



Geoprocessing as a contemporary tool for analyzing the data pertinent to medical interventions in the State Fire Service (SFS) - a 12-year retrospective study.

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ABSTRACT

INTRODUCTION: State Fire Service (SFS) officers are increasingly frequently carrying out medical rescue activities (MRA), especially in the scope of qualified first aid (QFA), providing assistance to people harmed in fires and other local threats. Due to the accepted medical procedures, possessed medical equipment and a high number of officers with medical background, SFS units are the second service, right after NEMS, in terms of the volume of provided medical support in different events, particularly fires (F) and local threats (LT).

MATERIAL AND METHODS: The paper used the statistical data regarding performance of QFA tasks by SFS officers from the Decision-Making Support System of the State Fire Service (DMSSFS), made available by the Operations Planning Office (OPO) in the Headquarters of the State Fire Service (HSFS). The analyzed material covered the period of 2010 – 2021 and the area of the capital city of Warsaw. Using the method of choropleth maps to present the administrative units of the city, the most overloaded places in terms of emergency activities were presented where QFA intervention was required.

RESULTS: The number of events recorded by SFS in Warsaw in the analyzed period was 150,209 (without false alarms – FA), during which QFA activities were performed 9,911 times. The average percentage number of such activities in relation to all events (fires and local threats) was 6.60% and a slow, yet systematic, growth of such events in consecutive years. The highest magnitude of QFA activities – and so the very high level (>201 points) was seen in the district of Śródmieście and the high level (121-200 points) in the following districts: Mokotów, Wola, PragaPółnoc, PragaPołudnie, Targówek. In particular, considering individual estates, these were: ŚródmieściePołudniowe (293), StaryMokotów (150), Mirów (139), Brudno (122), Zacisze (179), Grochów (155) and SaskaKępa (145).

CONCLUSIONS: Assessment of the usefulness of mapping medical interventions and the analyzed spatial data confirm that the KDE method is characterized by a more precise fitting of the fragments of the MIS estates to the scale of magnitude of the investigated event – QFA activities performed by SFS firefighters. Therefore, using the analytical techniques of GIS is a good tool for planning and interventional support for the SFS activities and it additionally shows phenomena not visible when the data are presented in a table.

KEY WORDS: Geoprocessing, mapping, fire brigade, qualified first aid, medical interventions.

INTRODUCTION

Rescuing a human life at threat is the priority of emergency services. State Fire Service (SFS) officers are increasingly frequently carrying out medical rescue activities (MRA), especially in the scope of qualified first aid (QFA), providing assistance to people harmed in fires and other local threats. The latest studies indicate that there is a constant upward trend of such activities [1]. In Poland 15,958 QFA activities were reported in 2010 and as many as 83,191 in 2021. This was a multiple growth of over 521% in such medical activities performed by SFS officers. The tendency is maintained in the Warsaw metropolis as well, which situation induced the authors of this paper to carry out more thorough studies into the capital city of Poland, including a spatial analysis. Over the last ten years, Warsaw has developed considerably, both in economic and demographic terms. In that period, its population has not increased much [2]. The population living in Warsaw permanently includes professionally active people, students and officials. Intensive migrations, development of numerous branches of the industry, transport – these are the factors threatening the health of the Warsaw population, which are complemented by diseases of civilization, ageing of society or stress.

The socioenvironmental factors led to the observed growth in events warranting medical activities, which are carried out by the services leading in this respect, i.e. the National Emergency Medical Services (NEMS). Due to the accepted medical procedures, possessed medical equipment and a high number of officers with medical background, SFS units are the second service, right after NEMS, in terms of the volume of provided medical support in different events, particularly fires (F) and local threats (LT) [3-4]. A new type of threat is the disease induced by the SARS-CoV-2 virus, previously not recorded in humans. The COVID-19 disease, classified as an acute contagious disease of the respiratory system, affected also the number of medical events in the last 2 years of the analysis. The pandemic declared in Poland and the increased number of infections led to healthcare service overload, which resulted in a considerable increase in the number of the medical activities [5].

The pandemic announced in Poland, in conjunction with an increased number of infections, ended in a burden on healthcare systems, which, in consequence, might have increased medical interventions performed by the SFS, incl. the number of events in the recent two years under analysis; however, those events were not a direct research objective.

Aim - The paper aimed to investigate the frequency with which QFA was provided by SFS officers in the area of Warsaw in 2010-2021 in connection with socioenvironmental changes and to use analytical GIS techniques and methods to prepare maps of rescue activities performed by SFS.

MATERIAL AND METHODS

The paper used the statistical data regarding performance of QFA tasks by SFS officers from the Decision-Making Support System of the State Fire Service (DMSSFS), made available by the Operations Planning Office (OPO) in the Headquarters of the State Fire Service (HSFS). The analyzed material covered the period of 2010 – 2021 and the area of the capital city of Warsaw.

The area of the city is secured by 18 rescue and firefighting units (RFU), including 1 school RFU of the Main School of Fire Service. Graphic illustration used materials from the Head Office of Land Surveying and Cartography (HOLSC), made available under Art. 40a(2)(1) of the Land Surveying and Cartography Law, i.e. the Topographic Objects Database (BDOT10k), the National Register of Boundaries (NRB) [6-8]. The database was prepared in Microsoft Excel in the MS Office 2016 suite for Windows 10. The results were statistically analyzed with the STATISTICA 12 software (Stat Soft Polska). The quantitative data were described with a mean and standard deviation – the obtained distribution was consistent with normal distribution. The normality was tested with the Shapiro–Wilk test and the dependencies between the groups were tested by the Spearman's rank correlation. The correlations and differences at the significance level of $p < 0.05$ were regarded as statistically significant. The original database was prepared with the Quantum GIS software (QGIS), which is an advanced statistical implement belonging to the group of free and open-source software for geospatial applications, FOSS4G for short. The software is made available under GNU GPL. [9-10]. Using QGIS, the spatial characteristics of the scope of QFA activities in the capital city of Warsaw was identified and visualized, taking into account 9 groups of performed activities:

- unblocking the airways or keeping them unblocked,
- performing external cardiac massage,
- oxygen therapy with 100% oxygen or artificial respiration,
- arresting external hemorrhages and dressing wounds,
- performing the preliminary anti-shock procedure,
- protecting from heat loss,
- cooling down burns,
- fixing fractures and suspected fractures and dislocations,
- providing mental support to harmed or threatened individuals [11].

