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Effects of spatial configuration on the patient's journey to the Emergency Department

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Abstract

Reaching the destination, users often encounter complex interfaces created between hospital spaces and the urban tissue. The literature highlights the influence of spatial configuration on the performance of external and internal spaces of healthcare settings. In this regard, studies related to Emergency Department (ED), mostly focus on internal spaces, without specific research on the accessibility of the structures themselves. By extending the research area to the entire system of territory-hospital-ED relations, the study conducted at the University Clinical Center of Kosovo (UCCK) in the city of Prishtina aims to investigate the effects of spatial configuration on the performance of spaces in the patient's journey to ED. The paper attempts to understand the causes that have shaped the spatial configuration of the city and the hospital over the years and their impact on ED accessibility. Through configurational theory of architecture, the paper quantitatively examines the interactions between the levels of this relational system at various spatial scales and time intervals. A methodological framework of spatial requirements and corresponding indicators was developed. It was observed that the declined syntactic values of the city affected the degree of the hospital accessibility, deteriorating the continuity of movement from the city to the hospital, followed by a subsequent disruption due to the change in the spatial configuration of the hospital and the relative position of ED. The outcome shows that configurational changes affect the continuity of movement sequentially in each segment of the patient's journey towards ED, with interrelated consequences at all levels.

Keywords Patient's journey, Emergency Department accessibility, Hospital, City, Layout transformation, Continuity of movement, Space Syntax

Introduction

The Emergency Department (ED) has become the main front door of the hospital and the focal point in the relationship between the user and the hospital. The majority of patients visiting the hospital go through ED, often encountering unintelligible environment between hospital spaces and the urban tissue. Waiting time, lack of privacy, navigation difficulties to the destination, are common ED challenges (NHS 2003). Multilayer ED problems can be synthesized as managerial and spatial, closely interrelated. Both start from the territory, continue with their effects throughout the hospital spaces and are reflected in the ED itself. Improvements in functional problems are mainly sought in management solutions. This paper focuses on spatial issues i.e., in understanding the path that the patient makes through the spaces towards ED, which is considered essential (Huddy 2017; SHPN22 2007; ACEM 2014). In this sense, all users must be provided with a dignified journey, which in certain circumstances can be traumatic with consequences in the epilogue of the patient's life. Disorders in the health sector caused by unforeseen circumstances similar to

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the recent pandemic have further strengthened awareness for patients physical, psychological and social needs (Capolongo et al. 2020). The current emergency planning strategy is based on "patient-centered" paradigm, paying special attention to meeting the individual needs of patients, among others, in terms of accessibility and legibility, by providing an intuitive wayfinding which is closely related to the quality of the spaces—the model of relationships between spaces known as spatial configuration (Hillier 2007), which is a variable process that leads to the changes in the dialogue between spaces in the patient's journey. The decisive role that spatial configuration has on the performance of external and internal spaces, is explained in the Hillier et al. (1993) theory of "natural movement". Research on this phenomenon has so far been carried out within ED facilities only, without specific research on the impact of spatial configuration on the accessibility of the structure themselves and their inclusion in the hospital and territorial context. By extending the research area to the entire system of territory[1]-hospital-ED relations, the paper, which is an excerpt from a doctoral dissertation (Meka 2022), aims to investigate the effects of spatial configuration on the performance of the spaces in the patient's journey to the ED. As a case study, it uses the University Clinical Center of Kosovo (UCCK) in the city of Prishtina. Cities and hospitals' spatial configuration undoubtedly show signs of changes that occur over time. Rapid growth of the city and hospital developments without long-term vision raise concerns about the quality of spaces on the patient journey toward ED. Therefore, the paper is structured around the following questions: What are the syntactic properties of spatial configurations of the city and the hospital? How the historical development of the city and the hospital, i.e., the respective social and political circumstances shape their spatial configurations? How these configurational transformations are reflected in the continuity of the patient's movement towards ED, i.e., on its accessibility? How the configurational values of ED position respond depending on whether the hospital spatial structure is analysed as detached from or connected to the city? To answer these questions, the research is leaning on the configurational approach, as the core of space syntax theory and methodology, developed by Bill Hillier and colleagues at University College London (UCL).

