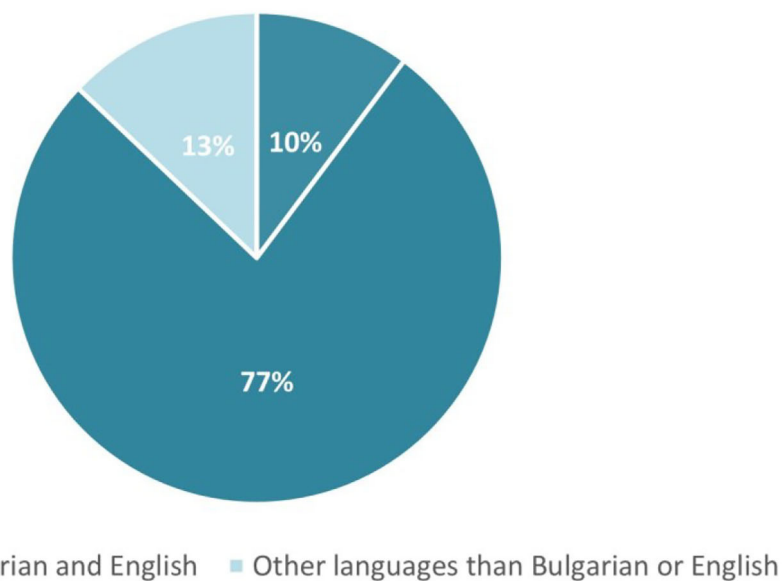
Question Q12 provides statements that concern students' attitudes toward the future. Each statement can reflect their attitude to different degrees. If a certain statement describes the attitude exactly, it is answered with "decidedly true." If the statement is not an accurate description of the attitude, it is answered with "decidedly false." Otherwise, it is answered with "Hard to say." Nine statements—options are provided as follows.

Q12-op.1–I am afraid that the problems which trouble me now will continue for a long time.

Q12-op.2–I am terrified by the thought that I might sometimes face life's crises or difficulties.

Q12-op.3–I am afraid that in the future my life will change for the worse.

Q12-op.4–I am afraid that changes in the economic and political situation will threaten my future.

Q12-op.5–I am disturbed by the thought that in the future I won't be able to realize my goals.

Q12-op.6–I fall into a state of tension and uneasiness when I think of my future affairs.

Q12-op.7–I am sure that in the future I will realize the most important goals (values) in my life.

Q12-op.8–I have the impression that the world tends toward collapse.

Q12-op.9–I am disturbed by the possibility of a sudden accident or serious illness (e.g., cancer, COVID-19).

The statements again are provided under a scale of seven degrees, this time from (1) Decidedly true, to (7) Decidedly false, with the middle option [Hard to say].

The use of the future anxiety levels evaluation is divided into two sub-components for the short and the long anxiety versions. The aim is to compare any existing tendencies related to thinking about the future with anxiety. The existing uncertainty and any further disaster anticipation in the future can be used as an evaluation criterion for computing students' way of dealing with area #9 "Understanding health information well-enough to know what to do" of the HLQ areas.

We matched the results from questions Q11 and Q12 with area 9. "Understanding health information well-enough to know what to do" of the HLQ areas. The lower level construct is defined as "Has problems understanding any written health information or instructions about treatments or medications. Unable to read or write well-enough to complete medical forms." The upper level of the construct is defined as "Is able to understand all written information (including numerical information) in relation to their health and able to write appropriately on forms where required."

The results received show that although the computing students are well-oriented in searching, allocating, and evaluating health information, they do not feel confident about the future, and they do not have a clear view and knowledge of what to do in the future with the health information they have (Figure 8).

4. Discussion

This section goes further in reviewing the available questions from the COVID-19 Health Literacy Questionnaire and the computing students' responses. Following the conceptual qualitative

FIGURE 7
Students' wellbeing self-evaluation.
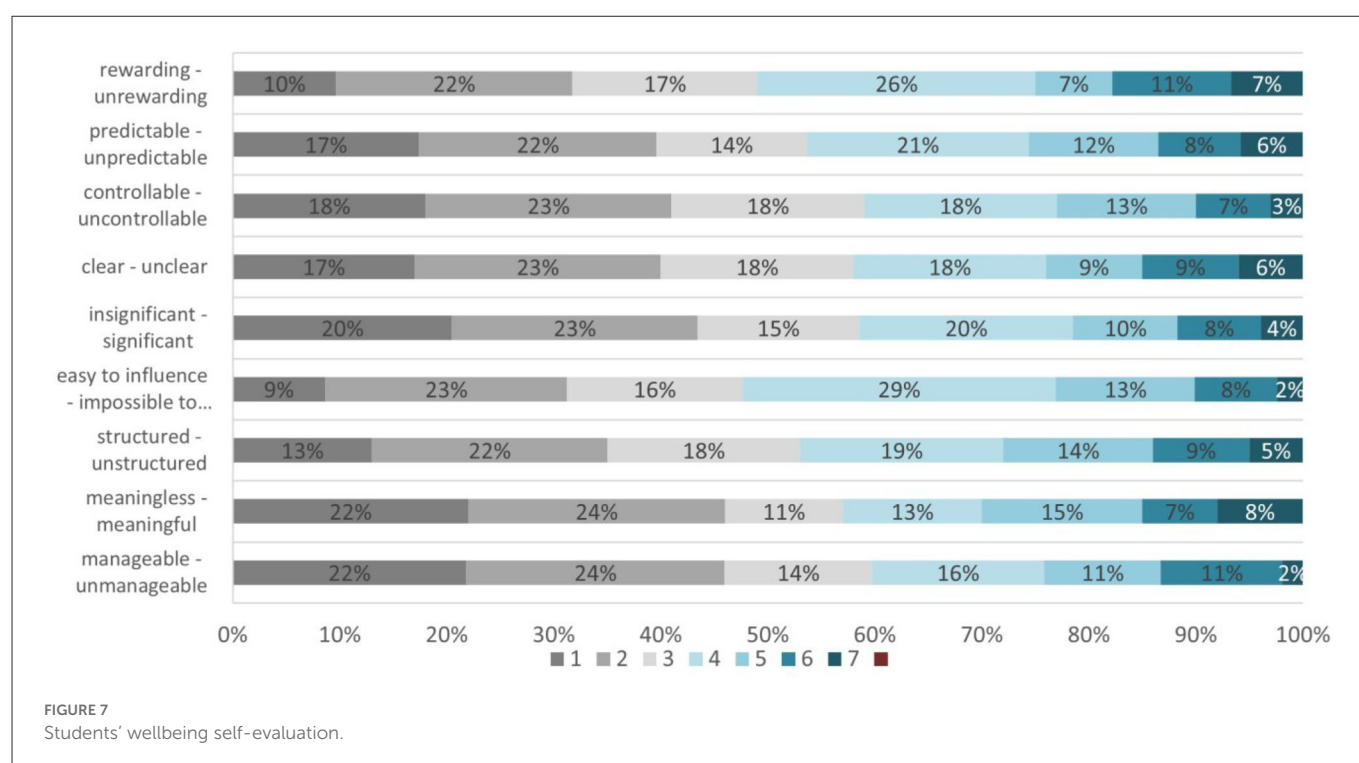
analysis on identifying common elements in both frameworks, DigComp 2.2 and HLQ in the previous section, now a quantitative analysis is the focus.

The method used starts with applying the correlation analysis of the received responses per question, as a major tool. This analysis allows us to identify whether there is a relationship between certain variables and then helps to determine the magnitude of such a relationship. The second step is to evaluate the received responses and determine the proficiency level (Dimension 3 of DigComp 2.2) corresponding to the related competence (Dimension 2 of DigComp 2.2) for the competence area under evaluation (Dimension 1 of DigComp 2.2), recognized in the previous section.

4.1. Information browsing, searching, and filtering as an ability to find good health information

The correlation analysis conducted on the results of question Q14 "When you search the Internet for information on the coronavirus or related topics, how easy or difficult is it for you to …" indicates a strong linear relationship between the provided options. The levels of the association are very high (0.82, 0.92, 0.93), which means the students' responses are changing in the same direction.

Computing students' proficiency level regarding competence 1.1. "Browsing, searching and filtering data, information, and digital content" of DigComp 2.2 competence area 1. Information and data literacy is evaluated at the *Advanced* level. According to the responses received, computing students cover the requirements of the ability to assess information needs, adapt searching strategy, and explain how to access data.

4.2. Evaluation of data, information, and digital content as an appraisal of health information

The proficiency level for the next competence 1.2. Evaluating data, information, and digital content was calculated based on three questions from the COVID-19 Health Literacy Survey—Q16, Q22, and Q23.

Correlation analysis was conducted on the results for questions Q16 and Q22. For both questions, we have results with a strong linear relationship between the provided options. The levels of the association are very high, and the lowest coefficient of all is 0.69. This exposes an aligned approach toward students' responses. These results are also confirmed by the answers in Q23 "Reached information satisfaction levels achieved" (see Figure 4), where we have more than two-thirds of the students feeling satisfied or very satisfied (Satisfied 55%, Very satisfied 9%) with the information they find on the Internet about coronavirus.

All those indicate an *Advanced* proficiency level for competence 1.2. Evaluating data, information, and digital content of DigComp 2.2 competence area 1. Information and data literacy. Computing students can critically assess the credibility of sources, data, information, and digital content they find on the Internet about coronavirus.

4.3. Managing data, information, and digital content for navigating the healthcare system

Two questions, Q19 and Q20, were used in relation to proficiency level evaluation for competence 1.3. Managing data, information, and digital content under the first competence area of DigComp
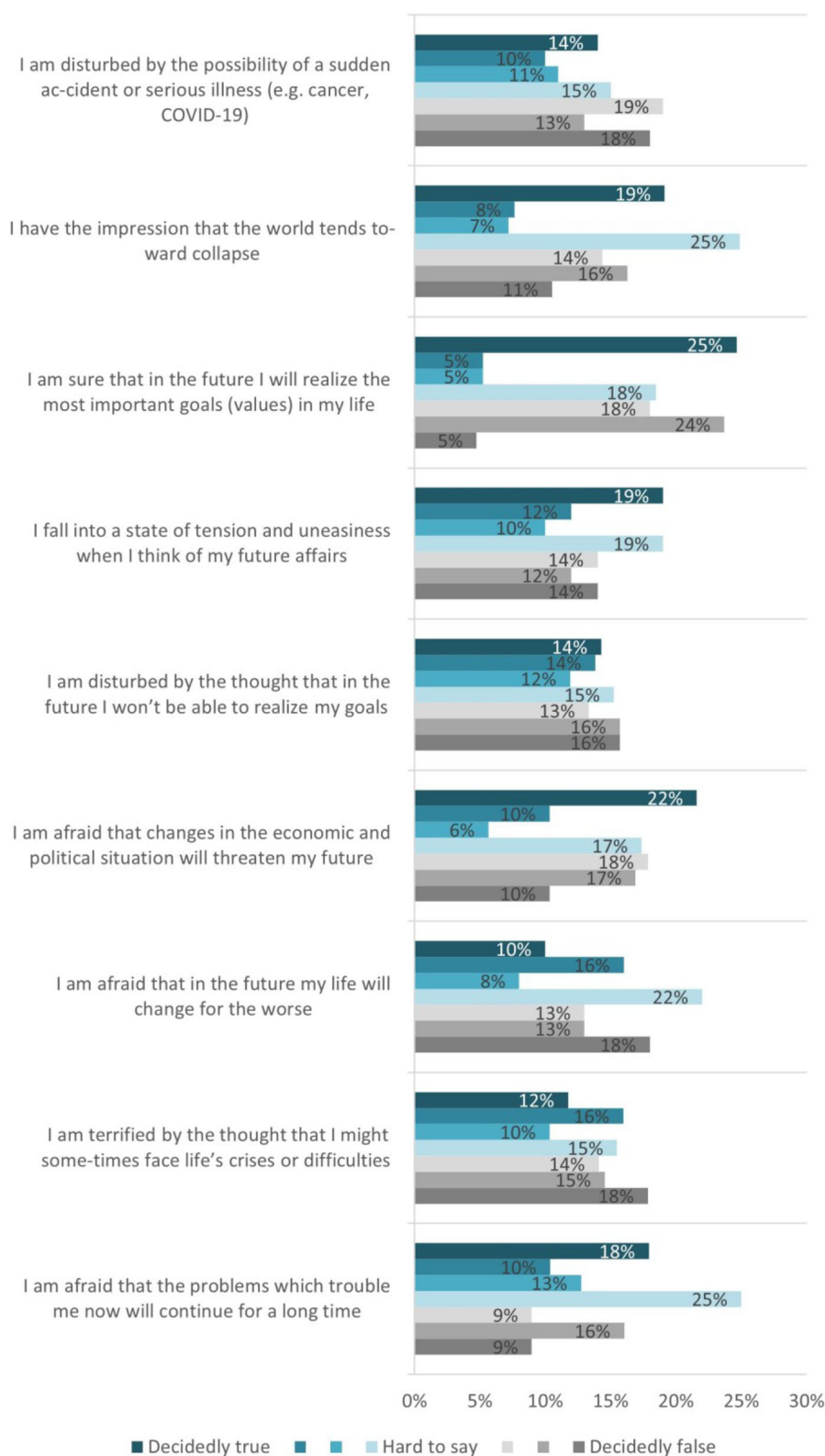
FIGURE 8
Students' health and wellbeing risk factors self-evaluation.

2.2. A correlation analysis was conducted only for question Q19 (see Table 2), regarding the various possibilities of sources used to get information about the coronavirus and related topics on the Internet.

The correlation analysis results show that the different sources used can be grouped into categories varying from extremely strong positive relationships down to strong negative relationships. That

TABLE 2   Q19 "Sources used by the students to get information about the coronavirus and related topics on the Internet" correlation analysis.

	op.1	op.2	op.3	op.4	op.5	op.6	op.7	op.8	op.9	op.10
Q19-op.1	1.00									
Q19-op.2	0.67	1.00								
Q19-op.3	0.35	0.85	1.00							
Q19-op.4	0.60	0.77	0.80	1.00						
Q19-op.5	0.60	0.71	0.82	0.96	1.00					
Q19-op.6	−0.58	−0.36	0.18	0.09	0.22	1.00				
Q19-op.7	−0.61	−0.59	−0.16	−0.02	0.03	0.89	1.00			
Q19-op.8	−0.55	−0.57	−0.16	0.03	0.07	0.85	1.00	1.00		
Q19-op.9	−0.58	−0.53	−0.10	0.06	0.09	0.88	1.00	1.00	1.00	
Q19-op.10	−0.17	0.48	0.80	0.65	0.60	0.54	0.33	0.33	0.39	1.00

means we have options with strong positive linear relationships toward each other, as well as options with a strong negative relationship, for example, students who trust, and often (op.2) use websites of public bodies (e.g., the Bulgarian national unified information portal, the current news provided by the Ministry of Health, and RHI—the Bulgarian Regional Health Inspectorate); and tend to distrust and not use (op.6) Blogs on health topics, (op.7) Guidebook-communities (e.g., zdrave.net), (op.8) Health portals (e.g., credoweb.bg), or (op.9) Websites of doctors or health insurance companies. At the same time, those students trust (op.4) Social media (e.g., Facebook, Instagram, Twitter) and (op.5) YouTube, despite the risks related to the use of unchecked sources of medical information.