Using the method of choropleth maps to present the administrative units of the city, the most overloaded places in terms of emergency activities were presented where QFA intervention was required. The vector layer of the events during which SFS firefighters provided QFA was moved to QGIS and then illustrated under a layer of the districts, a layer of estates (Municipal Information System, MIS) and a layer of areas protected by SFSRFUs. By means of a tool for spatial aggregation (combining data based on their spatial location) on each district and estate, a parameter was added describing the number of events which occurred within their borders, thus receiving a 5-point scale of the QFA activity magnitude. Such a scale of magnitude had the following levels: very high (>200), high (121-200), moderate (51-120), low (11-50) and slight (0-10). In order to better fit the fragments of the MIS estates to the scale of magnitude of the investigated event – QFA activities performed by SFS firefighters, the material underwent additional analysis by means of a nonparametric method of presentation of spatial data – kernel density estimation (KDE), also referred to as a heat map. It assumes estimation of the magnitude of QFA activities within the cells of the output raster, assuming the highest value of the surface area in the location of events and reducing that value as the search radius increases (2000 m were assumed at the calculation stage).

RESULTS

The number of events recorded by SFS in Warsaw in the analyzed period was 150,209 (without false alarms – FA), during which QFA activities were performed 9,911 times. The average percentage number of such activities in relation to all events (fires and local threats) was 6.60% and a slow, yet systematic, growth of such events in consecutive years. The rate is 8.25% at the national level [12].

The share of qualified first aid activities in all SFS operations in Warsaw crossed the 5% threshold for the first time in 2015. In the analyzed period of time, the number of rescue activities involving QFA provided by SFS officers soared by nearly 800% (Table 1, Table 2, Figure 1, Figure 2).

Table 1. Share of activities related to QFA in the total number of events in the area of the Capital City of Warsaw.

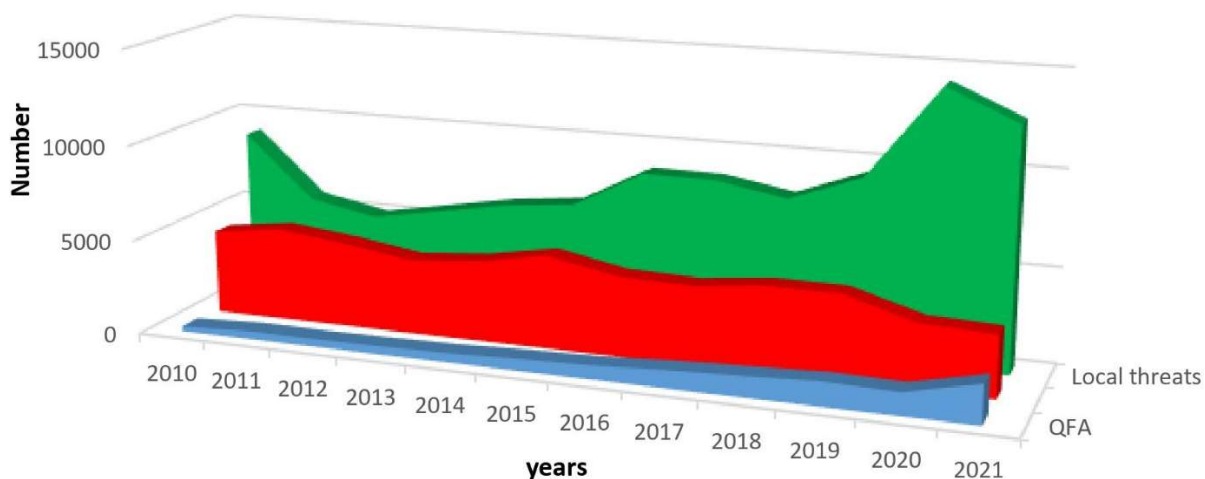
Year	QFA procedures	Total number of events Σ (F + LT)	Percentage of QFA activities in events	Population of Warsaw [in thous.]*
2010	262	13408	1.95 %	1720.4
2011	426	10562	4.03 %	1700.6
2012	411	9479	4.34 %	1715.5
2013	436	9585	4.63 %	1724.4
2014	495	10542	4.70 %	1735.4
2015	632	11576	5.46 %	1744.4
2016	727	12 812	5.67 %	1754.0
2017	942	12 674	7.43 %	1764.6
2018	1 089	12 437	8.76 %	1778.0
2019	1 257	13 796	9.11 %	1790.7
2020	1 187	17 551	6.76 %	1794.2
2021	2 047	15 787	12.97 %	1799.0
Total	9 911	150 209	M = 6.60 %	M = 1751.77

Abbreviations: F- fire, LT–local threat (with QFA), *Data: GUS

Table 2. Description of the analysed variables.