In order to analyse and evaluate the quality of spaces toward ED, the study developed a methodological framework of spatial requirements for the continuity of patient's movement and corresponding indicators related to syntactic attributes of space. UCCK in Prishtina is the only healthcare facility providing tertiary services throughout the country, which in the absence of a regional hospital, provides secondary services as well. Considering the mismanagement of the referral system in Kosovo, makes it an institution of high complexity, alongside the complexity of relationships of the typology with pavilions to which it belongs. However, these typologies are of greater potential in terms of open spaces to be used as roads, pedestrian areas and public spaces (Giofrè 2015), and can be considered in accordance with the general criteria of humanization (Torricelli 2005). They have proven to be more suitable in the event of mass flows as a consequence of various natural disasters and pandemics such as the recent COVID-19. This is due to the availability of different functional areas that can be easily separated from the rest of the hospital system, while outdoor areas can provide space for temporary structures (Capolongo et al. 2020; Setola et al. 2022). This study considers the city maps from the years 1953 to 2019, where 1953 is the year of adoption of the city's first general urban plan that defined the location of the hospital, while hospital plans cover the years 1999 and 2019, where 1999 is the year the ED was founded.

The paper below presents a theoretical framework that examines the patient's journey and explains the concept underlying the theory and method of space syntax, including the concept of spatial configuration and relationship variables between spaces. For the purpose of analysis, a brief overview of the historical and spatial development process of Prishtina, UCCK and ED is provided, followed by comparative syntactic analyses of spatial configurations created in different time periods. Discussions on the results attempts to highlight the most important findings from the configurational perspective.

Theoretical framework

The patient's journey

People's first experience with the hospital is influenced by the permeable spaces between the hospital complex and the urban context, which place the hospital in direct dialogue with the city (Giofrè 2015), expressing the potential of access that a hospital as a whole can provide. The physical continuity of these spaces provides greater accessibility to health care settings (Setola and Borgianni 2016). According to Martinez (2011), improvements in health care are influenced by the way a hospital building is integrated into the urban context. In this regard, the physical integration of the hospital into the urban structure is considered to be an important factor of designing healthcare institutions, which implies more physical connections between them (Wagenaar et al. 2018). An inefficient layout has a strong influence on shaping the patient experience, may increase travel time and waiting time,

[1] In this paper, the term territory refers to the city of Prishtina.

and may give patients a poor overall impression of the environment (Khan 2012).

Patients journey can facilitate or prevent the user's movement flows depending on the quality of spaces. According to Van der Zwart and van der Voordt (2015), the quality of the characteristics of these spaces consists in the connection between them. In this sense, Al-Sayed et al. (2014) points out that the created structure has an architecture, which implies a certain geometry and a certain topology, i.e., a certain pattern of connections, defined as a spatial configuration in the theory of space syntax. Spatial configuration is a dynamic process that depends on changes in the model of connections affected by over time circumstances. As such it introduces new interactions between different levels, creating a complex interface between the hospital spaces and the urban tissue. It is therefore important that these interactions offer an accessible and legible environment (Torricelli 2010). Accessibility as a spatial parameter expresses "how accessible each space of the system is from every other space in the system" (Setola and Borgianni 2016, p. 116). How legible these spaces are, according to Lynch's theory (1960), is shown by mental maps structured on the basis of user's memory, while according to Hillier's concept of intelligibility (1984), the urban environment can be better understood based on its spatial configuration (Mohamed 2012), which is the core of space syntax.

Regarding the complexity of patient journey, according to ACEM (2014) "the goal for any model of care should be to reduce unnecessary steps in the patient journey, and to optimise the timeliness of all the essential components of the journey". Determining the location of hospitals is a crucial factor that requires a multidimensional and integrated approach to find effective solutions (Dell'Ovo 2020). In this chain of components, an important place occupies the position of ED within the hospital, which "should be reached through easy and direct access" from the road network (HBN 2013; AusHFG 2019; Capolongo et al. 2019), both to the walk-in entrance (self-presented on foot or by vehicles) and to ambulance drop-off area (Huddy 2017). It is therefore important to differentiate hospital entrances in terms of their accessibility potential from the city for different means of arrival. According to Robinson et al. (2015), 60.2% of patients visiting ED present themselves to walk-in entrance. Thus, it is necessary to carefully consider their flows and ensure independent movement through the whole system of relations between streets. Its incoherence can produce spatial configurations of poor intelligibility, implying discontinuity of movement flows.