This lack of clear indications for navigating the healthcare system is confirmed by the results of question Q20, related to the language/s used for searching for information on coronavirus and related health topics the sources discussed. That means that computing students have the ability to also rely on English to cross-check the acquired information.

The proficiency level for competence 1.3. Managing data, information, and digital content of the first DigComp 2.2 competence area is evaluated as *Intermediate*. Computing students cannot go above selecting data, information, and content and organizing them. No signs of abilities related to manipulating such data are provided.

4.4. Safety and protection of health and wellbeing as a measure for understanding health information well-enough to know what to do

The proficiency level for Competence 4.3. Protecting health and wellbeing of DigComp 2.2 competence area 4. Safety calculation was done based on questions from the COVID-19 Health Literacy Survey—Q11 and Q12. Correlation analysis was conducted for both questions.

The correlation analysis conducted on the results of the question Q11 "How do you personally find your current life situation in general?" indicates in general very strong linear relationship between the provided options, excluding two options, which can be evaluated as not well-understood, as they do not change the overall evaluations.

The levels of the association are in general very high, which means the students' responses are consistently changing in the same direction.

The future anxiety levels analyzed by the correlation analysis results on question Q12, where student present their attitude to the future, reveal that answers to the different statements vary from strong and extremely strong positive relationships down to negative relationships. We have options changing in value, in the opposite direction than other options (Table 3).

There are no clearly identifiable trends regarding the health and risk factors evaluation. The computing students do not seem to understand health information to such a degree as to know what to do.

The proficiency level for competence 4.3. "Protecting health and wellbeing" of DigComp 2.2 competence area 4. Safety is evaluated as *Foundation*. Computing students can only differentiate, select, and identify ways to avoid health risks and threats.

5. Conclusion

Today, different competence frameworks and scales for assessing literacy in different domains exist. Particularly important are those related to health literacy, or rather digital health literacy and related digital skills. In this article, we presented the use of two tools, namely, DigComp 2.2 and HLQ, to assess the health literacy and digital skills of Sofia University computing students.

Although a targeted full study was not done and results from a previous study were used, which has some relevance to the digital competences and literacy levels discussed, the obtained results are promising. We conclude that the students show good coverage of the levels specified in these two widely used frameworks—they cover almost completely the formulated quality standards on several major indicators of both frameworks. The study found a stable level of health literacy in FMI students in several health literacy scales, although some cases reported not properly understanding health information to know what to do. These good results are mainly due to the high level of digital skills of the student of the Faculty of Mathematics and Informatics.

These findings confirm what WHO calls the health decision-making paradox, and reveal that the improvement in digital health

TABLE 3 Q12 "Students' health and wellbeing risk factors self-evaluation," correlation analysis.

	op.1	op.2	op.3	op.4	op.5	op.6	op.7	op.8	op.9
Q12-op.1	1.00								
Q12-op.2	−0.16	1.00							
Q12-op.3	0.29	0.85	1.00						
Q12-op.4	0.48	−0.02	0.12	1.00					
Q12-op.5	0.32	0.72	0.65	0.43	1.00				
Q12-op.6	0.63	0.16	0.43	0.76	0.44	1.00			
Q12-op.7	0.57	−0.24	−0.08	0.92	0.35	0.56	1.00		
Q12-op.8	0.85	0.05	0.41	0.81	0.51	0.83	0.79	1.00	
Q12-op.9	−0.13	0.34	0.32	0.37	0.33	0.37	0.22	0.33	1.00

literacy should be closely linked to the achievement of a good level of common digital skills, particularly in information and data literacy. The application of computer-based knowledge and skills to specific organizational context, like health area, could also be important for a future professional career and should be developed over time with both education and expertise. Most educational programs in the Faculty of Mathematics and Informatics support curricula that purposefully shape the good digital skills of students, which helps them maintain a good level of literacy in various fields. At the same time, in order to overcome any of the shortcomings identified, a clearer mention of the aspects of identified areas should be addressed in the next revision of the programs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Changes in mortality of Polish residents in the early and late old age due to main causes of death from 2000 to 2019

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Purpose: The aim of the study was to assess mortality trends in Poland between 2000 and 2019 in the early and late old age population (65−74 years and over 75 years).

Methods: The work used data on all deaths of Polish residents aged over 65 years ($N = 5,496,970$). The analysis included the five most common major groups of causes of death: diseases of the circulatory system, malignant neoplasms, diseases of the respiratory system, diseases of the digestive system and external causes of mortality. The analysis of time trends has been carried out with the use of joinpoint models. The Annual Percentage Change (APC) for each segments of broken lines, the Average Annual Percentage Change (AAPC) for the whole study period (95% CI), and standardized death rates (SDRs) were calculated.

Results: The percentage of deaths due to diseases of the circulatory system decreased in all the studied subgroups. Among malignant neoplasms, lung and bronchus cancers accounted for the largest percentage of deaths, for which the SDRs among men decreased, while those among women increased. In the early old age, the SDR value increased from 67.8 to 76.3 (AAPC = 0.6%, $p > 0.05$), while in the late old age group it increased from 112.1 to 155.2 (AAPC = 1.8%, $p < 0.05$). Among men, there was an upward trend for prostate cancer (AAPC = 0.4% in the early old age group and AAPC = 0.6% in the late old age group, $p > 0.05$) and a downward trend for stomach cancer (AAPC −3.2 and −2.7%, respectively, $p < 0.05$). Stomach cancer also showed a decreasing trend among women (AAPC −3.2 and −3.6%, $p < 0.05$). SDRs due to influenza and pneumonia were increasing. Increasing trends in mortality due to diseases of the digestive system in women and men in the early old age group have been observed in recent years, due to alcoholic liver disease. Among the external causes of mortality in the late old age group, the most common ones were falls.

Conclusions: It is necessary to conduct further research that will allow to diagnose risk and health problems of the elderly subpopulation in order to meet the health burden of the aging society.

KEYWORDS

aging, causes of death, mortality trends, epidemiology, Poland

Introduction

The process of population aging has demographic, economic, social and health dimensions. This is because the phenomenon is indirectly influenced by a number of factors, such as the level of affluence of the population, changes in the family model, professional activity of women, the quality of social and health care, education and government policies in the field of public health (1). Demographic forecasts predict that in 2050 the percentage of elderly people in the world will reach 16%. In EU countries, there will be only two people of working age for every person aged 65 years or over, while in Poland the share of people aged 65 years and over will be nearly 40%. The oldest age group, i.e., individuals over 85 years will constitute the largest group of people. The size of this group is expected to increase by more than 2.5 times as compared to 2020 (2). In Poland, at the end of 2020, the percentage of people aged 65 years and over was 23.8%, while the old-age dependency ratio, defined as the number of people aged 65 years and over per 100 people aged from 15 to 64 years, was 28.2. In view of the advancement of the population aging process, it is very important to analyse the health status of the elderly subpopulation (3, 4). Data on deaths are one of the most important sources of information on a population's health status in all age groups. Due to the fact that deaths have to be registered, they provide a database of complete information on the causes of mortality in societies around the world.

Based on the data from the Global Burden of Disease Study, between 1990 and 2017 as many as 12 million additional deaths worldwide were related to population aging. This accounted for 27.9% of all deaths, with the largest share attributed to ischemic heart disease (5).

The mortality structure and trends among the elderly reflect the mortality of the general population. In Poland, the predominant cause of death is cardiovascular disease, accounting for 42.6% of all deaths, with a ten-percentage-point decline since (6). The percentage of deaths from this cause in people aged over 65 years has also declined and is 41.1%. What is characteristic for the elderly is that the rate of deaths from cardiovascular disease among men only slightly exceeds that among women, while in younger age groups, mortality among men significantly exceeds that of women (7). The second most common cause of death in the general Polish population is cancer. The Health at a Glance 2021 report shows that the incidence of cancer in Poland has increased, which may indicate an improvement in early cancer diagnosis. However, the rate in Poland is still relatively low, reaching 267 per 100,000 population, with the average for OECD countries at 294, respectively. In contrast, the mortality rate from malignancies in Poland is one of the highest in OECD countries, at 228 deaths per 100,000 population, with an average of 191 per 100,000 (8). Cancer is also the second cause of death in people aged over 65 years (21.5%). Incidence trends in men in this age group showed an increase that continued until the mid-1990s, after which the phenomenon stabilized. In contrast, the elderly female population has seen an almost 1.6-fold increase in incidence over the past three decades. The majority of cancer deaths (75%) occur after the age of 60. The risk of dying from cancer increases with age, reaching a peak in the eighth and ninth decades of life (9). The

third cause of death among the elderly, as in the general population, is respiratory diseases. They accounted for 6.5% of all deaths in 2020 and have shown an upward trend over recent years. Among those aged 65 years and older, respiratory diseases are almost twice as common a cause of death as among those under the age of 65 years. The next most common causes of death in the elderly population are digestive diseases (2.7%) and external causes of mortality (2.0%) (7).

The described changes in the age structure of the population determine the health profile of the society and the nature of challenges facing the health care system. More than 30% of patients using health care are affected by multi-morbidity, which is strongly related to age. The average annual cost of treating a patient over 65 years of age is almost three times higher than that of people in younger age groups. The demand for long-term care services is also growing. This gives rise to the need to look for solutions that will minimize the effects of the population aging i.a. by monitoring and forecasting the health needs of subpopulations in older age groups, separately from the population of younger people and those affected by premature mortality.

The aim of this study was to assess mortality trends in Poland between 2000 and 2019 in the early and late old age population.

Materials and methods

The study used data on all deaths of Polish residents aged 65 years or more in the years 2000–2019 ($N = 5,496,970$). The database was based on death reports collected and made available for this study by the Department of Information of the Polish Central Statistical Office.

Mortality was analyzed in two age groups: early old age (65–74 years) and late old age (over 75 years). The analysis included the five most common major groups of causes of death: diseases of the circulatory system (according to the International Statistical Classification of Diseases and Health-Related Problems—Tenth Revision—ICD-10, coded as I00–I99), malignant neoplasms (C00–C97), diseases of the respiratory system (J00–J99), diseases of the digestive system (K00–K93) and external causes of mortality (V01–Y98). In each group, the most important causes of death were identified: ischemic heart diseases (I20–I25), cerebrovascular diseases (I60–I69), diseases of arteries, arterioles and capillaries (I70–I79), cancers of the lungs and bronchi (C34), stomach (C16), colorectal (C18–C20), breast (C50), prostate (C61), and pancreas (C25), chronic obstructive pulmonary disease (J44), influenza and pneumonia (J09–J18), alcoholic liver disease (K70), transport accidents (V01–V99), falls (W00–W19) and intentional self-harm (X60–X84).

The standardized death rates (SDRs) were calculated according to the following formula:

$$SDR = \frac{\sum_{i=1}^{N} \frac{k_i}{p_i} w_i}{\sum_{i=1}^{N} w_i}$$

where: k_i is the number of deaths in this i-age group, p_i is population size of this i-age group, w_i is the weight assigned to this i-age group, resulting from the distribution of the standard population, N—number of the age groups

The standardization procedure was performed using the direct method, in compliance with the European Standard Population, updated in 2012 (10). The Revised European Standard Population is the unweighted average of the individual populations of EU-27 plus EFTA countries in each five-year age band (with the exception of individuals under the age of five and the highest band, i.e., those aged over 85 years).

The analysis of time trends has been carried out with joinpoint models and Joinpoint Regression program, a statistical software package developed by the U.S. National Cancer Institute for the Surveillance, Epidemiology and End Results Program (11).

Joinpoint regression model is an advanced version of linear regression $y = bx + a$, where b is the slope coefficient, a is the y-intercept, $y = \ln(z)$, z is a measure evaluated in the study (SDR) and x is calendar year. Time trends were determined with the use of segments joining in joinpoints, where trend values significantly changed ($p < 0.05$). To confirm whether the changes were statistically significant, the Monte Carlo Permutation method was applied.

In addition, the authors also calculated the Annual Percentage Change (APC) for each segment of broken lines and the Average Annual Percentage Change (AAPC) for the whole study period with corresponding 95% confidence intervals (CI).

The Annual Percent Change is one of the ways to characterize trends in death rates over time and it was calculated according to the following formula:

$$APC = 100 * (\exp^b - 1)$$

where b is the slope coefficient.

With this approach, the death rates are assumed to change at a constant percentage of the rate of the previous year. For example, if the APC is 1%, and the rate is 50 per 100,000 in 2,000, the rate is $50 \times 1.01 = 50.5$ in 2001 and $50.5 \times 1.01 = 51.005$ in 2002. Rates that change at a constant percentage every year change linearly on a log scale.

The Average Annual Percent Change (AAPC) is a summary measure of the trend over a pre-specified fixed interval. It allows us to use a single number to describe the average APCs over a period of many years. It is valid even if the joinpoint model indicates that there were changes in trends during those years. It is computed as a weighted average of the APCs from the joinpoint model, with the weights equal to the length of the APC interval (12).

$$AAPC = \left\{ \exp \left(\frac{\sum w_i b_i}{\sum w_i} \right) - 1 \right\} \times 100$$

where b_i is the slope coefficient for each segment in the desired range of years and w_i corresponds to the length of each segment in the range of years.

Results

The most common major groups of causes of death among Polish residents aged over 65 years were the following: diseases of the circulatory system, malignant neoplasms, diseases of the respiratory system, diseases of the digestive system and external causes of mortality (Table 1).

The highest percentage of deaths in 2000 in both analyzed age groups (early old age and late old age cohorts), and in both gender groups were deaths caused by diseases of the circulatory system. Over the 20 years analyzed, this percentage decreased in all the subgroups studied. As a consequence, this led to a decrease in differences in death rates between diseases of the circulatory system and the second most common group of malignant neoplasms, while in the group of women in early old age in 2019, malignant neoplasms became the most frequent cause of death (Table 1).

The fastest percentage decline in deaths from cardiovascular diseases occurred in the group of women in early old age. The standardized death rate in this group decreased from 1027.3 in 2000 to 471.5 in 2019 (AAPC = −4.1%, $p < 0.05$) (Figure 1, Supplementary material 1, 2). In the other subgroups analyzed, AAPC was about −3.0% in 2019 (Supplementary material 2). In 2019, SDRs were 3,535.7 among women in late old age, 1,152.0 in the early old age male group, and 4,323.8 among men in late old age group (Supplementary material 1).