Variable	M	SD	R*	P-value
Population	1751.77	33.57	0.96	<0.001
QFA procedures	825.92	508.92		

Abbreviations: M – mean, SD – standard deviation, *R Spearman



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
■ QFA	262	426	411	436	495	632	727	942	1089	1257	1187	2047
■ Fires	4435	4890	4488	3943	4257	4903	4193	4092	4484	4454	3381	3239
■ Local threats	8973	5672	4991	5642	6285	6673	8619	8582	7953	9342	14170	12548

Figure 1. Share of activities in the field of QFA in the total number activities of the State Fire Service in the capital city Warsaw. [Own elaboration]

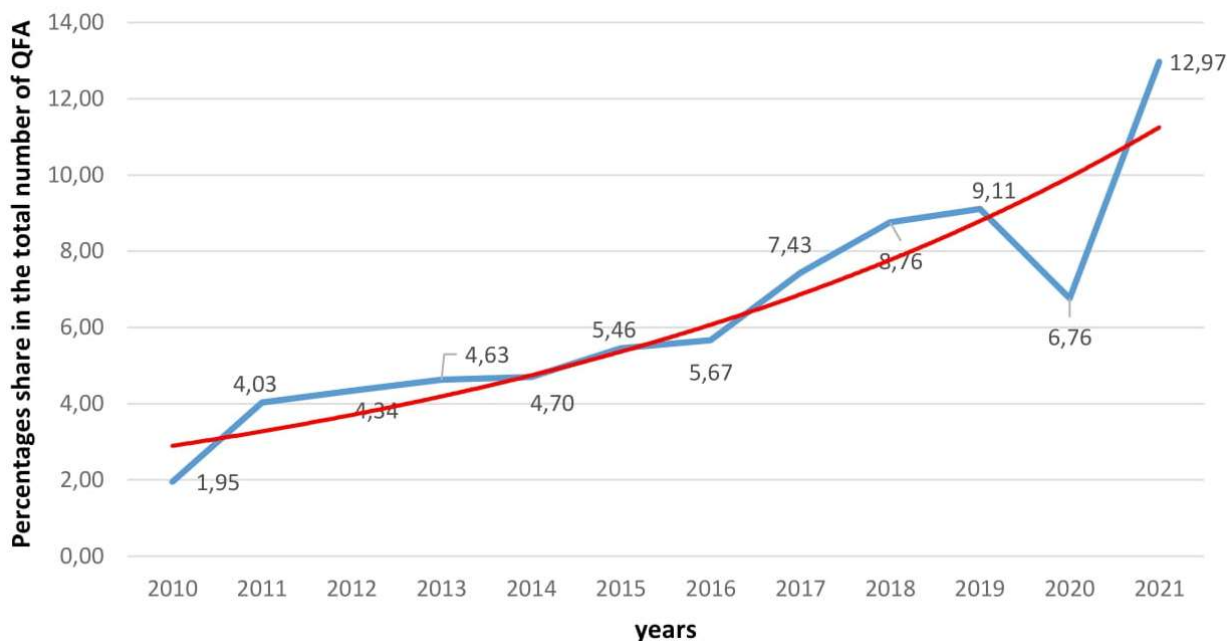


Figure 2. Percentage share of QFA in the total number of activities of the State Fire Service in 2010-2021. [Own elaboration]

Among the provided rescue activities, psychological support for casualties had the highest share in the general number of activities (46.11%), then providing oxygen therapy with 100% oxygen and/or artificial resuscitation (15.53%) and protecting from heat loss (10.16%). The rarest of the performed activities included: preliminary anti-shock procedure (1.53%), external cardiac massage (3.14%) and unblocking the airways or keeping them unblocked (3.70%). The highest growth in the analyzed period indicates psychological support for the harmed individuals (>6000%) (Figure 3).