Cases of maxi—emergencies, such as the rapid spread of COVID 19, has prompted health care researchers to develop strategies for hospital resilience in unusual circumstances. Common to all of these strategies is a particular focus on reducing potential sources of infection, reorganizing access, flows and routes, separating the routes of infected patients from others within and outside the premises, as well as separating functionally distinct parts from the rest of the hospital (Capolongo et al. 2020; Setola et al. 2022; Casagranda et al. 2022). One of the strategies for managing the flow of patients inside the ED led to the creation of two separate spatial areas, in which case, the CT scanner of the ED is dedicated exclusively to patients with respiratory problems, while the central radiology for all other patients of the department (Carenzo et al. 2020). An effective approach to emergency situations is the use of mobile units or healthcare on wheels, which are medical facilities that can be transported to provide healthcare services in various locations, with highly effective performance, providing quick response to mass casualties and medical aid (Gola et al. 2018).

Space syntax

The theory of space syntax is based on the assumption that the topological and geometric complexity of a network of spatial patterns of a built environment influences patterns of movement and human interaction and that there is a high correlation between the level of accessibility and movement flows (Hillier and Iida 2005; Penn 2008). The method is designed for configurational analysis according to that theory (Haq and Luo 2012), considered as an "objective and accurate method of description, which can simulate the performance of real and hypothetical schemes on a computer" (Hillier et al. 1983, p. 49). Space syntax, quantitatively and analytically enables the interpretation and prediction of the development of space. To be analysed as a configuration, the system of spaces decomposes into basic elements—axial lines and is represented as an axial map which is analysed through depthmap software developed at UCL. Axial lines defined as the "longest and fewest lines" (Hillier 1999, p. 1) indicate the routes for potential movements (Haq 2019), while axial map is defined as "the least set of such straight lines which passes through each convex space and makes all axial links" (Hillier and Hanson 1984, p. 92). To clarify the relationships that exist in the network of spaces of urban areas and buildings, a number of configurational variables are used, the most important of which are: connectivity—a syntactic feature that measures the number of spaces directly connected to the origin space (Al-Sayed et al. 2014), step depth—the number of turns that must be traversed to get from the current location to any other location within the layout (Turner 2004) and integration—the average distance of one space from all other spaces in a layout (Haq 2019). Through this parameter,

spaces can be ranked from the most integrated to the most segregated, where 10% of the most integrated values in the system is called integration core (IC). The global measure of integration (Rn) shows how deep or shallow a space is relative to all other spaces (Al-Sayed et al. 2014). Local integration (R3) takes into account the elements of the depth scale equal to 3 (n = 3). While the global integration variable correlates with vehicle movement patterns, local integration is related to pedestrian movement (Penn and Dalton 1994). The variable for the entire layout is intelligibility, which is measured by "the correlation coefficient between connectivity and integration of all the spaces in that layout" (Haq 2019, p. 14).

The application of space syntax in healthcare facilities

The application of space syntax in healthcare settings began in the 1990s (Haq and Luo 2012) on the grounds that it enables the quantification and optimization of spaces and has therefore been considered as an effective method for designing healthcare facilities. In this sense, Setola (2009) tested and confirmed the potential of the space syntax methodology and recommended it as a suitable tool to support hospital flow management and modelling. In order to evaluate the quality of spaces, a significant number of studies have analysed the spatial configurations of healthcare facilities in terms of accessibility and legibility. Peponis et al. (1990), among the first to apply space syntax in healthcare investigations, found that there is a correlation between the integration variable and movement flows, that well-integrated spaces are more accessible. Haq and Girotto (2003) found that the variable of intelligibility is a good predictor of wayfinding and environmental awareness. Haq (2003) suggests the degree of accessibility of hospital entrances as an important indicator affecting wayfinding. Both Terranova (2005) and Setola and Borgianni (2016) emphasize the importance of entry points to the healthcare facilities, stating that they should ensure road continuity and good accessibility. Martinez (2011) suggests that the way the hospital complex is connected to the urban context provides clues about the circulation structure and the location of the entrance. As for the ED, the configuration studies were mainly carried out at the building level. In this context, Gharaveis et al. (2018) has explored the relationship between ED physical model and visibility and found that a high level of visibility affects productivity and teamwork efficiency, while Zamani (2019) analysed the impact of ED physical design on security, wayfinding, visibility and privacy and found that they were significant predictors of staff satisfaction and performance. The paper did not identify any research addressing the effects of spatial configuration on the patient's journey to ED. Therefore, the study focuses on examining the impact of configurational changes on the continuity of patient flow, which, supported by the paradigm shift towards "patient-centered design", should not be compromised, potentially causing disruption to the patient journey.