Among cardiovascular diseases, ischemic heart diseases were the most common cause of death, except for women in late old age, where it was diseases of arteries, arterioles and capillaries (Figure 2). The third most common cause of death in the cardiovascular disease group involved cerebrovascular diseases. In each of the three aforementioned subgroups of causes of death among diseases of the circulatory system, in all the analyzed gender and age subgroups, decreasing trends were observed in the period between 2000 and 2019 (Supplementary material 2). A more detailed trend analysis, however, shows that SDRs due to ischemic heart disease have been increasing for a few years (Figure 2). In the early old age group of women and men, the upward trend began in 2015 and 2016, respectively, and was not statistically significant (APC = 2.1 and 2.0%). In the late old age group of women and men, the increase in SDR between 2014 and 2019 was statistically significant, i.e., APC was 3.5% in the female group and 2.5% in the male group (Supplementary material 2).

The share of malignant neoplasms among causes of death differed by gender and age. Among women in early late age, SDR was 631.4 in 2000 and decreased until 2006 at a rate of 1.0% ($p < 0.05$). After 2006, SDR began to increase (APC = 0.5%, $p < 0.05$). As a result, the SDR value in 2019 was 628.7 (Supplementary material 1, 2). There was a statistically insignificant decrease in SDR in the group of women in late old age between 2000 and 2011, and a statistically significant increase between 2011 and 2019 (APC = 0.7%). As a result, the SDR value decreased from 1,114.6 in 2000 to 1,004.1 in 2011, and then increased to 1,052.4 in 2019.

Among men, declining trends in SDR due to malignant neoplasms were observed in both age groups analyzed (Figure 2). A slightly faster decline occurred in the early old age group— from 1,440.1 in 2000 to 1,106.6 in 2019 (AAPC = −1.3%, $p < 0.05$). In the late old age group, the SDR values decreased from 2,226.5 in 2000 to 2,099.3 in 2019 (AAPC = −0.4%, $p < 0.05$) (Supplementary material 1, 2).

Among malignancies, lung and bronchus cancer accounted for the largest share among causes of death, and while SDRs declined gradually in the male group, a continuous increase was observed in the female group (Figure 3). Among women in early old age,

TABLE 1 Percentage of deaths from the most common causes of death by gender in the groups aged 65–74 years and 75 years and older in 2000 and 2019.

Sex	Men				Women			
Age group	65–74		75+		65–74		75+	
Year	2000	2019	2000	2019	2000	2019	2000	2019
Diseases of the circulatory system (I00–I99) including:	45.63	35.19	56.22	44.87	48.40	30.82	63.34	51.84
Ischemic heart diseases (I20–I25)	18.01	11.91	16.27	13.05	15.71	9.13	15.62	12.62
Cerebrovascular diseases (I60–I69)	10.28	6.46	12.26	7.31	14.18	6.57	15.22	9.11
Diseases of arteries, arterioles and capillaries (I70–I79)	5.62	4.13	13.28	9.63	5.58	3.46	16.53	13.04
Malignant neoplasms (C00–C97) including:	31.96	33.97	18.90	22.31	29.83	41.84	12.35	14.33
Malignant neoplasm of bronchus and lung (C34)	11.89	10.99	4.77	4.82	3.51	10.24	1.02	1.77
Malignant neoplasm of stomach (C16)	2.58	1.91	1.75	1.26	1.82	1.33	0.94	0.59
Malignant neoplasm of colon (C18–C20)	2.76	4.11	2.01	3.37	3.25	4.07	1.67	2.08
Malignant neoplasm of breast (C50)	0.02	0.04	0.01	0.05	3.21	5.10	1.24	2.14
Malignant neoplasm of prostate (C61)	2.04	2.76	2.59	3.96	0	0	0	0
Malignant neoplasm of pancreas (C25)	1.15	1.63	0.66	0.75	1.66	2.61	0.73	0.87
Diseases of the respiratory system (J00–J99) including:	6.09	6.48	7.85	9.45	4.10	5.99	5.14	6.44
Chronic obstructive pulmonary disease (J44)	2.62	2.02	2.21	2.24	1.14	2.07	0.61	0.97
Influenza and pneumonia (J09–J18)	1.71	3.71	3.68	6.43	1.70	3.12	3.61	4.88
Diseases of the digestive system (K00–K93) including:	3.56	4.58	2.87	2.34	4.07	4.25	3.03	2.63
Alcoholic liver disease (K70) (K70–K74)	0.15	1.68	0.03	0.17	0.04	0.92	0	0.03
External causes of mortality (V01–Y98) including:	3.39	3.61	2.53	2.18	2.23	1.87	2.65	1.92
Transport accidents (V01–V99)	0.90	0.58	0.49	0.28	0.60	0.40	0.25	0.16
Falls (W00–W19)	0.57	0.80	1.05	1.13	0.66	0.53	1.76	1.35
Intentional self-harm (X60–X84)	0.67	0.84	0.34	0.34	0.30	0.29	0.09	0.05

SDR increased from 74.2 in 2000 to 153.2 in 2019, with a small and statistically insignificant increase between 2000 and 2005 (APC = 1.5%, $p > 0.05$). After 2005, SDRs began to increase at a rapid rate of 5.0% ($p < 0.05$). Among women in late old age, there was an increase in SDR from 89.4 in 2000 to 105.0 in 2013 (APC = 1.1%, $p < 0.05$). Between 2013 and 2019, the increase accelerated to 3.5% ($p < 0.05$), with SDR reaching 136.7 in 2019. Among men in early old age, the SDR values decreased between 2000 and 2019 from 535.9 to 357.4 (AAPC = −2.1%, $p < 0.05$), and in late old age from 520.9 to 450.3 (AAPC = −0.6%, $p < 0.05$).

Among women, breast cancer was the second highest SDR cause of death among malignancies in the early old age group and the most common cancer causing death in the late old age group (Figure 3). In the early old age group, SDR increased in years between 2000 and 2014, and then began to decrease. As a result of these changes, the SDR value increased from 67.8 in 2000 to 76.3 in 2019 (AAPC = 0.6%, $p > 0.05$). In the group of women in late old age, a slight decrease in SDR between 2000 and 2012 (APC = −0.1%, $p > 0.05$) was followed by a rapid increase between 2012 and 2019 (APC = 5.1%, $p < 0.05$). As a result, the SDR value increased from 112.1 in 2000 to 155.2 in 2019 (AAPC = 1.8%, $p < 0.05$) (Supplementary material 1, 2).

Among men, prostate cancer and stomach cancer are the second and third causes of death among malignancies in the late old age group and the third and second causes in the early old age group. The opposite direction of trends was observed for these two cancers among men—increasing for prostate cancer (AAPC = 0.4% in the early old age group and AAPC = 0.6% in the late old age group, $p > 0.05$), and decreasing for stomach cancer (AAPC −3.2 and −2.7%, respectively, $p < 0.05$). There was also a downward trend observed among women in both analyzed age groups (AAPC −3.2 and −3.6%, respectively, $p < 0.05$) (Supplementary material 2).

Colorectal cancer mortality trends were stable among women in the early old age group (APC = −0.3%, $p > 0.05$) and in the late old age group (APC = −0.1%, $p > 0.05$). In the group of elderly men, SDRs due to colorectal cancer increased in the years 2000–2010 at a rate of 1.8% ($p < 0.05$), after 2010 they began to decrease at a rate of −0.8% ($p < 0.05$). In the group of elderly men, an increase in SDRs was observed in the years 2000–2016 (APC = 2.0%, $p < 0.05$) and a statistically insignificant decrease after 2016 (APC = −1.5%, $p > 0.05$) (Supplementary material 2).

Changes due to the fifth highest SDR cause of death among malignancies—pancreas cancer—were also analyzed.
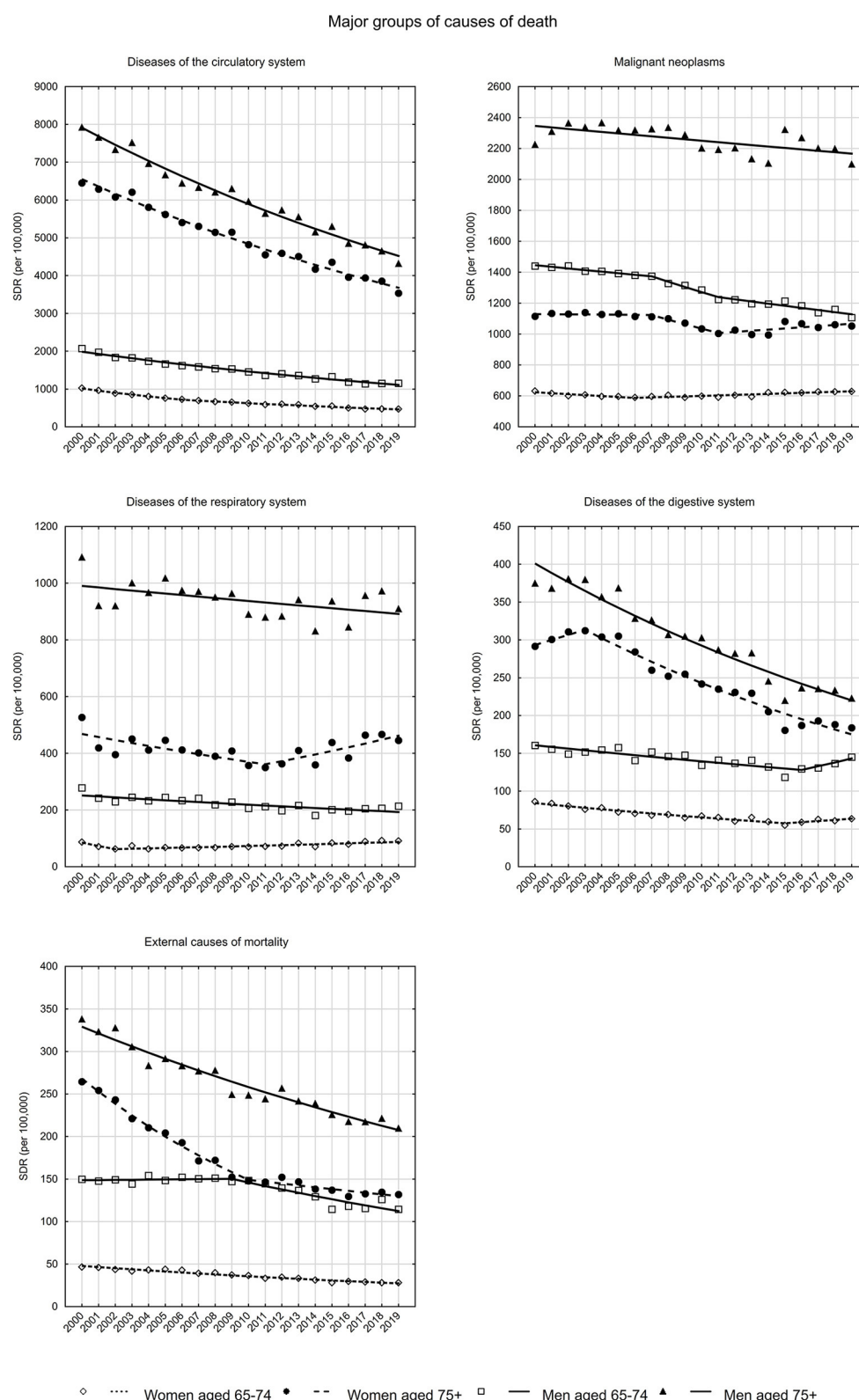
Increasing trends were observed in the early old age group (AAPC = 0.7%, $p < 0.05$ among women and AAPC = 0.2%, $p > 0.05$ among men) and decreasing trends in the late old age group (AAPC = -0.3%, $p < 0.05$ among women and AAPC = -0.1%, $p > 0.05$ among men) (Supplementary material 2).

FIGURE 2

SDR trends in the Polish population aged 65–74 years and 75 years and older due to diseases of the circulatory system in the years 2000–2019.

Diseases of the respiratory system are becoming an increasingly common cause of death among women (Figure 1). In the early old age group, SDR increased from 63.1 to 90.9 between 2002 and 2009 (APC = 2.0%, $p < 0.05$), while in the late old age group, after a decline between 2000 and 2011 from 526.6 to 349.9 (APC = −2.3%, $p < 0.05$), an increase to a value of 445.5 in 2019 (APC = 3.1%, $p < 0.05$) began (Supplementary material 2). The increase in SDR due to diseases of the respiratory system was mainly influenced by influenza and pneumonia (Figure 4). Among early old age women, rates increased by 6.4% annually since 2008 ($p < 0.05$), while in the late old age group they increased by 5.1% per year since 2011 ($p < 0.05$). For the second most common chronic obstructive pulmonary disease, a stable SDR was observed throughout the analyzed period in the early old age group (APC = 0.1%, $p > 0.05$) and a decrease in the late old age group (APC = −1.6%, $p < 0.05$) (Supplementary material 1).

Among men, SDR values due to diseases of the respiratory system were decreasing. In the early old age group, SDRs decreased from 278.1 in 2000 to 213.4 in 2019 (APC = −1.4%, $p < 0.05$). In

the late old age group, SDRs decreased from 1092.1 to 910.5 (APC = −0.5%, $p < 0.05$) (Supplementary material 1, 2). As in the female group, SDRs from influenza and pneumonia also increased in the male group. In the early old age group, the 2002–2019 APC was 4.0% ($p < 0.05$), while in the late old age group, the 2010–2019 APC was 4.3% ($p < 0.05$). In contrast, SDRs due to chronic obstructive pulmonary disease decreased, with an AAPC of −4.6% ($p < 0.05$) in the early old age group, and −3.1% ($p < 0.05$) in the late old age group (Supplementary material 2).