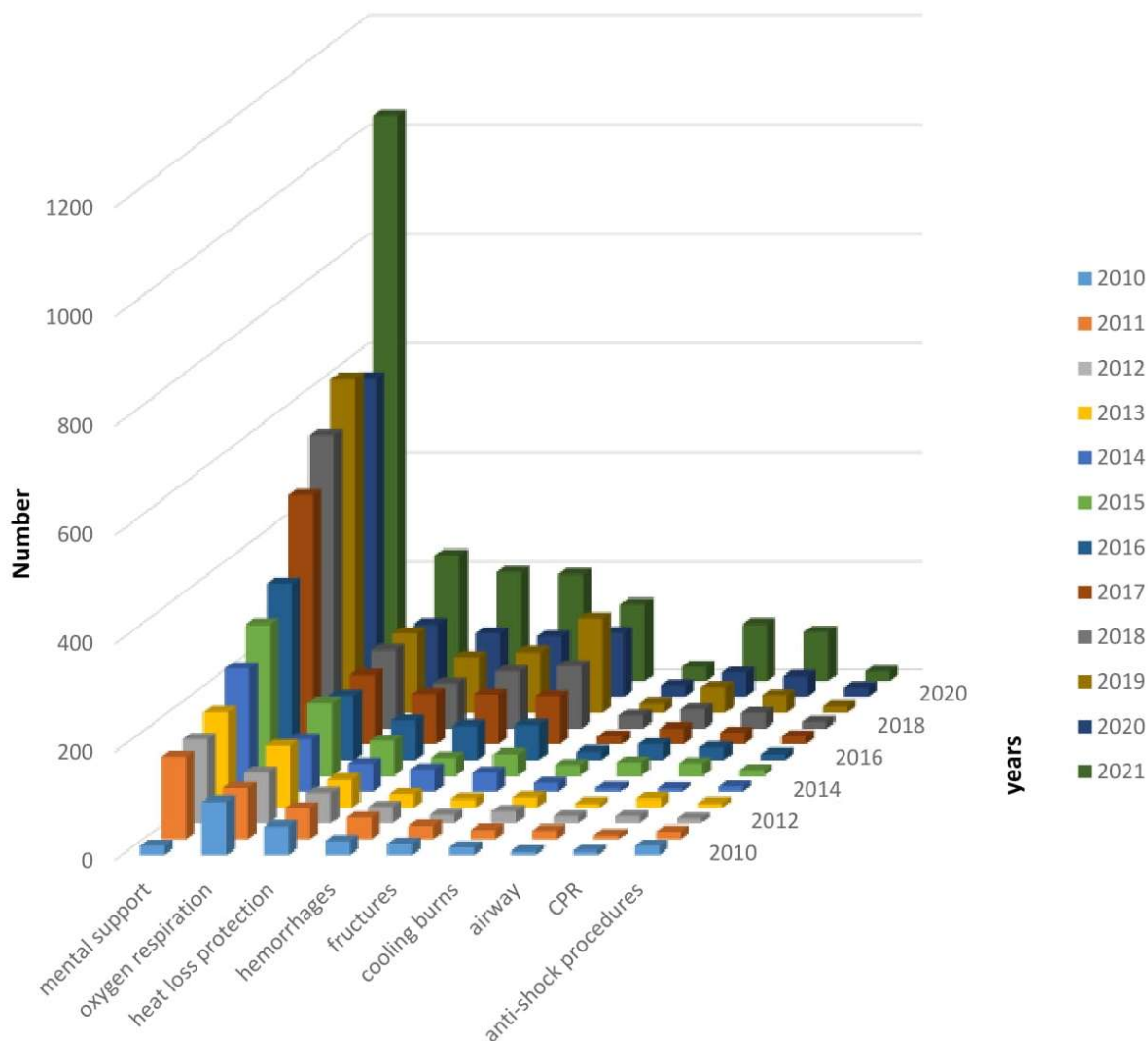


Figure 3. Activities in the field of QFA, broken down into groups of performed activities. [Own elaboration]

Spatial characteristics

The highest magnitude of QFA activities – and so the very high level (>201 points) was seen in the district of Śródmieście and the high level (121-200 points) in the following districts: Mokotów, Wola, Praga Północ, Praga Południe, Targówek. In particular, considering individual estates, these were: Śródmieście Południowe (293), Stary Mokotów (150), Mirów (139), Brudno (122), Zacisze (179), Grochów (155) and Saska Kępa (145) (Figure 4 and 5).

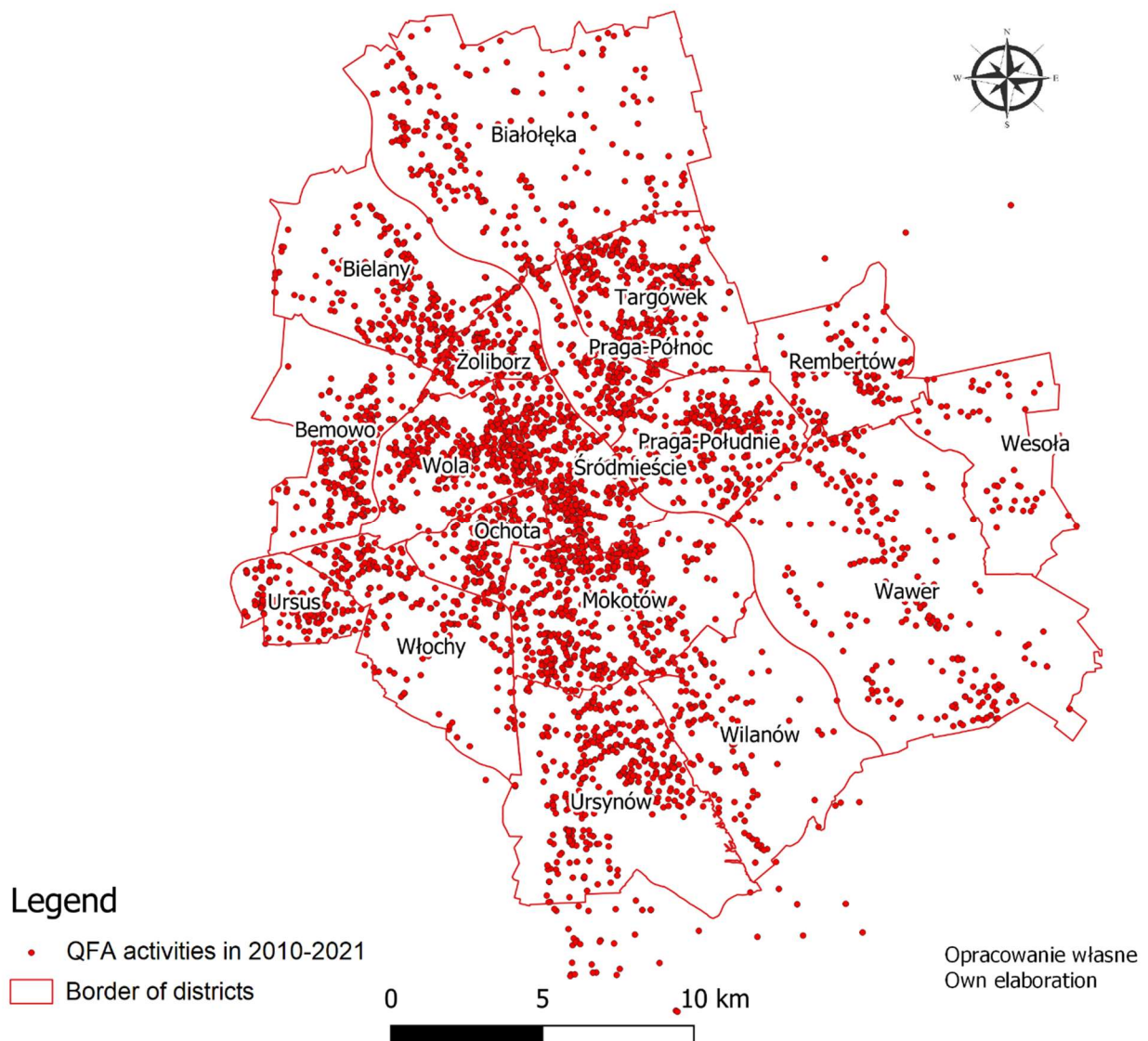


Figure 4. QFA activities in 2010-2021. [Own elaboration]