Brief overview of the development process of Prishtina, UCCK and Ed

The urban development of Prishtina before the Second World War (WW2) was organized in an organic street network, where the bazaar occupied the central part of the city, typical of the architecture of Ottoman cities developed mainly around the core in the center, while the city itself developed almost radially in all four directions (PPU 1987). According to the same source, in the first years after WW2, Prishtina experienced demographic growth and territorial expansion, but a large part of the city was developed without control and without basic conditions for normal life. In 1953, the general urban plan of Prishtina was approved (Fig. 1), which envisaged the development of the city in the north–south direction, the implementation of which would lay the foundations of the modern city, but ultimately affecting the vernacular heritage (PPU 1987). Over time, Prishtina has expanded in all directions, with a clear trend of development towards the southwest (PZHK 2012–2022). Subsequent urban development plans (1988, 2004 and 2013) although approved, were not fully implemented due to socio-political circumstances. The trend of irregularities continued for a long time and the consequences of this process are currently present.

The 1953 general urban plan determined the location of the Prishtina Hospital Center in the southern part of the city where UCCK will later be developed. The urban plan of Prishtina Hospital Centre was approved in 1956 (Vujic 1956). As the city expanded, the UCCK location, once on the outskirts of the city, became part of Prishtina urban area. The detailed plan of the hospital complex was approved in 1967 (Fig. 2). The plan was quite advanced for the needs of the time in terms of spatial layout, street hierarchy and differentiated flows (Meka and Ferati 2021). The construction was planned to be of the pavilion type, connected by internal connections. The plan was not fully implemented, the complex was partially built, while the expansion was carried out without a master plan (Fig. 3). This could change the configuration of the hospital with consequences in circulation system, orientation and the appearance of informal roads.

The ED at UCCK provides tertiary services and is a reference medical institution (SHME 2016), but also serves as a reference department for primary care cases, since it provides secondary level services in the absence of the general hospital of Prishtina. Information about current ED (ED1) and its usage was gathered from hospital