As for mortality from gastrointestinal diseases, in the last few years of the period studied, increasing trends in mortality were observed in the early old age group of women (as of 2015 APC = 2.5%, $p > 0.05$) and men (as of 2016 APC = 6.6%, $p < 0.05$) (Figure 1, Supplementary material 2). It is alcoholic liver disease, the most common cause of death in this disease group, that is responsible for these unfavorable trends. In 2016, in the group of women in early old age, APC was 10.2% ($p < 0.05$), while in 2015, in the group of men in early old age, it was 6.6% ($p < 0.05$). Moreover, SDRs due to alcoholic liver disease have also begun to increase in recent years in the late old age group. Among women, APC has
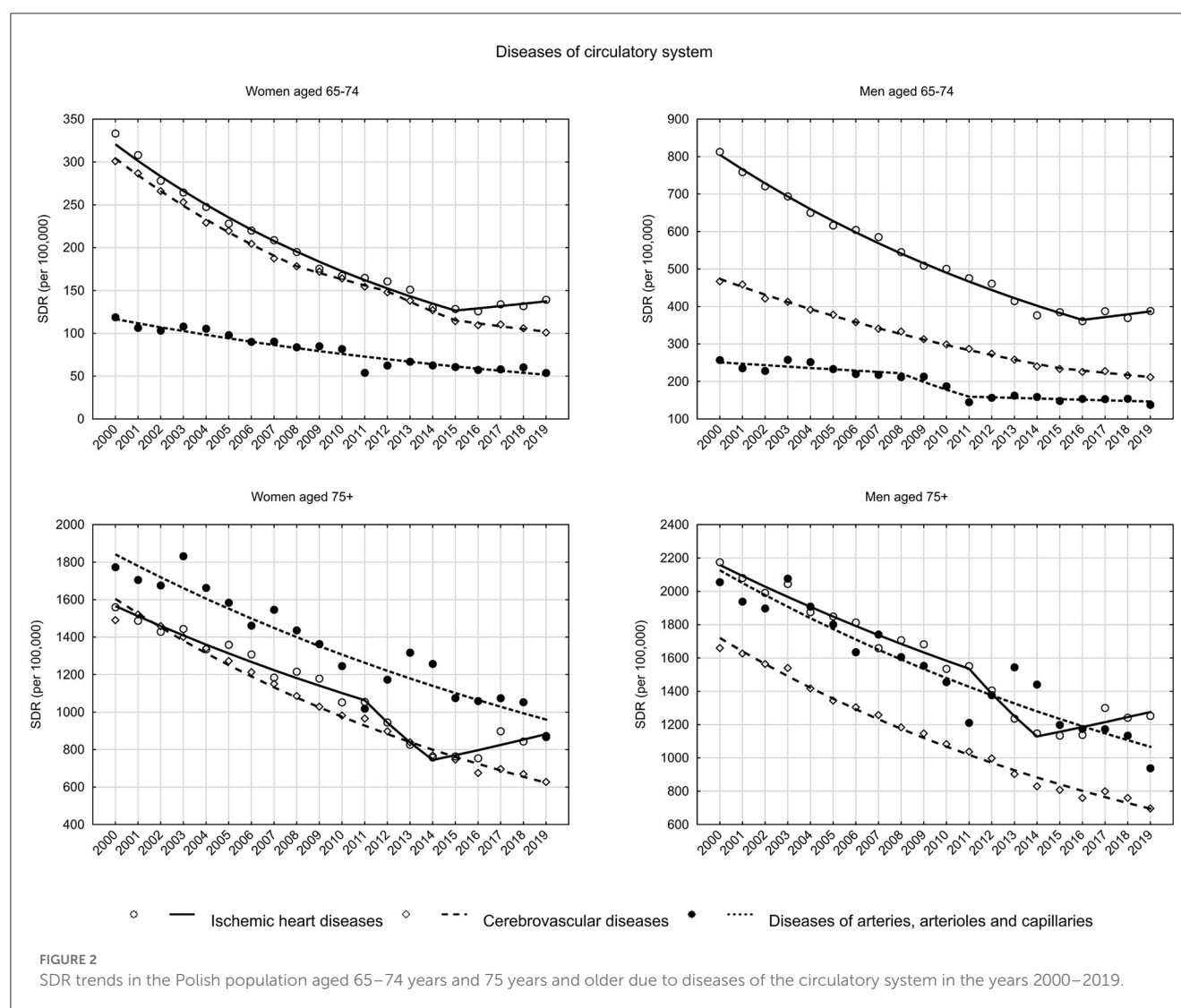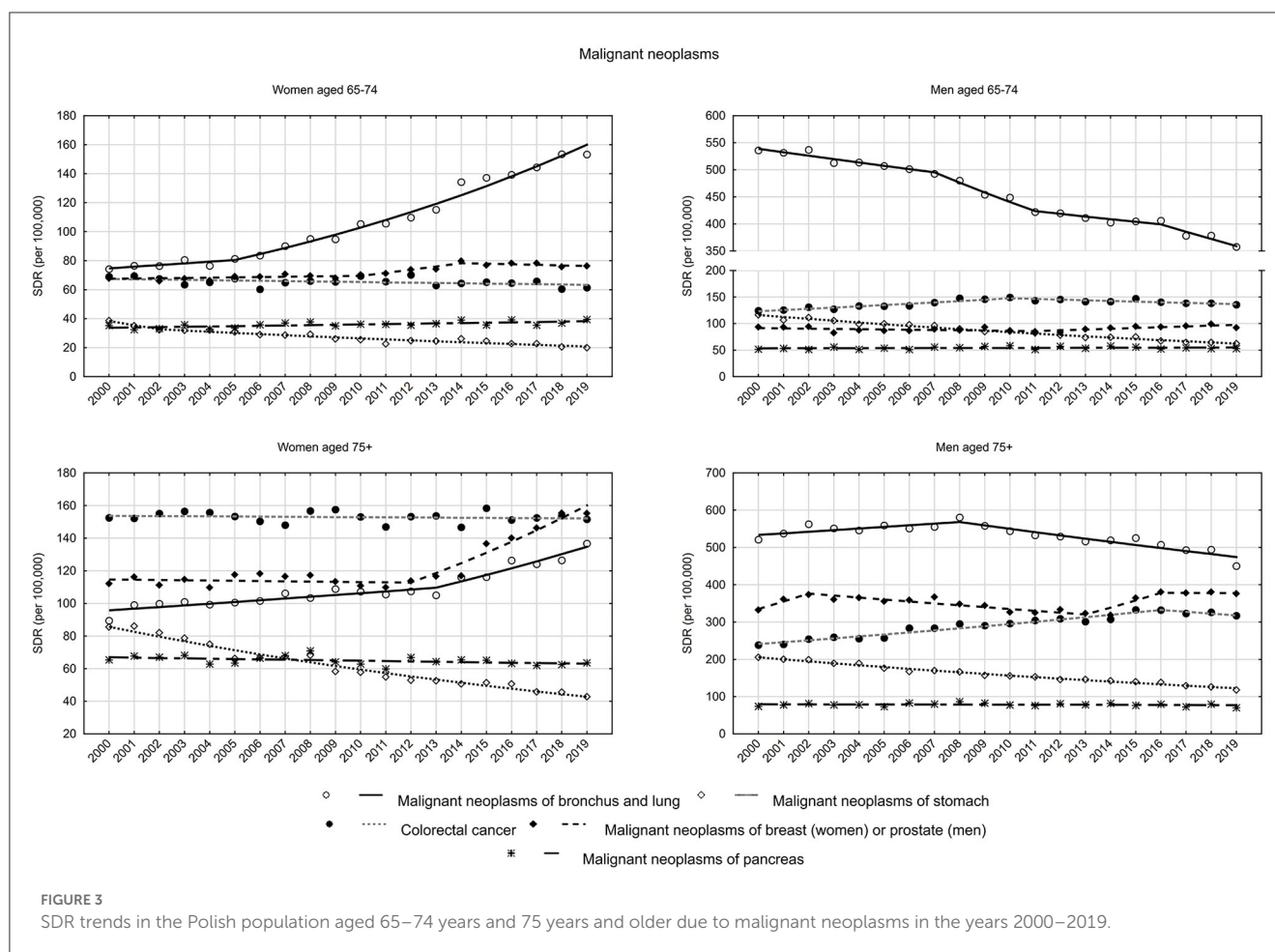
FIGURE 3
SDR trends in the Polish population aged 65−74 years and 75 years and older due to malignant neoplasms in the years 2000−2019.

been 3.7% ($p > 0.05$) since 2015, and among men it has been 3.3% ($p > 0.05$) since 2016 (Supplementary material 2).

The standardized death rates due to external causes decreased from 46.6 in 2000 to 28.1 in 2019 in the early old age group of women (AAPC = −2.9%, $p < 0.05$), whereas in the late old age group from 264.5 to 131.8 (AAPC = −3.7%, $p < 0.05$) (Figure 1, Supplementary material 1, 2).

A decreasing trend in SDR due to transport accidents was observed in both age groups of women (in the early old age group AAPC = −3.9%, $p < 0.05$, in the late old age group AAPC = −3.2%, $p > 0.05$). Among men, a downward trend occurred between 2000 and 2016 in the early old age group (APC = −5.0%, $p < 0.05$) and between 2000 and 2015 in the late old age group (APC = −5.8%, $p < 0.05$). After this period, a statistically insignificant increase in SDR began (4.2 and 2.9%, respectively) (Figure 5, Supplementary material 2).

Among external causes of mortality in the late old age groups of both women and men, falls occurred most frequently. In the late old age group of women, a rapid decline in SDR between 2000 and 2009 (APC = −7.4%, $p < 0.05$) was followed by a period of stabilization (APC = −0.3%, $p > 0.05$). In the late old age group of men, there was a decreasing trend from 2000 to 2009 (APC = −4.4%, $p < 0.05$), then an increasing trend from 2009 to 2013 (APC = 3.1, $p > 0.05$) and again a decreasing trend from 2013 to 2019 (APC = −2.3%, $p < 0.05$) (Supplementary material 2).

As for suicides, downward trends were observed in the groups of early and late old age women (both groups AAPC = −2.8%, $p < 0.05$) as well as in the group of late old age of men (AAPC = −0.9%, $p < 0.05$). In the group of early old-age group men, SDRs increased between 2000 and 2012 at a rate of 1.2% ($p < 0.05$), after 2012 they began to decrease at a rate of −5.5% ($p < 0.05$) (Supplementary material 2). In both male age groups, SDRs due to suicide had higher values than those resulting from transport accidents in 2019 (Supplementary material 1).

Discussion

Mortality in the elderly population is influenced by health and non-health determinants, particularly those of psychosocial nature. According to a study by J. S. House, these primarily include anti-health behaviors, such as poor dietary patterns, lack of physical activity, use of stimulants, lack of social contacts and support, stress, and inability to make decisions about one's own life (13). In order to explain the changes occurring in the mortality pattern of the elderly over the years, the causes of death have to be analyzed and their trends need to be assessed, which was accomplished in this study. The most common cause of death in the population of people aged 65 years and older were cardiovascular diseases. The risk of developing these conditions increases with age (14). According to
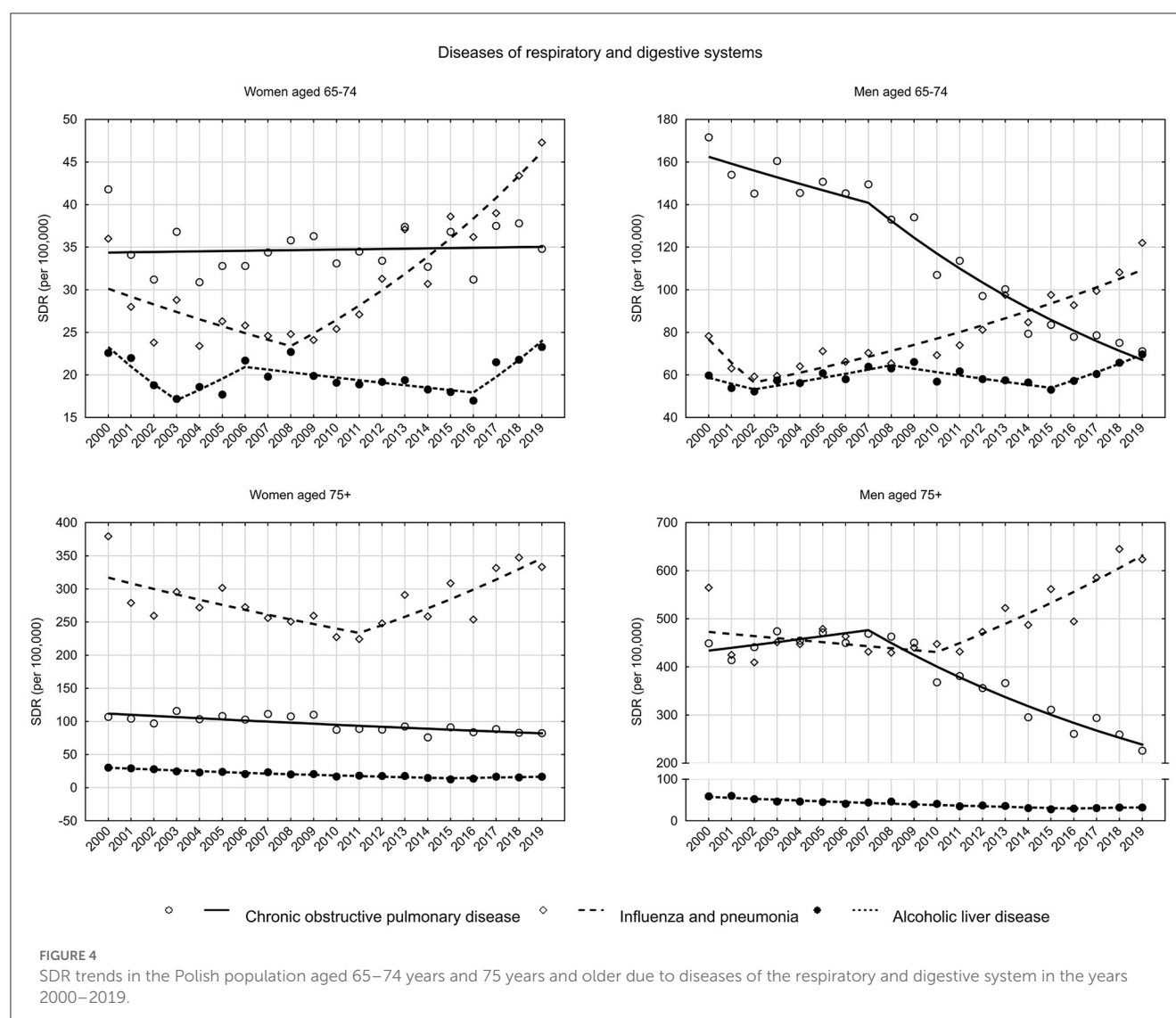
data from the American Heart Association on Heart Disease and Stroke Statistics, the incidence of cardiovascular disease among patients aged 40–60 years is on average 35–40%, 60–80 years 75–78%, while among those aged over 80 years it exceeds 85%. At the same time, more than 80% of deaths in people aged over 65 years result from cardiovascular causes, and the same percentage of hospitalizations in this age group is due to this group of diseases (15). The Framingham Heart Study showed a significant relation of an increase in the incidence of coronary heart disease with age, in both men and women (16). In the Polish population, since 1990, favorable changes in overall mortality in all age groups have been observed, especially in relation to cardiovascular disease, which indicates the effectiveness of preventive measures taken, involving mainly those associated with lifestyle changes, including dietary improvements (17). In Poland, at the turn of 1989/1990, a socio-political transformation took place. Food was no longer subsidized after 1990; this caused big changes in relative prices. As a consequence, the structure of food consumed by Polish citizens changed substantially. For example, between 1989 and 2008

annual butter consumption decreased from 7 to 3.8 kg per head, and beef consumption fell by 75%. At the same time availability and consumption of fruits increased markedly (18). According to Bandosz et al. in the period between 1991 and 2005 about 54% of the deaths from coronary heart disease prevented or postponed were attributable to changes in risk factors and 37% to the increased use of evidence based treatments. Most (41% of the fall in men and 33% in women) were attributable to large decreases in mean cholesterol concentration (declining by 0.4 mmol/L). This fall in deaths concerns changes in mean cholesterol concentration related to diet only and was calculated by subtraction of drug related effects from total effect of mean cholesterol change. The effects of changes in smoking in men were observed also. The prevalence of smoking decreased by 15.7%, explaining about 15% of their fall in mortality. Mean systolic blood pressure fell by 2.7 mm Hg in men and by 5.2 mm Hg in women. After subtraction of the effects of treatments for hypertension, these falls in blood pressure explained about 29% of the decrease in mortality in women and 8% of the increase in deaths in men. Increased leisure