The above methodology of constructing maps of magnitude of QFA activities assumes their spatial aggregation to estates (MIS). Their structure is slightly different if based on the method of kernel density estimation (KDE) [13-15]. The estimation of the magnitude of QFA activities is determined by the density of heats of the events (Fig. 6 and 7), which is substantially important for classifying the given fragment of the catchment area or a part of a MIS estate on a scale of magnitude and for indicating the actual places where SFS firefighters provided QFA. For example, in the first method, the qualification of the entire estate into a moderate magnitude (Ujazdów) is changed to low according to KDE, which also states that only its western part can be put in the moderate, and even high, magnitude group.

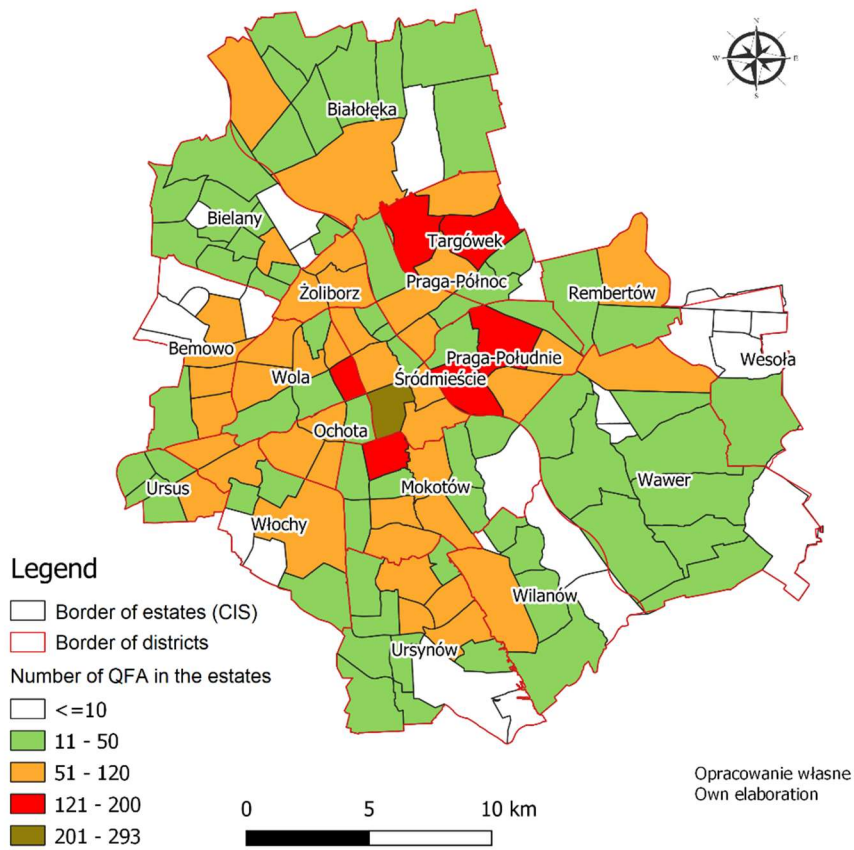


Figure 5. QFA activities in the estates. [Own elaboration]

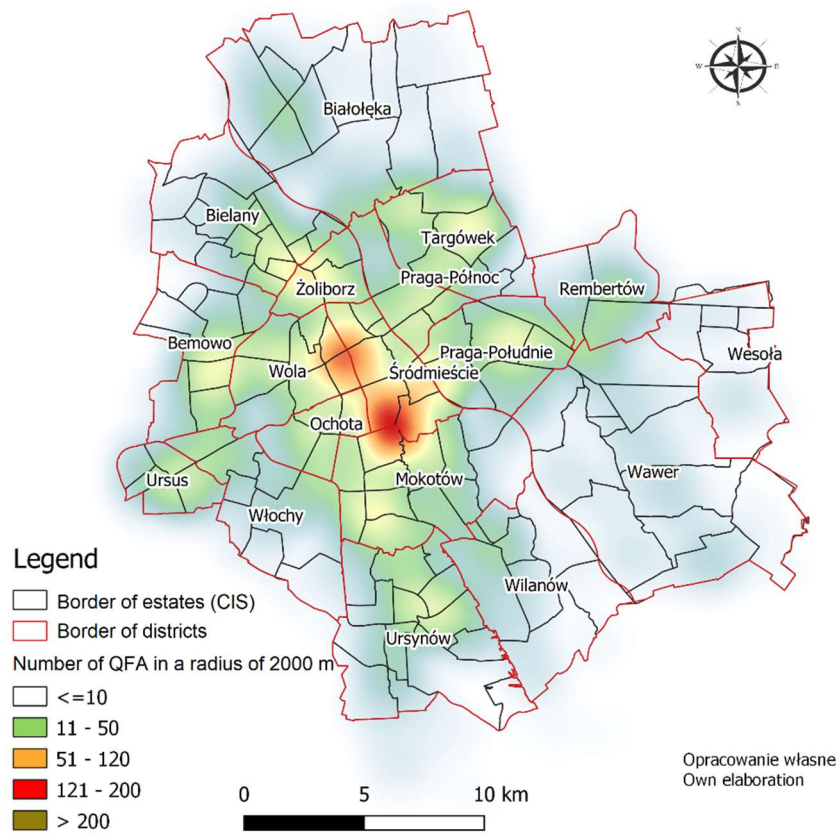


Figure 6. QFA heat map – KDE. [Own elaboration]