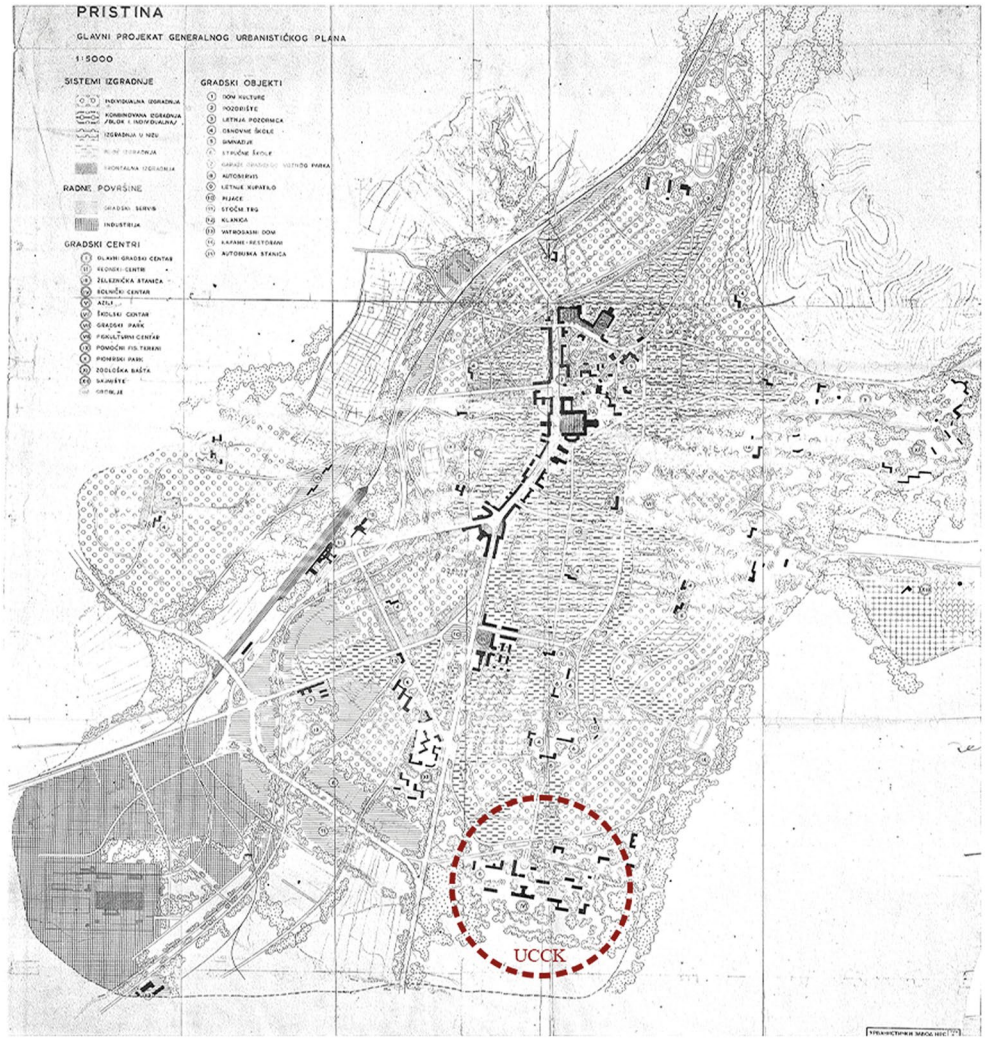


Fig. 1 The general urban plan of Prishtina, 1953 (source: Archive of the Municipality of Prishtina, fund 71, no. 587)

archives, direct field analysis, and staff interviews. It was first established as an independent unit within the UCCK in 1999 and organized on an area of approx. 500–600 m^2, which does not meet the requirements of approx. 60,000 annual visits. It is part of the interconnected buildings located in the central part of the hospital complex, connected to the most specialized hospital services. The facility is accessible from all three campus entrances and other informal entrances on the northern part of the campus. Because ED1 does not meet the criteria for such a large flow, construction of a new ED (ED2) has begun and is ongoing. In the absence of a master plan of the hospital complex, ED2 (Fig. 3) is being built as a separate facility, organized along a vertical axis, in the area behind existing facilities of important functions, with no internal connection to other parts of the hospital. The absence of interconnections between the ED and other parts of the hospital can be viewed as a disadvantage. When organizing and locating emergency care areas, it is crucial to consider inter-departmental connections, as a significant criterion (Capolongo et al. 2019; Brambilla et al. 2022).

Research methodology

The research methodology consists in the idea of assessing the quality of spaces sequentially across the levels of the city-hospital-ED (macro, meso and micro) relational system, using the space syntax methodology. The paper introduces a specific research approach by developing a methodological framework (Table 1) that identifies spatial accessibility, legibility and proximity as spatial requirements for continuity of movement and corresponding indicators as the degree of the requirements. These indicators are evaluated through diachronic and synchronic analyses by measuring the syntactic

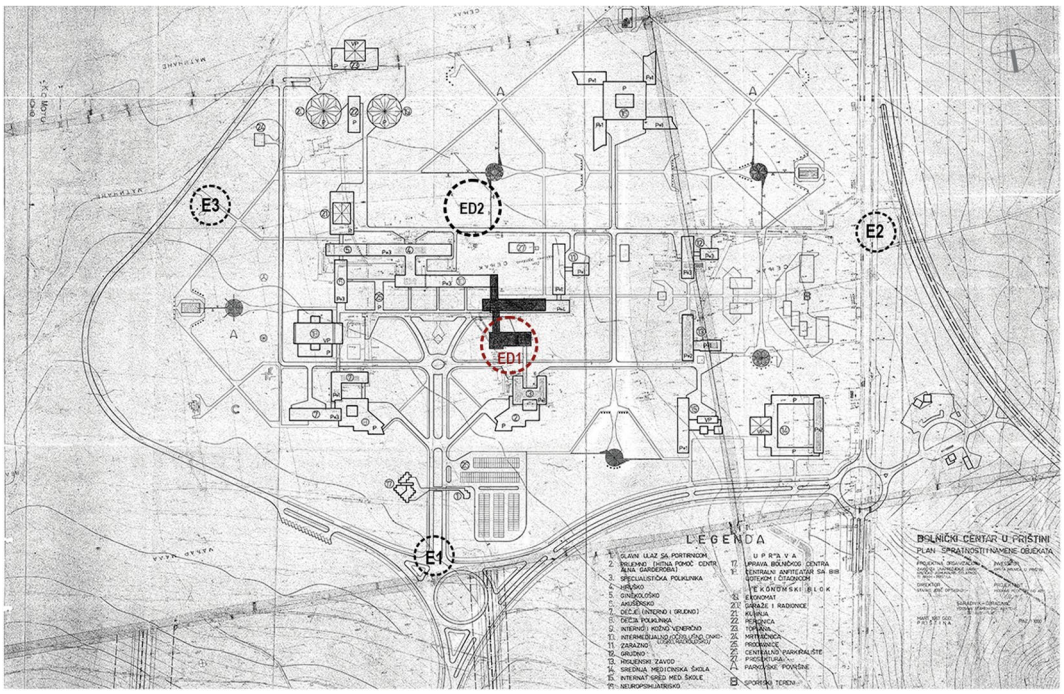


Fig. 2 The master plan of the hospital complex, 1967; circled in red—current ED; circled in gray—the location of the future ED; Current hospital entrances—E1, E2, E3 (source: Archives of the municipality of Prishtina, fund 71, no. 1392)

parameters such as integration (global and local), step depth and intelligibility with axial line technique through depthmap software. The configuration model to be analyzed is constructed by axial lines connecting all three levels of the patient journey. Axial lines of Prishtina and UCCK are drawn manually through the CAD program.