FIGURE 5
SDR trends in the Polish population aged 65–74 years and 75 years and older due to external causes in the years 2000–2019.
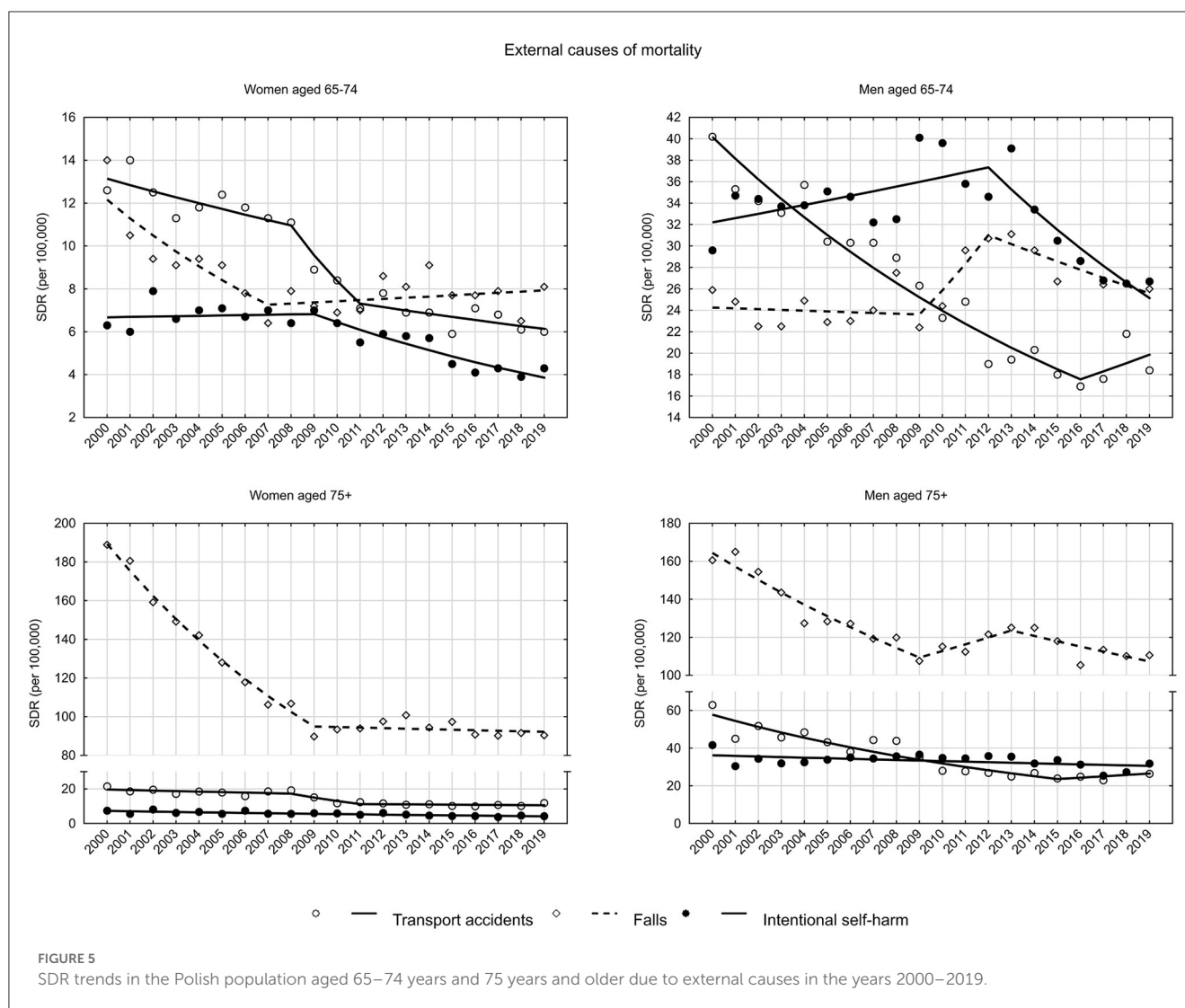
time physical activity explained about 10% of the decrease in deaths. These gains were partially offset by about 1,810 additional deaths attributable to increases in BMI (−4 and −5% for men and women, respectively) and prevalence of diabetes (−1 and −8%, respectively) (6). However, these relatively favorable patterns weren't continued. As indicated by the results of the National Multicentre Health Survey WOBASZ II (2013–2014), the quality of Poles' eating habits, physical activity frequency, prevalence of obesity and overweight aren't satisfactory (19–21). This trend was confirmed in the present study. The favorable trend has been reversed for several years and the values of standardized mortality rates due to ischemic heart diseases (IHD) among the elderly, in all separate age groups in both sexes have increased. Studies show that the foundation of preventive and therapeutic measures among the elderly is regular physical activity (22, 23). In seniors with ischemic heart disease, appropriate physical exercise effectively slows the progression of the disease and lowers the risk of acute cardiac incidents, commonly referred to as myocardial infarctions, thus reducing the risk of death (24).

Although the percentage of people aged 60–69 who are physically active, meeting the dose of PA required for health recommendations, increased in Poland between 2014 and 2018 from 31.7 to 46.3%, age is the determining factor in these trends (25). In a study conducted in the Czech population, time spent on work-related and recreational physical activity decreased with age, while time spent in sedentary behaviors increased (26). A study by Biernat and Piatkowska shows that the problem of inactivity begins at the age of 50 years. On average, as many as 48.2% of Polish people aged 50–64 years do not follow the WHO recommendations (27). In the PolSenior2 study, age was also the most important determinant of declining physical activity (28). Also, a 2018 report issued by the Central Statistical Office (CSO) confirms that older Polish residents are less active as compared to younger individuals (25.1 vs. 46.4% on average) (4). This results in the fact the share of physically active people aged 65 years or more remains insufficient and much lower than in other EU countries (29). Considering how important regular physical activity is for prevention of chronic non-communicable diseases, including

ischemic heart disease, it may be assumed that it is this factor that plays a significant role in the unfavorable mortality trends due to IHD, offsetting the impact of favorable changes in other lifestyle components (30). The worsening trend in mortality in the elderly population from this cause observed in recent years can also be attributed to the significant increase in the prevalence of obesity, diabetes and metabolic syndrome, the co-presence of which significantly increases the risk of death from IHD (31). Another important health problem whose incidence is closely correlated with age is cancer (32). In 2019, nearly 50% of cancer deaths were reported in the subpopulation of people aged 65 years and older (33). According to the authors' results, malignant neoplasms were, as in the general population, the second cause of death in the population aged over 65 years. However, mortality trends have been inconclusive both in general and with regard to individual malignancies. An overall increase in standardized mortality rates from malignant neoplasms in the female group has been observed in recent years, with a concomitant decline in men in both age groups. Studies of cancer mortality trends from 1970 to 2015 conducted in 11 countries around the world confirm these unfavorable Polish trends in comparison with other countries, for which mortality patterns over the past few decades have varied, however, have been more optimistic. They also confirm a significantly faster reduction in mortality levels for men than for women (34). It is also worth referring to trends in mortality due to specific types of cancer. The analysis showed that bronchus and lung cancers accounted for the largest share among causes of death, and while SDRs declined steadily in the male group, a steady upward tendency was observed in the female group. Similar trends have been observed in most European countries, with decreases in incidence and mortality from lung cancer since 2000. A significant decrease has also been recorded in North America and the United Kingdom (35). This is due to the decline in smoking prevalence among generations of men. In comparison, among women, smoking prevalence increased in the US and UK after World War II, and in the 1970's in most other countries as well, i.e., in the generation born between the 1930's and 1950's (36). Moreover, middle-aged and older men were more likely to quit smoking than women. It should also be remembered that lung cancer risk factors translate into morbidity and resulting mortality with a lag of up to even more than 20 years. Therefore, the incidence and mortality of lung cancer in women aged over 65 years in various regions of the world continues to increase (37). The positive change in the mortality trend among Polish men is also a consequence of the declining prevalence of smoking in all age groups. In contrast to women, where active smoking varies greatly by cohort effect (period of birth in calendar time). The highest smoking rate was observed in the generation of women born between 1940 and 1960. In the population of women born after 1960, smoking prevalence has halved and is now 20.0–25.0%. Exposure to the carcinogens of tobacco smoke, after taking into account the 20-year latency period, accurately explains the trends of lung cancers in older women in Poland, while the observed cohort effect means that the incidence of the disease, and the resulting mortality, still shows an upward trend that will continue for some time in the future (38). Prostate cancer is also listed among malignancies strongly associated with smoking. It is estimated that by 2040, mortality related to prostate cancer in the general population will double as compared to 2018, reaching 379,005 deaths worldwide. The highest mortality rate will occur in Africa (+124.4%) and Asia (116.7%), while the lowest in Europe (+58.3%) (39). Currently, prostate cancer mortality trends are not clear-cut and show global territorial variations. In the population of older men, after an increase in mortality occurring until the 1990's, significant declines in SDR from this cause are observed in North American countries, Argentina, Australia and most European countries, except Poland and Russia. The most favorable changes are recorded in Japan. The rates declined between 2002 and 2012 (9.8%), reaching 61.6/100,000 men in 2012 (40). Since 2015, the number of deaths from prostate cancer in EU countries has dropped by an average of 7%, which is attributed to improved treatment and better diagnosis (41). Unfortunately, Poland is the only country to which this indicator does not apply, as for the past 5 years there has been a steady increase in mortality due to late diagnosis, among others. A significant number of patients still remain undiagnosed. According to the National Cancer Registry in Poland, the annual rate of increase in incidence is estimated at 2.5%, however, the risk of incidence increases markedly after the age of 50, and after the age of 80 the cancer is found in almost 80% of men (42), which explains the increasing trend for prostate cancer observed in our study in men aged over 65 years, in early and late old age.

Negative trends have also been observed in the early old age group for pancreas cancer in both men and women. Similar trends have also been observed in younger age groups in the rest of the world. However, the reason for these unfavorable tendencies remains largely unexplained (43).

Beginning in the 1990s, as a result of the introduction of screening tests, early diagnosis and improved treatment, favorable global trends in breast cancer mortality among older women have been observed (44). At the same time, however, upward trends have been observed in Asian countries. In Japan, the rate of increase in the mortality rate between 1970 and 2015 was 2.2. An upward trend in the mortality rate was also observed in Russia (by 10.3%), as well as in Poland (45), which was confirmed in our study in the group of women in late old age. At the time they entered the age of increased risk of developing the disease, preventive measures leading to early detection and high survival rates were not yet as widespread as they are today. The reduction in mortality from breast cancer is influenced by population-based screening programs, participation in which increases the chance of rapid diagnosis and effective treatment. In Poland, the breast cancer screening program began in 2006. By comparison, in the United States it was introduced 20 years earlier. Thus, the current epidemiological picture does not yet show clear unidirectional changes resulting from the participation of Polish women in this program (46).

Our study also analyzed trends in mortality from stomach cancer, showing a decrease in all four age and gender groups. The absolute incidence of stomach cancer has been growing slightly worldwide as a result of an increase in the size and average age of some populations. However, in most countries, the incidence of stomach cancer has declined by about 75% over the past 50 years. Mortality from this cause in all age groups has also declined. In the United States, the mortality rate has dropped from 37 to 6 per 100,000 people. Japan, too, has seen a decline of almost 40%.

Studies suggest that this is due to early detection of stomach cancer, changes in dietary habits, increased levels of hygiene, reduced tobacco smoking among men and, most importantly, a decrease in the incidence of *Helicobacter pylori* infection (47). A study by Ostrowski et al. found an ∼30% lower prevalence of *Helicobacter pylori* infection in Poland as compared to studies conducted 15 years ago (48).

Our study showed that diseases of the respiratory system were an increasingly common cause of death in the group of women aged over 65 years during the period analyzed, mainly due to an increase in mortality from influenza and pneumonia. Although, in general, decreasing trends in mortality from diseases of the respiratory system were observed in the group of men, the values of standardized mortality rates for influenza and pneumonia were increasing. This unfavorable trend observed in Poland is attributed to the unsatisfactory level of vaccination against influenza and the change in its etiological factor. Year by year, the disease is increasingly caused by the A strain (78% of cases in 2019), which is responsible for the severe course of the disease and increases the risk of complications such as pneumonia, exacerbation of chronic disease or myocarditis, which become the ultimate cause of death in the elderly. The likelihood of death, as well as severe flu complications requiring hospitalization, increase nearly threefold in people aged over 65 years. Of critical importance in protecting the safety of the elderly is immunization (49). According to the WHO recommendations, influenza vaccination among the elderly in the WHO European Region should be implemented at 75% of the vaccination status in this age group. Data on the influenza vaccination status of the elderly in EU countries show that it is about 44% on average, but varies from country to country (above 75% in the Netherlands, 43% in Denmark, 68% in the UK, 57.6 in Ireland, 10% in Poland, 6.9% in Latvia and 4.8% in Estonia) (50). According to data from the National Institute of Public Health - National Institute of Hygiene, the level of influenza vaccination in the population aged over 65 years fluctuated between 2009 and 2018, and unfortunately shows a downward trend from 11.35% in 2009 to the lowest value in 2016–6.87%. In 2018, the percentage of seniors vaccinated against influenza was 8.31% (51). In Poland, in response to these unfavorable trends, a 50% reimbursement of influenza vaccination for people aged over 65 years was introduced in 2018, while in 2020 it was extended to include free vaccination for people aged over 75 years. Interest in this form of prevention, especially in the senior population, increased during the COVID-19 pandemic, which gives hope that social awareness of the role of immunization in the fight against infectious diseases will gradually improve.

Another group of diseases whose incidence increases with age are those of the digestive system. The most common cause of deaths analyzed, accounting for adverse mortality trends in this group, was alcoholic liver disease (ALD). Mortality from this cause continues to be an important public health problem. Globally, alcohol accounts for 7.6% of deaths in men and 4.0% of deaths in women. It is Europe that consumes the most-−10.9 liters per person per year. For the past 25 years or so, average alcohol consumption in Central and Eastern Europe has remained stable, in Western and Southern Europe it has decreased, while in the UK and Finland it has increased (52). According to data from the National Agency for Solving Alcohol Problems, consumption of 100% alcohol per capita in Poland, despite isolated declines (related to higher rates excise tax introduced in 2009 and 2014, among others) has shown an upward trend. Currently, recorded levels are significantly higher than in the early 1990s (53). Deaths related to excessive alcohol consumption are most often due to cardiovascular diseases, transport accidents and alcoholic liver disease. In the European Union, 41% of liver disease deaths have alcohol-consumption background, and in 46% the cause is unknown, however, it is likely to be very often related to alcohol as well. The social and economic costs of excessive alcohol consumption are enormous, hence ALD remains a very important civilization challenge (54).