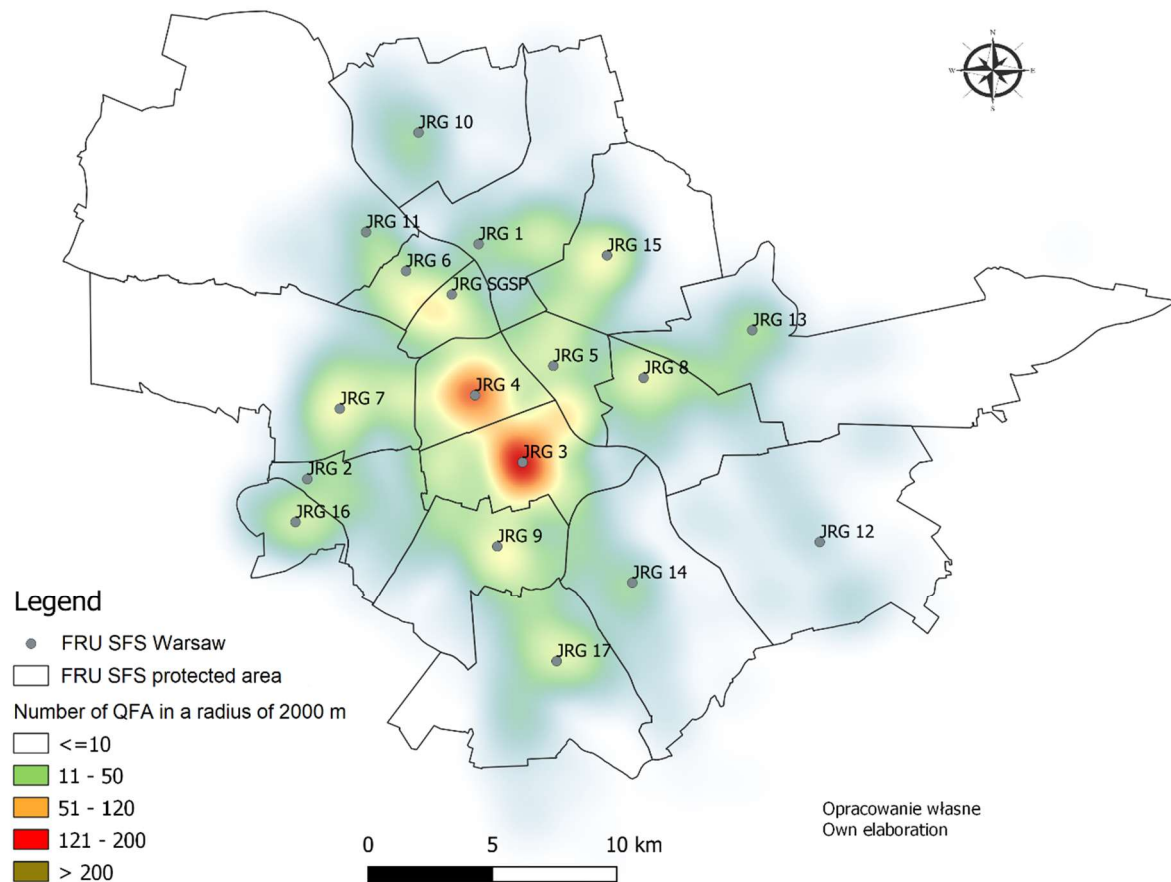


Figure 7. QFA heat map in FRU SFS protected area. [Own elaboration]

DISCUSSION

The main reason for conducting this study was the observation of an upward trend of activities, one which remained at a stable level in the recent years, regarding a constant growth in the QFA activities in the interventional activities of fire protection units. The results of studies using the latest IT tools confirmed the occurrence of such a tendency in the area of Warsaw and, in addition, indicated the places with the highest intensity of QFA activities performed by SFS firefighters. At the same time, the data found in the original database confirm the observations of foreign authors, indicating increased frequency of provision of medical support, including QFA, by firefighters [16]. In the authors' opinion, the obtained results may be used for:

- recording and mapping of places where medical rescue activities are carried out;
- finding the emergency units closest to the place of an event and coordinating their work;
- planning the distribution of additional medical equipment in SFS rescue and firefighting units (SFSRFU);
- identifying facilities near the event site significant in terms of safety and facilitation of a rescue operation.

Using spatial information systems is becoming a universal tool applied in public health sciences [17]. However, it must be remembered that its usefulness directly depends on the accuracy of the input data. According to the authors' knowledge, this study is the first in Poland to use and compare geoprocessing tools for analysis of information from the intervention activity of the fire service in the GIS software, one regarding medical support in particular. Reports of other authors on the distribution of the intensity of fires, traffic events and out-of-hospital cardiac arrests in urban agglomerations confirm the usefulness of the methods of choropleth maps and heat maps in constructing spatial and temporal characteristics of the analyzed event [18-22]. Over the last 12 years (the period of own analysis), large cities of Europe (including capital cities) changed considerably. The changes pertained to the appearance of the cities, as well as the profile and problems of their inhabitants (including health problems). Large cities were expanding and developed technologically and their population density went up. The inhabitants of those agglomerations underwent major changes as well. The authors' observations concentrated on health-related changes. The pace of life and work- and bank-loan-related stress intensified; in addition, people have suffered from the stress related to the SARS-CoV-2 pandemic for the last 2 years. Despite the development of medicine and increased expenditure on healthcare, the inhabitants of large cities, including Warsaw, are exposed to numerous health-related threats and the obtained results confirm this fact.