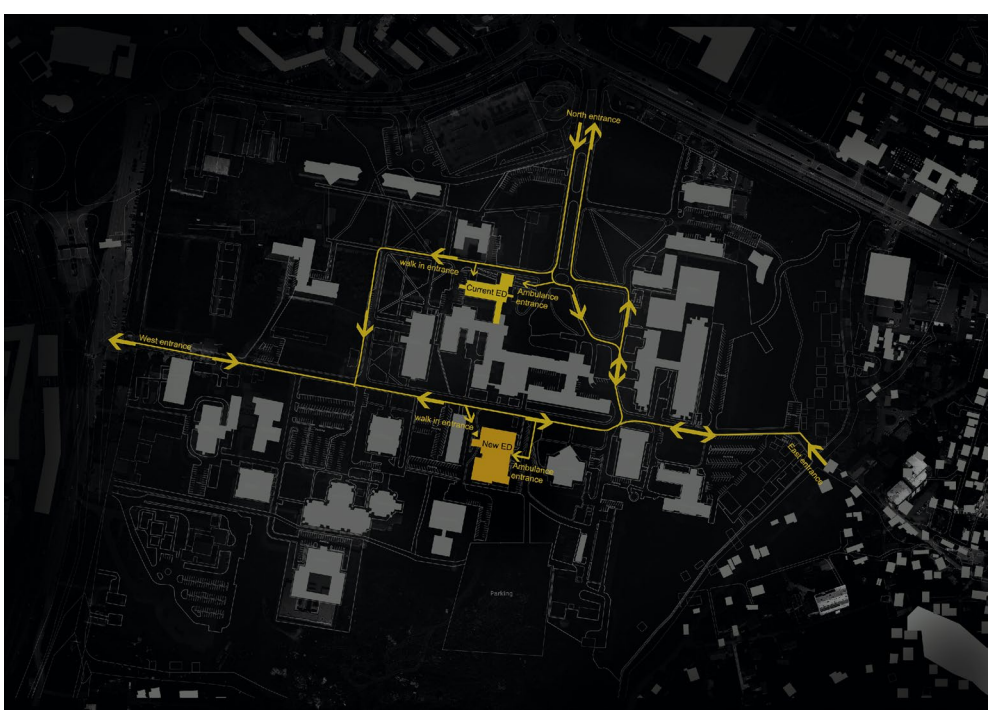


Fig. 3 The layout of the University Clinical Centre of Kosovo, 2019. Current ED and new ED (source: author)

Table 1 Methodological framework for assessing continuity of movement towards ED

User need	Spatial requirements	Indicators	Parameters	Method	Level
Continuity integration city-hospital-ED	Spatial Accessibility/spatial proximity/spatial legibility	The degree of accessibility and legibility in the entire road network of the city	Integration Rn Integration R3 Intelligibility	Space syntax-Axial line technique	Macro
		Proximity values between the hospital complex and primary care/reference facilities	Topological Step Depth		
		The degree of accessibility of the hospital entrances from the city	Integration Rn Integration R3		
		The degree of accessibility and legibility of the entire road network of the hospital complex	Integration Rn Intelligibility		Meso
		The relation between hospital entrances and its integration core	Integration Rn		
		The relation of ED entrances with the hospital accessibility core	Integration Rn		Micro
		Proximity values between ED and hospital entrances	Topological step depth		

CAD maps were then imported into the depthmap program and converted into an axial map ready for further analysis. Red colour in axial maps indicates higher levels of integration, as opposed to blue, which indicate lower values.

Configurational analyses

The initial procedure investigated the changes of the spatial configuration of the city's street network over the years and the impact of these changes on interactions with the hospital, to continue with the research of the transformation of the hospital's street network and their impact in the ED accessibility. This includes the measurement and interpretation of main syntactic features of spatial configuration to enable comparison through certain periods of time.