Unfavorable trends regarding total deaths related to alcohol consumption were demonstrated in a study by Zatoński et al. Although the highest mortality rates were recorded in the group of Polish residents aged 45–64 years, the rate of increase in the years 2002–2017 was the fastest in the population of people aged over 65 years, both among men and women (AAPCs were 8.5 and 12.2, respectively). These unfavorable trends can be fully linked to the weakening of alcohol control measures in Poland. At the same time, alcohol-related mortality has decreased in countries such as Russia and Lithuania, where new, stricter methods for controlling alcohol consumption in the population have been introduced (55). In the United States, between 1999 and 2019, there was also a statistically significant increase in mortality from alcoholic cirrhosis in each of the 10-year age groups analyzed (25–85 years and older). The largest increase also occurred in early old age—in individuals aged 65 to 74 years—and the differences between men and women in this group gradually disappeared to the disadvantage of women (56).

A study on drinking culture among people aged 60–64 years in Poland was the Standardized European Alcohol Survey (RARHA SEAS). The subpopulation covered by it included retirees from the so-called "baby boomers" generation, those born between 1945 and 1964. This is the generation of the post-war demographic peak coinciding with widespread shortages of consumer goods. As they entered adulthood, echoes of the cultural revolution of the 1960's reached Poland and influenced the generation of Polish baby boomers, including in terms of alcohol consumption. Statistics from the 1970's and early 1980's show very high levels of alcohol consumption, which may indicate a risky drinking pattern for many people of this generation (57). Considering the fact that ALD is diagnosed with a long delay (58), after many years of alcohol dependence, this may explain the unfavorable trends related to alcoholic liver disease among those included in this study. Undoubtedly, these alarming trends in mortality from this cause represent a health challenge aimed at reducing alcohol consumption in Polish society (59), especially in the era of the COVID-19 pandemic, which had a negative impact on its patterns (60).

One of the most important public health problems globally are injuries, resulting from external causes, mainly transport accidents, self-harm and suicide attempts (61). Data on the incidence of hospital treatment in Europe indicate that the incidence of injuries is bimodal—clearly increasing among both young people and those aged over 60 years, however, with a change in the hierarchy of their causes (62). In the old population, the share of falls increases,

accounting for nearly 69% of outpatient and inpatient treatment for all external causes in EU countries vs. 41% in the under-65 group. In contrast, the share of transport accidents decreases with age (6 vs. 10%, respectively). Despite the relatively favorable trends in mortality from falls and transport accidents shown in this study, the risk of death for Polish seniors from each of these causes is higher than the EU average by 23 and 53%, respectively (63).

A significant problem in the group of external causes of death among the elderly is suicide (64). The study including a group of people aged 65 years and more shows that the average suicide rate among older men in Europe is significantly higher than the average among older women (65), as also shown in a study by Law *et al.* conducted in Australia (66), as well as our own study. At the same time, the mental health of the Polish population is deteriorating. Between 1997 and 2010, the number of people suffering from mental disorders increased (67). This is particularly worrisome in old age, when deteriorating health with age, multi-morbidity and polypharmacy increase the risk of mental disorders predisposing to a suicidal act (68). A factor that increases this risk is the moment when people decide to retire. The inability to fulfill oneself at work, as well as deterioration of the financial condition often associated with retirement, increase the risk of depression, from which the risk of death increases with the severity of symptoms (69, 70). Studies also show that seniors do not report their suicidal intentions and are more likely to make attempts in conditions where intervention is not possible, which is especially true for men (71). Our own study showed favorable trends in mortality from suicide in all groups except for men in early old age. This calls for special observation in order to take appropriate preventive measures in the male population, for whom SDRs due to suicide had higher values in 2019 than those due to transport accidents in both early and late old age.

The results of the Survey of Health, Aging and Retirement in Europe, carried out in 2017 in 27 European countries, indicate that the health status of Polish people aged 50 years and older is significantly worse than that of populations of other countries, such as Sweden, Greece, or Spain. The survey also proves a higher risk of chronic diseases and a faster rate of their increase with age (72).

Our study had some limitations. Quality of the analyses performed on the mortality statistics depend on the completeness and accuracy of the information contained in the death certificate and the proper and precise description of the cause of death. Poland is a country with 100% completeness of death registration. In order to standardize death causes, which are subject to further statistical analyses, it was determined that the doctor who pronounces death is responsible for filling in the death card, into which he or she puts the primary, secondary and direct death cause, whereas qualified teams of doctors are responsible for coding death causes according to the ICD-10 classification. The data relating to 2000 shows that the cause of 24.8% of deaths were inaccurately described. In 2015 this percentage was the highest and amounted to 31.2%, after which it steadily decreased and in 2019 it amounted to 27.4%.In the majority of cases garbage codes concerned deaths due to cardiovascular diseases. Significantly fewer incorrect codes number concerns other causes of death (73).

However, from the perspective of public health, it is so important to assess the health burden of the elderly population (74). It will allow for taking appropriate measures aimed at improving the quality of life and gradually increasing the years lived in health.

Conclusions

The percentage of deaths due to diseases of the circulatory system decreased in the studied subgroups but this problem still remains the greatest health risk in the elderly population, primarily due to ischemic heart disease for which growing trends were observed in recent years of analyzed period. Among malignant neoplasms, lung and bronchus cancer accounted for the largest percentage of deaths, for which the analyzed trends were growing among women and decreasing in male group. Unfavorable trends in mortality due to prostate cancer in the group of men in the early old age and due to breast cancer in the group of women in the late old age were observed. Mortality due to stomach cancer was steadily decreasing in all analyzed subgroups. Diseases of the respiratory system are becoming an increasingly common cause of death among women, mainly due to influenza and pneumonia. Increasing trends in mortality due to diseases of the digestive system in women and men in the early old age group have been observed in recent years, due to alcoholic liver disease—the most common cause of death in this disease group. Downward trends of mortality due to external causes, mainly according to suicides, were observed in both gender groups. It is necessary to conduct further research that will allow to diagnose risk and health problems of the elderly subpopulation in order to meet the health burden of the aging society.

Institutional review board statement

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Bioethics Committee of the Medical University of Lodz on 22 May 2012 No. RNN/422/12/KB.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Bioethics Committee of the Medical University of Lodz, No. RNN/422/12/KB. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

MB contributed to study design and writing the article. MP conducted the statistical analysis and interpreted the data. All

authors participated in the critical revision of the article and approved the final article.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1060028/full#supplementary-material

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The hard way from the Beveridge to the Bismarck model of health finance: Expectations and reality in Russia

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Most post-Soviet countries have introduced mandatory health insurance (MHI) systems which completely or partially replaced national health systems known as budgetary models. In Russia, an attempt was made to introduce a competitive MHI model with multiple health insurers. The current MHI system has, however, acquired an increasing number of features inherent in the previous budgetary model. This study analyzes the institutional characteristics and the outcomes of a new mixed model. A combination of two analytical approaches is used as follows: (1) considering three functions of the financing system (revenue collection, pooling funds, and purchasing healthcare) and (2) exploring three types of the model regulation (state, societal, and market). We analyze the types of regulation that are used to implement each of the three financial functions. The model has contributed to more sustainable health funding, its geographical equalization, and service delivery restructuring, while the implementation of its purchasing function has many unsolved problems. We highlight the dilemma of the further development of the model by (a) continuing to replace the remaining market and societal regulatory mechanisms with state regulations or (b) developing market mechanisms and thereby strengthening the impact of health insurers on the health system performance. Lessons for countries considering the transformation of their budgetary health finance model to the MHI model are presented.

KEYWORDS

health finance, health finance functions, health finance models, mandatory health insurance, collection of funds, pooling funds, purchasing health care, Russia

1. Introduction

Most post-Soviet countries have completely or partially replaced their national healthcare finance system, which is often referred to as the Beveridge model or the budgetary model, with mandatory health insurance (MHI)—the Bismarck model—which is a statutory public scheme of healthcare financing based on earmarked contributions of specified actors to stand-alone funds (1). In 1991, Russia was one of the first post-Soviet countries to introduce MHI.

The new finance system raised expectations including the possibility of increasing health funding (which had traditionally been low); promoting provider competition, patient choice, and the cross-border movement of financial resources and patients; and improving the performance of the healthcare system. Competition among insurers was seen as a driving force to protect patients and make more effective use of resources (2).

The Russian MHI model was initially formed under the influence of theories about the design of an effective public health system. Liberal economists and the World Bank were active in calling for a competitive MHI model with consumers' choice of insurers and competition among providers (3). The competitive model, however, faced serious problems due to the lack of market institutions and the short window of opportunity for large-scale reforms. The law on health insurance was adopted in 1991 and the MHI system was introduced in 1993. The desire to not miss the chance to receive a new source of health funding—earmarked for contributions to MHI funds—prompted initiators of the reform to ignore the number of institutions needed to build a competitive MHI model (4). In this difficult socioeconomic transition from a command economy to a market one, a delay in introducing the new model was seen as taking the serious risk of losing MHI contributions as a new source of funding.

In the course of reforms over the next 30 years, the MHI system has evolved substantially, with an increasing number of characteristics inherent in the traditional budgetary model and a diminishing number of characteristics of a market-driven competitive model.

This trend has prompted a number of questions: What kind of healthcare finance system has been built in Russia? What is the outcome? Were the initial expectations met? What are the prospects for the further transformation of the Russian MHI model? What lessons can be learned from the Russian reform in countries considering a transition from the Beveridge to the Bismarck model?

Although these reforms have been addressed in some international studies (5, 6), satisfactory answers to these questions have yet to be found. This study analyzes the institutional characteristics, outcomes, and prospects of the mixed healthcare finance model.

2. Methods and data

2.1. Study design

We followed a four-step methodological framework. The first stage involved an analysis of the institutional features of the Russian MHI system. The combination of two theoretical and methodological approaches was used. We followed the functional approach to analyze the healthcare finance systems, which was proposed by Kutzin (1) and has been used in many studies and the official documents of the WHO. According to this approach, any healthcare finance system performs the following functions: the collection of financial resources, their pooling, and the purchasing of healthcare. The subjects of the analysis are the institutions that implement these functions.

As an analytical tool for addressing such functions, we used an approach suggested by Rothgang et al. (7). The three types of model regulation are state, societal, and market. The first type is regulation through power coercion; the second is regulation through collective bargaining between public actors who are not authorities; and the third is regulation through market interactions.

The second stage is the evaluation of the MHI model's contribution to the performance of the healthcare system in Russia, including its impact on revenue collection, its allocation across regions and the sectors of service delivery, pooling funds, service delivery restructuring, and the accessibility and quality of medical care. To describe the outcomes, we used qualitative characteristics and quantitative indicators that highlight them to the greatest extent.

The third stage is the identification of unsolved problems of the MHI model. We followed the functional approach with a focus on the purchasing function. We mainly used the qualitative characteristics of the institutions that facilitate (or complicate) these functions.

The fourth stage is the discussion of the current state of the healthcare finance system in Russia and the potential ways it could be transformed in future.

2.2. Data sources

We extracted data from national and international databases and reports and calculated secondary estimates. Regulatory documents on health finance and international and Russian literature on the trends in the health system over the last 3 decades were used. We also used the gray literature related to the Russian health finance system, including those in limited circulation, unpublished documents, memorandums, and presentations from our personal collections covering more than 30 years.

This was supplemented with data from our surveys completed by physicians and interviews with senior health managers, including managers of regional MHI funds, conducted over the last decade (the latest was in 2019 before the COVID-19 pandemic).

3. Institutional characteristics of the current MHI system

A scheme of the Russian MHI system is presented in Figure 1.

3.1. Revenue collection

The major sources of funds are the mandatory contributions of employers and regional governments to MHI for the working and non-working populations, respectively (employees do not pay directly). The rates of contributions for the non-working population vary according to regional differences in the costs of medical services. Contributions are paid into the federal MHI fund and are then allocated to 86 regional MHI funds that act as operators of the regional healthcare finance systems. The regional government may transfer supplementary contributions to the regional MHI fund for the non-working population, which is a budgetary contribution exceeding the mandatory regional rate of contribution. Thus, the revenue of a regional MHI system consists of federal allocation and supplementary regional contributions.

The earmarked nature of contributions indicates that there is a sustainable flow of funds into the healthcare system. The funds are less dependent on the priorities of budget allocation, which have traditionally been skewed to non-health sectors, particularly

FIGURE 1
Financial flows in the Russian MHI system.
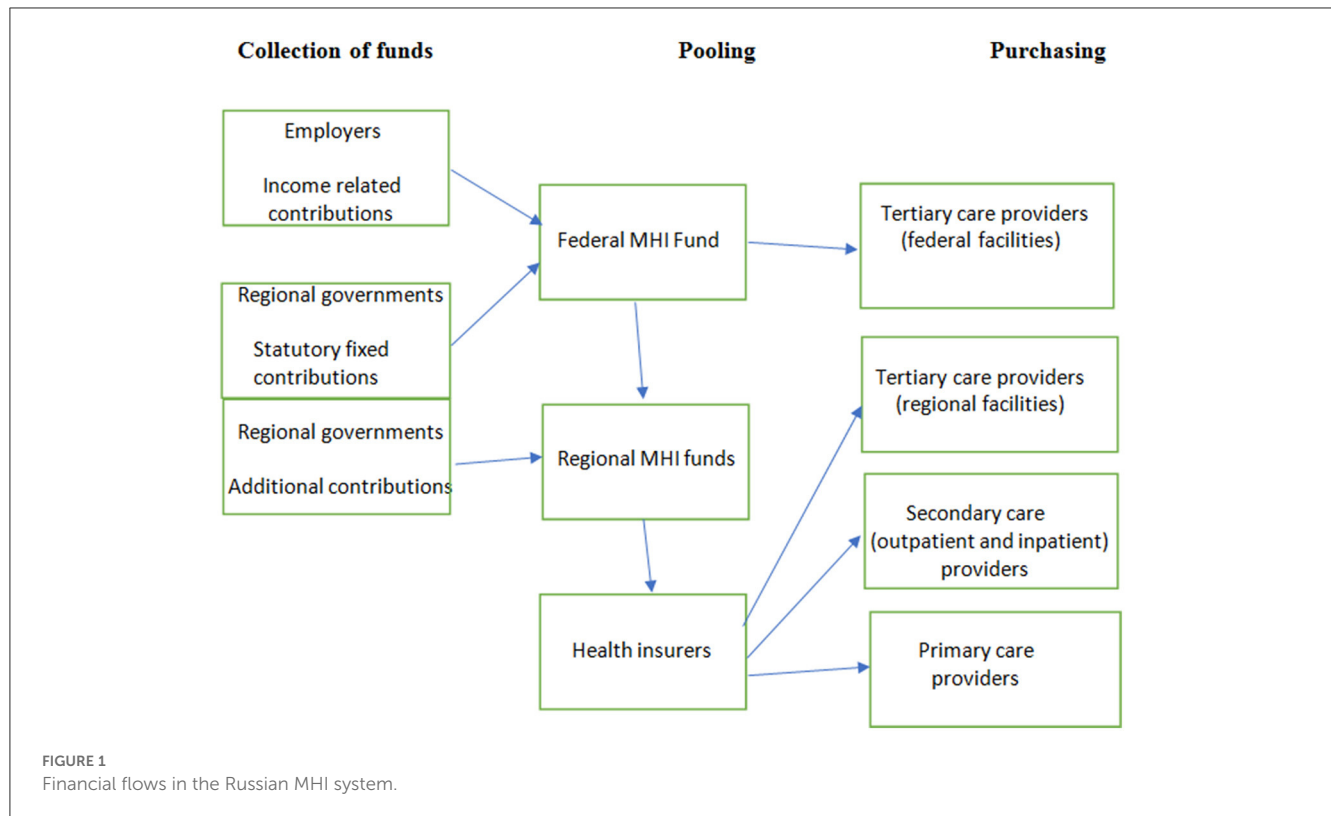
defense. However, this dependence has not disappeared completely, partly due to the relatively low rate of the employers' contribution- −5.1% of the payroll—compared with 12–18% in most Central and Eastern European countries (8). In 2020, 41.5% of the federal MHI fund revenue was collected from the general budget revenue, including 31.1% from mandatory regional contributions for the non-working population and 10.1% from the federal budget as budgetary transfers for the compensation of fund shortages to cover the cost of the package of medical benefits (9).