In 2016, Pecio analyzed the fire threats for the historically old part of Warsaw (the old town). This district feature densely developed buildings, there is a lot of public utility buildings, culture-related facilities, buildings for tourists, including hotels and restaurants, and offices. An interesting conclusion was drawn: there was a problem with fire security in those areas and issues with carrying out rescue and firefighting operations there, resulting from strict protection on the part of the art restorer. Own results show a high number of medical interventions in that area of Warsaw (Figure 6) [23]. In a study from 2017, authors looked at the crisis management system in Warsaw, a large monocentric urban agglomeration. The authors observed that intensive urbanization of areas adjacent to large urban centers creates new challenges for the crisis management system. The results of a diagnostic survey conducted among officials weigh in favor of the crisis management system implemented in Warsaw [24]. Another study confirms that its fire protection system is at a high level compared to the countries behind the eastern border. The fire statistics in Ukraine are characterized by an extremely low level of fire protection for the population. The number of fire fatalities in Ukraine exceeds the average of the UE member states 18 times [25]. Piec et al. took up the topic of safety in transport in a large city. The authors investigated threats related to the subway and the possibility for efficient evacuation in case of emergency situations. The subway is one of the branches of transport functioning in large cities, but not the dominant one in Warsaw. The authors observed that the key parameter determining the safety of passengers is a safe and predictable time of evacuation in case of the occurrence of critical environmental conditions for the human life or health (e.g. air temperature exceeding 60°C on the evacuation route, the temperature of hot fire gases exceeding 200°C or reduced oxygen content). The own analysis did not cover any interventions in the subway [26].

Based on numerous observations, it could be inferred that SFS frequently supports NEMS in their statutory activity. In a study from 2019, Wiszniewski observed that when NEMS has not arrived yet, firefighters can perform the necessary medical procedures while waiting for an ambulance. A study for central Poland enrolling 100 patients showed that before the arrival of MRT, firefighters took care of them for 5.88 (SD \pm 4.45) on average. The most common type of injury was trauma to the cervical section of the spine (41.34%) and the least common one – hypothermia (19.23%) [27].

For instance, according to the first method, an entire district is qualified for and assigned the degree of medium intensity, whereas KED (Kernel Density Estimation) method brings it down to a low level. This suggests that only some areas within a district may be assigned the degree of medium or even high intensity. Plotting the data on a map with KDE method may change the qualification of the given region in view of burdening with events. In the authors' opinion, the division of operational areas of Rescue and Firefighting Units (RFU) in Warsaw (Figures 6 and 7) is optimal in view of performing medical interventions. It should be stressed that the leading service, dedicated to deal with such a type of events is the State Medical Rescue *System*, whereas fire protection units (FPU) constitute an auxiliary service. A probable need of changes, imposed by the burden of calls, may concern other aspects of firemen's work and other fields of specialization (e.g. chemical and ecological rescue, technical rescue or firefighting activities); anyway, this may be the subject of other analyses targeted at a specific type of events.

Limitations - A limitation on the study performed hereunder was an analysis of events exclusively related to medical interventions, based upon QFA procedures, without other SFS's actions which might possibly be correlated to the number of QFA's interventions in the respective years. The execution of medical procedures within the SFS takes place in the case of events of various nature, viz. fire incidents, local hazards and disasters. In the submitted paper, attention was focused upon medical procedures within the occurring events, leaving out, however, analyses and statistical significance of the reasons and types of events. Another limitation is SARS-CoV-2 pandemic which covered the two last years of analysis, although at no place among the results obtained do the authors consider its effect upon the number of interventions; nevertheless, such a relationship, especially in the time of peak incidences, referred to as subsequent pandemic waves in Poland, might have occurred, too.

CONCLUSIONS

Assessment of the usefulness of mapping medical intervention and the analyzed spatial data confirm that the KDE method is characterized by a more precise fitting of the fragments of the MIS estates to the scale of magnitude of the investigated event – QFA activities performed by SFS firefighters. The determination of the places with the highest level of QFA activities suggests in which SFSRFUs an analysis of equipment should be conducted to improve the interventional capacity regarding QFA. Therefore, using the analytical techniques of GIS is a good tool for planning and interventional support for the SFS activities and it additionally shows phenomena not visible when the data are presented in a table. The SARS-CoV-2 pandemic brought about an increase in the number of medical interventions performed by firefighters.

SUPPLEMENTARY INFORMATION

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Institutional Review Statement: The study was conducted according to the guidelines of the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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