Macro: the city

Accessibility and legibility of the city

In order to get a better overview of the relationship of UCCK in the wider context of Prishtina, considering the continuous changes in the configuration over the years, diachronic and synchronic spatial analyzes of the configuration of the city street network were carried out on the maps of the time scale 1953–2019. Cadastral maps of 1953 and 1964 (Figs. 4, 5) were available from archival sources, whilst maps of 1999 and 2019 (Figs. 6, 7) were provided by the Kosovo Cadastral Agency

Fig. 4 Map of Prishtina, 1953 (Source: Strategic Plan of Prishtina, 2004–2020)

(State Geoportal) and processed for additional analysis. Beside cadastral maps, the 1953 Prishtina general urban plan will be analyzed to better understand the development of the city. The degree of spatial accessibility and

Fig. 5 Map of Prishtina, 1964 (Source: Strategic Plan of Prishtina, 2004–2020)

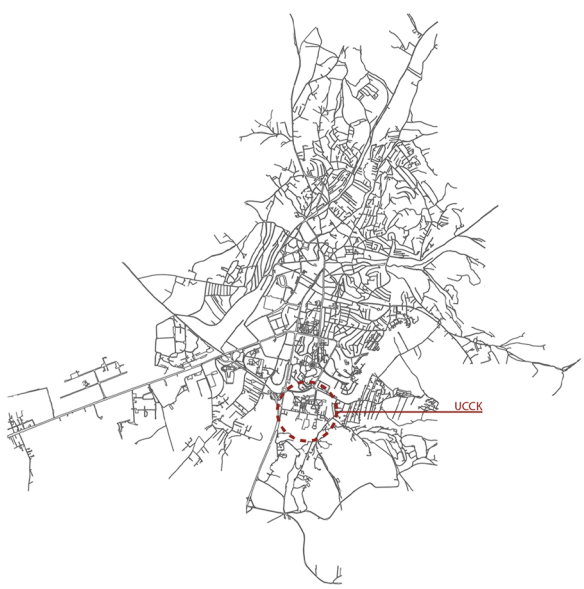


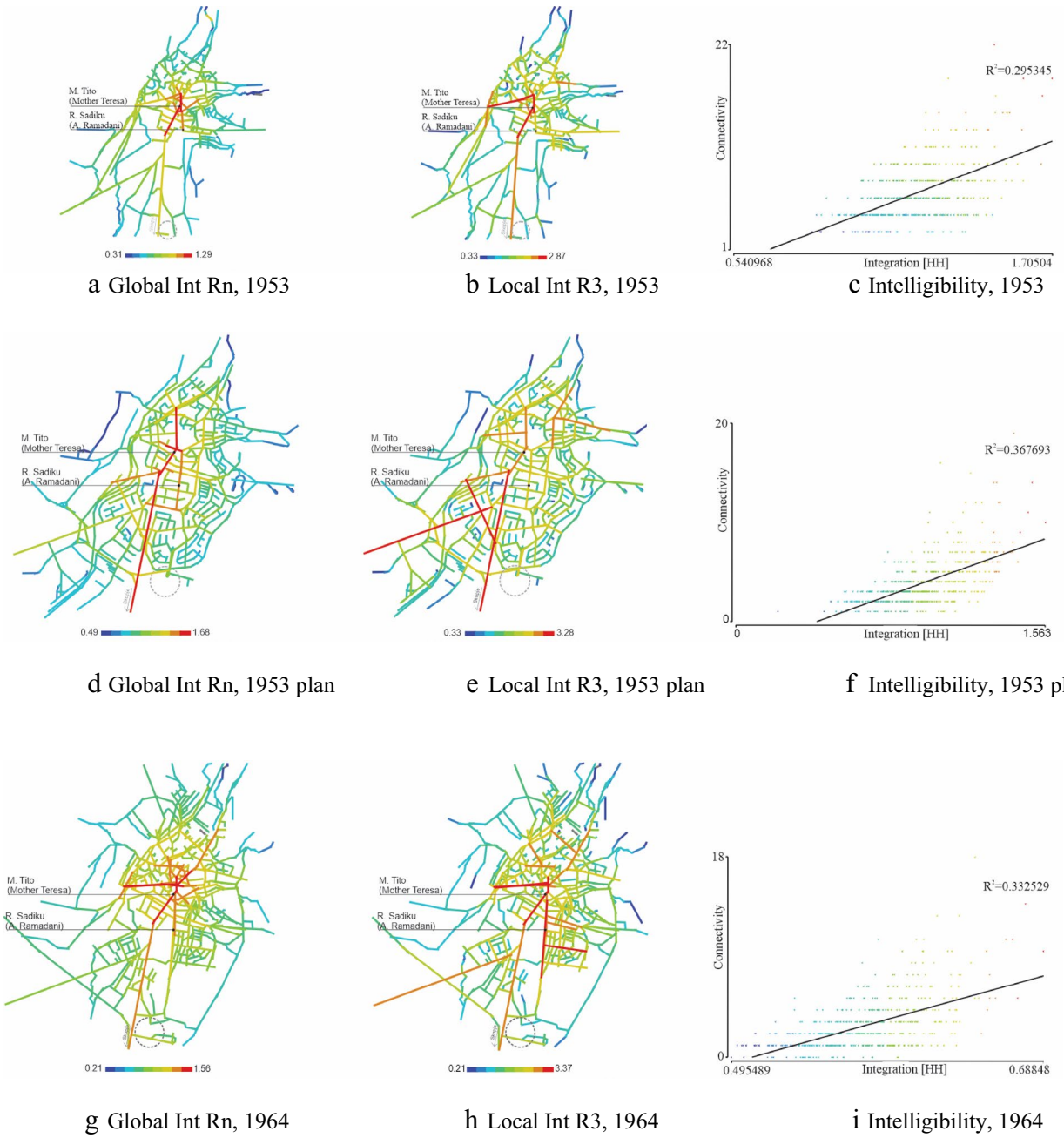
Fig. 6 Map of Prishtina, 1999 (Source: KSA—Kosovo Cadastral Agency—geoportal)