Revenue collection is based on the cost of the annual federal program of state guarantees of free healthcare (the program), which determines the package of medical benefits. This package includes practically all medical services and covers the entire population, although informal rationing is very common in practice. Regions develop their own programs of state guarantees. They have a uniform package of benefits, while its funding is more generous in the richer regions (10).

3.2. Pooling funds

MHI contributions are pooled in the federal MHI fund to ensure the equalization of regional funding. The pooled funding is allocated to regional MHI funds according to an age/sex-adjusted capitation rate and the cost of care in different regions. Subsidies from the federal MHI fund to regional MHI funds reduce gaps in healthcare funding across regions but do not result in equal spending per capita throughout the country. The richer regions supplement MHI funding from their general budget sources and spend up to three times more on healthcare than poorer regions.

Pooling at the regional level is designed to ensure the risk-adjusted funding of health insurers by regional MHI funds. These insurers are mostly private companies that carry out a number of functions in the MHI system. Currently, there are 29 health insurers. Citizens are entitled to select an insurer. They are funded per enrollee, with risk equalization by regional funds—the redistribution of funds to health insurers who have a relatively high share of risks. The system of risk adjustment is simple, taking into account only the age and sex of the enrollee.

There is limited health insurer competition. Health insurers attract people through customer services (issuing MHI policies more quickly, better processing of patient complaints, and call center quality), but there is no competition on the benefits package, the size of the premium, or the quality of care. These are excluded by the design of the MHI system. Health insurers cannot offer insurance plans with variable premiums or a limited network of providers with specific benefits and premium rates, which is the case in many countries with multiple purchasers of care (e.g., Germany, the Netherlands, Switzerland, and Israel). A declared quality competition ("the best insurers contract the best providers") is hard to implement due to the lack of consumer information. The decisions to collect such information are not made by the insurers themselves. They work under the pressure of administrative bodies. The results of insurers' "thematic expertise" of provider performance may be useful, but they are not made public and are rarely used by health authorities (11).

There is some element of risk sharing between the regional MHI fund and health insurers, which is also a part of the pooling scheme. In the case of underspending (when an insurer's healthcare spending falls below the insurer's revenue), health insurers must

return most of the savings to the fund. The presumption is that MHI financial resources belong to the federal government, except for administration costs (which are specified by the regulation). In the more common case of overspending, health insurers can apply to the regional MHI fund for subsidies that are paid from a so-called "normalized insurance reserve" (5% of regional MHI revenue). It is operated by the regional MHI fund and acts as a pool to ensure the solvency of health insurers (11).

Health insurers are liable for financial risks only within the limits of their capitation-based revenue. The rest of the risks are borne by the regional MHI fund and medical organizations. The proportion of risk-bearing is not determined explicitly.

3.3. Purchasing care

Purchasing care in Russia is a combination of centralized planning and the direct contractual interaction of payers and providers. The major instrument of purchasing is planned care utilization across sectors of the healthcare system with further allocation of the planned volumes of care to each service provider. Planning in regions is based on utilization targets (e.g., the number of physician visits, hospital admissions per capita), and unit cost targets (per visit, per admission) established in the program. Over the last 2 decades, the annual programs have been issued by the federal government. While utilization targets are implemented nationwide, adjustment of the targets to regional health needs has been allowed recently (12). National utilization planning promotes service restructuring by ensuring a shift of care from inpatient to outpatient settings, strengthening primary care, and developing daycare centers, among others. Accordingly, federal and regional utilization targets are set and used for contracting payers and providers.

The purchasing function is shared by the commission for the regional program of MHI (the commission) and health insurers. The commission acts as a mix of state and societal regulations. It represents all actors of the healthcare system and acts as the collective purchaser of care. However, the voice of the individual actors varies substantially. The regional health authority and MHI fund play a major role in decision-making about the allocation of volumes of care and funding. Some health insurers are involved in the discussion of plans in the commission, but their role is limited. They contract medical facilities for the provision of care authorized by the collective purchaser.

After planning and negotiating volumes of care, health insurers contract providers for the delivery of care and to pay their bills. The reimbursement is based on provider payment methods used in the region (they determine the units of care that are subjected to reimbursement). The underprovision of the planned volume indicates that a provider will not receive the planned amount of funding, while overprovision might be not reimbursed. The contractual volumes can be adjusted through a new round of negotiations with providers with some chance of setting higher volumes. Sometimes, payments are made only after court proceedings. Thus, some risks are borne by providers.

Provider payment methods are determined by the federal and regional authorities. Uniform payment methods are used in all

regions (with minor variations)—capitation for primary care and the diagnosis-related group (DRG) method for inpatient care. Polyclinics as primary care providers are paid additionally by fee-for-service for preventive and some other selected services. Capitation payments can be reduced when a polyclinic has fewer physician visits than the negotiated plan. The DRG-based payment scheme has more than 500 groups. The rates are usually adjusted for hospitals that lose revenue under this method. The so-called "coefficients of DRG" are determined for such hospitals (13).

3.4. Governance of MHI

Governance is highly centralized with the federal MHI fund at the top of the system. The design of the financial flows and payment schemes is the joint responsibility of the federal Ministry of Health and the federal MHI fund with the former having a leading role. Although the legislation sets the responsibility of regional MHI funds for the implementation of the MHI scheme in each region, it has to follow federal decisions on most issues of governance and funding, including planning, payment methods, and patterns of resource use. Discretion on decision-making is limited to minor operational areas. Health insurers act as billing companies paying for the volumes of care that are determined by the commission.

MHI funds are managed by a board and an executive director. The board includes representatives of state authorities, health insurers, professional medical associations, and trade unions of health professionals. The board is the institution of societal regulations. However, the attitude of health authorities is usually the most important factor in the decision-making of health policy and on the allocation of resources. According to one of our respondents, "*My attitude when I worked as a director of a health department was very simple. What is an MHI fund? It is a financial division of the department. Nothing more.*"

The design of the MHI system does not treat providers as independent contractors. The managers of state-owned facilities are hired and fired by health authorities. The major decisions on the capacity of such facilities, the scope of services, and their involvement in national and regional vertical programs are made by administrative bodies. There are many other limitations to the operational autonomy of providers as state-owned entities. Thus, the major advantage of contracting—the separation of purchasers and providers (1)—is not fully utilized in the current MHI model.

4. Contribution of the MHI model in improving the performance of the healthcare system

4.1. Impact on revenue collection

The introduction of the MHI model allowed the earmarking of a substantial portion of healthcare revenue. According to one respondent, the head of the national medical association, "*In the 1990's, there was no alternative, there was no money for healthcare at all, and mandatory health insurance was introduced as an additional tax, which at least somehow supported the system.*" In the 1990's,

this earmarking mitigated the negative effect of transformational economic crisis during the shift from a planned to a market economy. The decline in healthcare funding was not as deep as in other industries of the social sector—mostly due to employer contributions as a new source of health funding (14). Public health funding (MHI contributions and budgetary allocations) reduced in real terms until 1999. The 1991 level was reached only in 2006 (Figure 2).

The dependency of MHI revenue on general budget priorities remains high since the contributions for the non-working population are made by regional governments, and the federal government increasingly subsidizes regional MHI schemes (15). The role of budgetary allocations to MHI is increasing, which is the prevailing trend in many OECD countries (16).

4.2. Impact on regional equity

The centralization of MHI revenue contributed to the equalization of healthcare funding across regions. The allocation of MHI revenue has been focused on strengthening healthcare funding in poorer regions. In 2010, total public healthcare funding per capita (MHI and budgetary health expenditure) in the richest regions was 3.8 times higher than that in the poorest regions, whereas, by 2018, it was three times higher. Regionally, MHI funds provide some equalization of healthcare funding across local communities through capitation formulas for allocating resources to health insurers. The equalization policy within a budgetary system was much less radical due to the presence of many legislative barriers (17).

Regional equity is also strengthened by cross-boundary flows of patients—mostly from poor to rich regions. The number of patients who received inpatient care outside their region of residence has increased over the last two decades to 16% of the total number of

hospital admissions in 2020 (9). This is more evidence of the free movement of money in the Bismarck model compared with the former Beveridge model in Russia.

4.3. Impact on service delivery restructuring

The MHI model has become a catalyst for service delivery changes. Activity-based purchasing contributed to the shift of some inpatient care to outpatient settings and day care centers. This process has accelerated since 1999 under the annual federal utilization targets. The number of bed-days per capita decreased from 3.4 in 2000 to 2.4 in 2018—much faster than the EU average (Figure 3). Most of this decrease resulted from a substantial drop in the average length of hospital stay—from 15.5 to 10.7 days. The number of hospital admissions per 100 residents was stable (21.9 in 2000 and 22.4 in 2018) in contrast to the EU average over this period (18.4 in 2000 and 16.9 in 2018). Regional MHI funds encourage the deployment of day care centers by increasing their reimbursement rates. The share of patients treated in day wards in the total number of patients treated in hospitals increased from 7.6% in 2000 to 20.8% in 2018 (18).

4.4. Impact on the accessibility and quality of healthcare

In the budgetary system of healthcare finance, patients had almost no opportunity to choose providers. They were attached to specific state polyclinics in their place of residence, while hospital admission was strictly regulated by the pathways of patient flows in the region. An important advantage of the MHI in comparison to the budgetary system of health finance is that MHI allows patients to contract any provider irrespective of their ownership, including
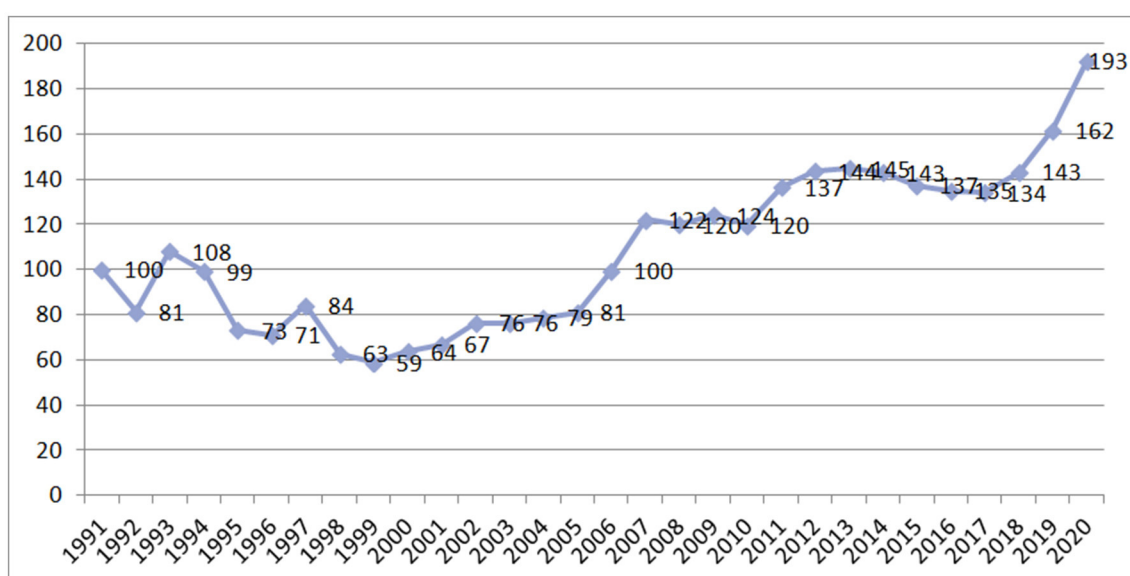

FIGURE 2
Public funding of health care at constant prices in Russia in 1991–2020. *Source*: Authors' estimates based on official data.
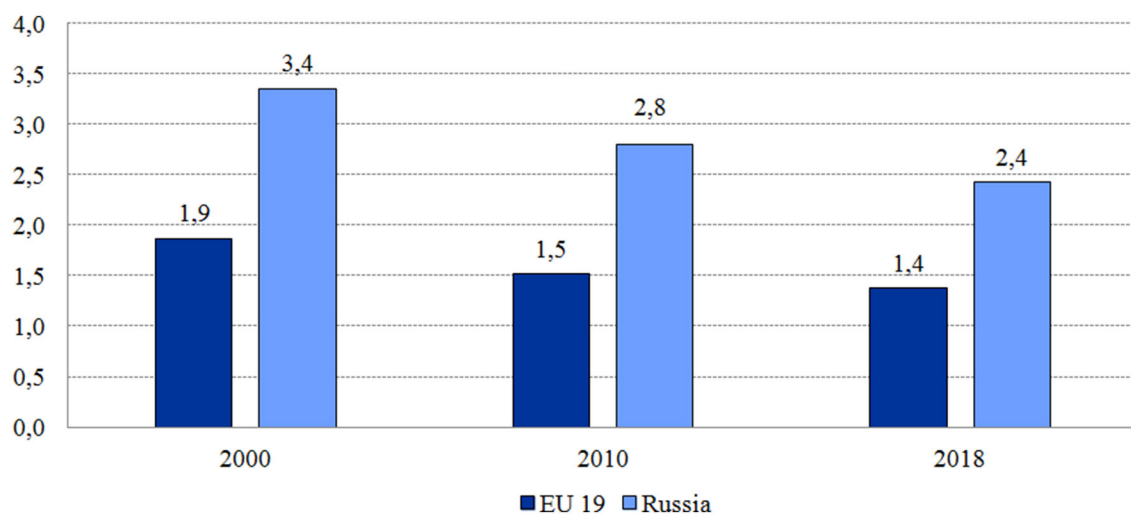
FIGURE 3
Number of hospital bed-days per person in Russia and the EU average. *Source*: (18).

private providers. Providers of the "parallel" health system that have traditionally served only specific groups of residents (e.g., the staff of some ministries) can work currently under the MHI scheme. Patients can select a polyclinic (once a year) and a hospital (if referred by a polyclinic physician). Patients can also receive care outside their place of residence. The borders between territories are being erased by MHI.