REFERENCES

- [1] Dudziński Ł, Glinka M, Dudzińska M, Kubiak T, Glinka P, Feltynowski M, et al. Evaluation of the abilities of the staff to perform medical rescue procedures at the advanced level in the State Fire Service in Poland in connection with an update of the Principles of Medical Rescue Organisation in the National Emergency and Fire System. *Med Res J.* 2022; 7(1): 46-53.
doi: <https://doi.org/10.5603/MRJ.a2022.0008>
- [2] Główny Urząd Statystyczny, Powierzchnia i ludność w przekroju terytorialnym w 2020 roku.
[WWW]: <https://stat.gov.pl/obszary-tematyczne/ludnosc/ludnosc/powierzchnia-i-ludnosc-w-przekroju-terytorialnym-w-2020-roku,7,17.html>
(accessed 4 January 2021)
- [3] Chomonic M, Nitecki J, Poparda W. KPP w KSRG, PZWL Wydawnictwo Lekarskie, 2018.
- [4] Wykaz ważniejszych zasad obowiązujących w KSRG.
[WWW]: <https://www.gov.pl/web/kgpsp/wykaz-wazniejszych-zasad-obowiazujacych-w-ksrg>
(accessed 4 January 2021)
- [5] Dudziński Ł, Glinka M, Glinka P. Medical interventions of the Fire Service during the COVID-19 pandemic in Poland. *Crit. Care Innov.* 2021; 4(2): 23-31.
doi: <https://doi.org/10.32114/CCI.2021.4.2.23.31>
- [6] Bogobowicz M, Domański J. Kilka uwag o GIS. *Przeg Geodez.* 2012; 84(2): 18-19.
- [7] Żukowska W. Analizy przestrzenne w systemach informacji geograficznej. *Pol Przeg Kartog.* 2003; 35(2): 100-113.
- [8] Ustawa z dnia 17 maja 1989 r. Prawo geodezyjne i kartograficzne (Dz.U. 1989 nr 30 poz. 163 ze zm.).
- [9] Gotlib D, Iwaniak A, Olszewski R. GIS obszary zastosowań. Warszawa: Wyd. PWN; 2007.
- [10] Quantum GIS Polska.
[WWW]: <http://www.quantum-gis.pl/>
(accessed 1 August 2021)
- [11] Rozporządzenia Ministra Spraw Wewnętrznych i Administracji z dn. 17 września 2021 r. w sprawie szczegółowej organizacji krajowego systemu ratowniczo-gaśniczego (Dz.U. 2021, poz. 1737; załącznik nr 5).
- [12] Burgess JL, Bevan A, Bergzoll S, Perot A, Bui D, Descatha A. Case studies of fire and emergency medical services: risk management in the european union. *Internat Fire Service J Leader Manag.* 2019; 13 (7): 7-18.
- [13] Elgammal A, Duraiswami R, Harwood D, Davis LS. Background and foreground modeling using nonparametric kernel density estimation for visual surveillance. *Proceedings of the IEEE.* 2002; 90(7): 1151-1163.
doi: <https://doi.org/10.1109/JPROC.2002.801448>
- [14] Sheather SJ, Jones MC. A reliable data-based bandwidth selection method for kernel density estimation. *J Royal Stat Soc B.* 1991; 53(3): 683-690.

- [15] Silverman BW. Density estimation for statistics and data analysis. London: Chapman and Hall; 1986.
- [16] Cannuscio CC, Davis AL, Kermis AD, Khan Y, Dupuis R, Taylor JA. A Strained 9-1-1 System and Threats to Public Health. *J Community Health*. 2016; 41: 658-666.
doi: <https://doi.org/10.1007/s10900-015-0142-x>
- [17] Higgs G. A literature review of the use of GIS-based measures of access to health care services. *Heal Serv Outcomes Res Methodol*. 2004; 5: 119–139.
doi: <https://doi.org/10.1007/s10742-005-4304-7>
- [18] Mazur R, Guzowski P. Assessment of Safety Levels in the Context of 2000-2012 Statistics. A Statistical Analysis of Residential Building Fires Causes at the National and City Level. *BiTP*. 2014; 35(3): 47-59.
doi: <https://doi.org/10.12845/bitp.35.3.2014.5>
- [19] Lerner EB, Fairbanks RJ, Shah MN. Identification of out-of-hospital cardiac arrest clusters using a geographic information system. *Acad Emerg Med*. 2005; 12(1): 81-84.
doi: <https://doi.org/10.1197/j.aem.2004.08.044>
- [20] Ahn KO, Sang DS, Cha WC, Jun C, Lee TS, Pirralo RG. A model for the association of the call volume and the unavailable-for-response interval on the delayed ambulance response for out-of-hospital cardiac arrest using a geographic information system. *Prehosp Emerg Care*. 2010; 14(4): 469-476.
doi: <https://doi.org/10.3109/10903127.2010.497895>
- [21] Warden CR, Daya M, LeGrady LA. Using geographic information systems to evaluate cardiac arrest survival. *Prehosp Emerg Care*. 2007; 11(1): 19-24.
doi: <https://doi.org/10.1080/10903120601023461>
- [22] Bjorn S. Developing an analytical tool for evaluating EMS system design changes and their impact on cardiac arrest outcomes: combining geographic information systems with register data on survival rates. *Scand J Trauma Resusc Emerg Med*. 2013; 21: 8.
doi: <https://doi.org/10.1186/1757-7241-21-8>
- [23] Pecio M. Analysis of Selected Aspects of Fire Safety and Operating Capability in Warsaw's Old Town. *BiTP* 2017; 46 (2): 88–98.
doi: <https://doi.org/10.12845/bitp.46.2.2017.6>
- [24] Szczurek T, Bryczek-Wróbel P. Crisis Management Model for Large Urban Agglomerations. *BiTP* 2018; 49 (1): 102–110.
doi: <https://doi.org/10.12845/bitp.49.1.2018.10>
- [25] Pawlowych OB. Review of Fire Statistics Data in Ukraine. *BiTP* 2017; 47(3): 62–67.
doi: <https://doi.org/10.12845/bitp.47.3.2017.4>
- [26] Piec R, Cisek M, Wróbel R, Sowa M, Wiechetek M, Gawroński W, et al. Passenger Safety in the Warsaw Metro. Research Report. *Safe Fire Tech*. 2020; 56 (2): 40–60.
doi: <https://doi.org/10.12845/sft.56.2.2020.3>
- [27] Wiszniewski R, Gorgone C. Characteristics of medical procedures performed by firefighters. *Crit Care Innov*. 2019; 2(4): 17-24.
doi: <https://doi.org/10.32114/CCI.2019.2.4.17.24>