The major mechanism of MHI's impact on the quality of care is quality control by health insurers. Health insurers check the claims of providers and identify "incomplete care," that is, care violating clinical protocols as well as defects in medical recording (the latter is the most common). They can impose penalties on providers (they vary from 30 to 50% of the cost). Another form of quality control is the "thematic review" of clinical practice, that is, the identification of common mistakes in a selected clinical area.

Quality control by insurers has prompted serious discussion in the medical community. Health professionals often do not agree with the monitoring of their activities, which often comes down to checking that patients' medical records are filled out correctly. The ability of external experts to verify the performance of experienced clinicians has been questioned. With all these concerns, even simplified schemes of quality control allow insurers to mitigate the most visible manifestations of the poor qualifications of some doctors, negligence, and sometimes even clear violations of medical ethics (17).

5. Unsolved problems of MHI

5.1. Revenue collection

The current MHI system still lacks clear-cut rules for responding to the shortage of public funding. The budget of the MHI system is determined politically and is practically unconnected with the actual cost. The aforementioned targets of utilization and unit cost are based on budget estimates and

are adjusted irrespective of the actual cost of services and healthcare needs. When a shortage of revenue is expected, these financial parameters are adjusted downward. This adjustment allows the government to formally balance MHI revenue with the government's commitments to free care. However, a real balance does not exist and the search for ways to reach it is irrelevant. Potential mechanisms of adjustment known internationally [longer waiting times targets for elective care, cuts in benefits packages, a rise in co-payment rates, encouraging voluntary health insurance, and higher requirements for the cost-effectiveness of new medical technologies (19)] are not used in Russia. They are replaced by the implicit rationing of healthcare without attempts to assess the potential outcomes (what can be cut and which cuts are impossible). For example, with the growing deficit of funding, existing federal targets of waiting times (for physician visits, diagnostic tests, and hospital admissions) are increasingly violated, but information on actual waiting times is not available. Uncertainty is a real problem. Patients understand that resources are limited, but do not understand why they are not told the actual waiting time. The uncertainty limits their opportunity to use alternative providers in other parts of the country or in the private sector (20).

When the actual shortage is not recognized by the government, then there is no clear claim for additional funding and there is no explicit cost containment policy. Flexible adjustment to the shortages gives way to the illusion of healthcare funding sustainability.

5.2. Pooling MHI revenue

Some medical services are still beyond the MHI system. Regional and municipal governments pay directly for public health, mental healthcare, cases of infectious diseases, AIDS, and some tertiary care. Investment expenditure is also covered by the

government. The budgetary and MHI parts of the entire public health system currently function under separate regulations.

A special problem of pooling is that the bulk of investment costs are beyond the MHI system. These are covered by health authorities through budgetary subsidies. Decision-making on purchasing major medical equipment is not transparent. There is no link between the volume of provider activity and the allocation of funding. State-owned polyclinics and hospitals do not pay for major equipment as a result of its poor responsibility for their rational use. There are many examples of the underutilization of this equipment (13). This funding pattern also discriminates against private providers who are involved in MHI. They cover investment costs without government support, and their cost of services is usually higher than the current tariffs in the MHI system. Therefore, the level of private sector involvement in MHI remains low, and its services are provided mostly from out-of-pocket payments.

Internationally, the degree of pooling current and investment costs is much higher. Paris et al. (19) provided evidence that hospitals purchase major equipment jointly with governments of various levels in most European countries with MHI systems. In Germany and the Netherlands, hospital revenue is the major source of investment. In other words, hospitals earn resources for investment—their service reimbursement includes investment costs. The government does not lose the leverage of major investment regulation but recognizes the important role of providers in its funding.

5.3. Purchasing healthcare

The main problems of the current MHI model are concentrated in the purchasing of healthcare. The first problem is that care utilization planning and the allocation of volumes of care across providers are poorly focused on improving healthcare performance. A survey of the heads of 86 regional MHI funds conducted by HSE University in 2019 provides some insights into the specific criteria determining the allocation of volumes. They were estimated according to a 6-point scale with the average estimates given in Figure 4.

When distributing volumes of care across providers, the commission mostly takes into account last year's volumes of care and the prevailing patterns of patient movement in a multi-level system of service delivery (patient pathways). Next in importance is the availability of medical equipment and staff. Another important criterion is the need to ensure the financial stability of providers. The physical accessibility of providers and their performance characteristics are the least frequently used criteria.

There is practically no accounting for the quality of medical care, its complexity, or the development of new medical technologies. It is a common situation when a hospital develops a new medical intervention, treats the most complex patients, and has higher outcomes and shorter hospital stays compared with other hospitals in the region but receives the same planned volumes of inpatient care when the number of beds is equal (hence, the same funding). Contrary to many European countries, which increasingly account for the cost-effectiveness

of alternative interventions, these important parameters are practically ignored in care purchasing in Russia. This approach hinders the development of new medical technologies.

Even these criteria are not transparent for health providers. We could not find information on the individual criteria on the websites of regional health authorities. This lack of information indicates that providers cannot compare their performance with their competitors or assess the fairness of the resource allocation.

The emerging private sector is contracted for the provision of services under MHI, but it accounts for only 5% of the entire volume of care. There are many barriers to its involvement. In general, 70% of survey respondents refer to the priority of state medical organizations in the allocation of volumes of care and 65% to the excessive and complicated reporting of private providers in the MHI system.

The same survey indicates that 70% of regional MHI leaders are happy with this pattern of care utilization planning and are not looking for ways to change it. The inertia of "simple solutions" is a strong factor in the (lack of) development of the system.

Related to this is the formal contracting between purchasers and providers. According to the legislation, health insurers select providers and determine the scope of services. However, the actual practice is based on a "typical contract" that consists of a standard set of provisions with references to the general regulatory requirements on service delivery. The scope of the negotiated contract parameters is very narrow. The volume of care is determined by the commission with no or little involvement of a health insurer as a contracting party. According to one respondent, the head of the MHI fund in a central Russian region, "*Health insurers in our region do not take an active part in the allocation of the volumes of medical care, while health providers often initiate changes in tariffs and in the allocation of resources.*"

Risk-sharing arrangements are unavailable in contracts. Therefore, the reimbursement of the overprovision of contracted volumes, as indicated earlier, is always a problem and is usually solved through the adjustment of contracted volumes. Risks of overprovision are shifted mostly to MHI funds.
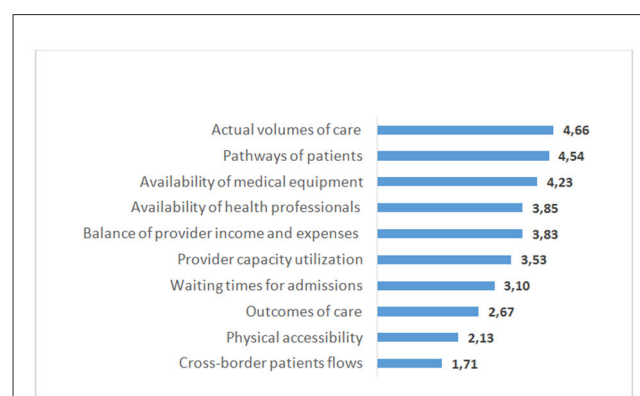

FIGURE 4
Average values of the criteria used by 86 regional MHI funds in Russia for the care volume allocation among medical care providers. *Note*: Respondents rated the value of each criterion on a 6-point scale from 0—not used, up to 5—high value. *Source*: The survey of regional MHI fund manager in 2019 (21).

The market pressure of selective contracting for providers is negligible. Providers may have some competitive advantages in terms of quality, but they must prove them in the commission where the negotiating procedure is focused on the volume of services and not the quality. While contracting providers, health insurers are not allowed to use methods of payment and pay-for-performance schemes differing from those determined by the regional MHI fund. Therefore, the capacity of health insurers to use their own instruments to encourage the provision of value-based care is unavailable. Also, medium- and long-term contracts with providers are not used, which hinders the realization of investment projects.

The prevailing pattern of contracting does not provide for multilateral arrangements to promote the integration of care. Contracts involving many providers to ensure their joint work on chronic disease management, continuity of care, and other integrative activities, which have become popular internationally (22), are unknown in Russia, although the need for them is growing. Attempts to integrate care are limited to mergers of providers without any real integrative activities under new contracting schemes (23).

Interviews with health leaders indicate a lack of interest in innovative practices of planning and contracting. According to the respondent from central Russia, "*We are too busy with the current problems, therefore do not have the opportunity to think about using alternative approaches to planning volumes of care.*"

Thus, contrary to declarations about negotiating volumes of care between purchasers and providers, the pattern of resource allocation has more resemblance to the Soviet style of directive planning.

6. Discussion

The analysis indicates that the collection function in the Russian MHI system is based on state regulations with the separation of powers between federal and regional governments, while the revenue of MHI funds is separated from the general budgetary revenue.

The function and rules of pooling are based on state regulations, including the accumulation of contributions in the federal MHI fund with their further allocation to the lower levels of accumulation—in regional MHI funds and health insurers. The governance of funds has elements of societal regulation. The implementation of pooling in the MHI system is separated from the budgetary system. Healthcare purchasing is based mainly on state regulations with the minimum use of societal and market regulation. The major role is played by federal and regional governments. Thus, the current MHI system maintains elements determined by its initial design of building a competitive model of MHI with the major role of the market regulation—multiple insurers and their interaction with regional MHI funds and health providers. While the actual performance of this system is completely regulated by the state.

The dominant role of state regulation distinguishes the Russian model from MHI models in Western Europe, where societal regulation plays a major role (24, 25) and makes it closer to the MHI models in Central and Eastern European countries—Czechia,

Hungary, Poland, Slovakia, and Estonia (26). However, unlike the countries of Central and Eastern Europe, which have MHI systems of this type, the Russian system is not totally separated from the state budgetary system. It is separated from the budgetary system in revenue collection and pooling, while it is not separated in purchasing. The latter has a hybrid regulation that combines state regulation used in the budgetary system with regulations (state, societal, and market) used in the health insurance systems.

The introduction of the competitive model of MHI in Russia has been limited to multiple private insurers. The institutions to promote their competition have not been built.

Health insurers may look like the vestiges of the market model of MHI, but in the specific conditions of the Russian healthcare governance, they perform the important function of deterring violations of patients' rights by health providers and officials. The liquidation of insurers will most likely make patients totally dependent on health providers and officials.

Were other expectations of the MHI model met? The Russian MHI system has improved the structure of service delivery and promoted patient choice and the cross-border movement of financial resources and patients. However, the hybrid nature of health purchasing in the Russian public administration system limits its impact on the performance of the health system.

The actors of the MHI system do not have sufficient motivation to improve the performance of the healthcare system. MHI funds are state-owned institutions that report to the government. Their priority is the fulfillment of tasks formulated by higher levels of government and ensuring the stable operation of state medical organizations. The most efficient use of resources is of little relevance to MHI funds.

Health insurers are primarily required to ensure financial support for the stable operation of health providers and to protect the rights of patients. Insurers have practically no opportunities and incentives to select the best providers for their clients or improve the efficiency of using MHI financial resources. However, the rules of MHI create some economic motivation for health insurers to monitor the quality of healthcare and the appropriateness of providers' bills. This is based on financial penalties imposed on providers and the right to keep a certain percentage of these penalties.

Health providers are interested in maximizing the revenue received from the MHI system. However, there is no strong economic pressure from health insurers, other providers, or patients, which may force them to optimize their costs and improve the quality of care.

People cannot choose insurers based on their promises to monitor the quality of care. This monitoring does not provide the information required by individuals on where and how to receive value-based care. This lack of information limits the ability of citizens to exert competitive pressure on insurers and providers, which would stimulate them to improve their work.

Major components of the strategic purchasing conceptual framework (promoted by the European office of the WHO) are not widely used in Russia. Empowering citizens is in its infancy since there are no specific policies that incorporate citizens' views into purchasing decisions. Incorporating cost-effective contracting has been discussed, but there are no strong incentives to implement it. The government is developing some activities to strengthen

its stewardship (training health managers and outsourcing some services to the private sector), but they are not enough to improve the use of cost-effective contracting. Similar to many other European countries (27), there is little evidence in Russia of purchasing health insurance being strategic according to any of the established definitions (21).

The dilemmas in the further development of the Russian MHI system are whether (a) replacing the remaining elements of the societal and market regulation with state regulation, eliminating the separation of the MHI system, and integrating it into the budgetary system or (b) maintaining its separation from the budgetary system and attempting to strengthen the societal and the market mechanisms of regulation, including strengthening the role of health insurers, are helpful for the development.

The first alternative is very likely in the current political and economic situation. However, with this choice, the problems discussed earlier will persist and be more difficult to address. Dismantling the MHI system would provide very small administrative savings, but it would require building new legislative and operational mechanisms in the budgetary system for the purchaser–provider split, including contracting and changing the functions of health authorities of all levels.

The second alternative would create the conditions for sustainable progress in the performance of the MHI system and its more substantial contribution to strengthening the healthcare system. This would require a consistent state policy of developing regulatory mechanisms that are alternative to the administrative governance of healthcare.

7. Conclusion

During the transition from the planned Soviet economy to a market economy, an attempt was made in Russia to replace the budgetary model of health finance with the MHI model. The original intention was to introduce a competitive model, but this has not been realized; the resulting model is a hybrid one with three main characteristics.

First, MHI has not completely replaced the system of budgetary funding—some healthcare provisions and investment costs are still financed with the use of budgetary model mechanisms.

Second, the MHI system is not completely separated from the system of budgetary funding. It is separated in the collection and pooling of funds, while the purchase of healthcare combines elements of both models.

Third, the current model is a unique combination of state regulation and societal and market regulation. The latter are the rudiments of the initial design of the model that has not been fully realized.

The initial expectations have been only partially met. The MHI model has contributed to more stable health funding, to its geographical equalization, and to service delivery restructuring. However, the finance functions have many serious unsolved problems, which require a change in the design of the model.

The analysis of the Russian MHI system allows us to formulate the following lessons for countries considering the possibility of replacing their budgetary health financing systems with the MHI systems.

The main lesson is that the MHI system regulated only by the state enhances the effectiveness of the pooling (and distribution) function but creates obstacles to the purchasing function. Developing the mechanisms of strategic purchasing is a serious problem.

A competitive MHI model is not automatically ensured by having multiple health insurers and contracting health providers but requires a diversity of benefit packages, rates of insurance premiums, selective contracting, and schemes for service reimbursement. Developing these institutions require long-term efforts by health policymakers.

A clear understanding is needed that, with weak democratic institutions, the government will most likely cope with the unsolved problems of the MHI system by replacing or supplementing the institutions of societal and market regulations with state regulations. Such a policy may lead to some positive outcomes for healthcare performance in the short term, but their impact in the longer term remains undetermined. A major lesson is that market and societal regulation are poorly compatible with weak democratic institutions.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://rosstat.gov.ru/.

Author contributions

Both authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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