legibility in the entire city's road network was evaluated through the measurement of global integration (Rn), local integration (R3) and intelligibility using the axial line method.

Until the year 1953, when the first city plan was approved, the city developed spontaneously. Axial analyses of Prishtina map dating from1953 (Fig. 8a,

Fig. 7 Map of Prishtina, 2019 (Source: KSA—Kosovo Cadastral Agency—geoportal)

b) show that the city IC is concentrated in the city center ("Mother Teresa" street) with an expansion to the southern part toward the hospital location, which appears more accessible at the local level (R3) from "Shkupi" street. The 1953 axial maps of Prishtina also reveal relatively lower average integration values (Table 2) both globally (Int_Rn 0.7) and locally (Int_ R3 1.4) compared to the 1953 general urban plan of Prishtina and lower level of intelligibility values $R^2 = 0.29$ (Fig. 8c). The IC of the city in 1964 (Fig. 8d, e) expands through other new roads, such as "Agim Ramadani", which is well integrated and oriented towards the location of the hospital. In this year, the hospital becomes more accessible from "Shkupi" streets on both levels. From 1953 until 1964, the analyses show an increase in the values of global and local integration (Int_Rn 0.93 and Int_ R3 1.6) and intelligibility $R^2 = 0.33$ (Fig. 8f), making the city more accessible and more legible, which can be attributed to the development of the city according to the general urban plan of 1953, which was partially implemented. Axial maps analyses of 1953 general urban plan (Fig. 8g, h) show the highest syntactic values of global and local integration (Int_Rn 0.99



a Global Int Rn, 1953 b Local Int R3, 1953 c Intelligibility, 1953

d Global Int Rn, 1953 plan e Local Int R3, 1953 plan f Intelligibility, 1953 plan

g Global Int Rn, 1964 h Local Int R3, 1964 i Intelligibility, 1964

Fig. 8 Syntactic analyses of Prishtina—1953, 1964 and 1953 general urban plan

Table 2 Syntactic characteristics of Prishtina

Map/years	Connectivity	Glob. Int. (Rn)	Loc. Int. (R3)	Intelligibility
1953	3.3	0.7	1.4	0.29
1953 general urb. plan	3.7	0.99	1.7	0.36
1964	3.6	0.93	1.6	0.33
1999	2.8	0.4	1.3	0.1
2019	2.6	0.3	1.2	0.06

a Global Int Rn, 1999

b Local Int R3, 1999

c Global Int Rn, 2019

d Local Int R3, 2019

e Intelligibility, 1999

f Intelligibility, 2019

Fig. 9 Syntactic analysis of Prishtina—1999 and 2019

and Int_R3 1.7) and the value of regression coefficient $R^2 = 0.36$ (Fig. 8i). Until 1999, while the city's street network expended, the IC changed its shape into convex (Fig. 9a, b). In 2019, the road network expanded in all directions, mostly towards the south (Fig. 9c, d). The IC is concentrated in the center, tangentially reaching

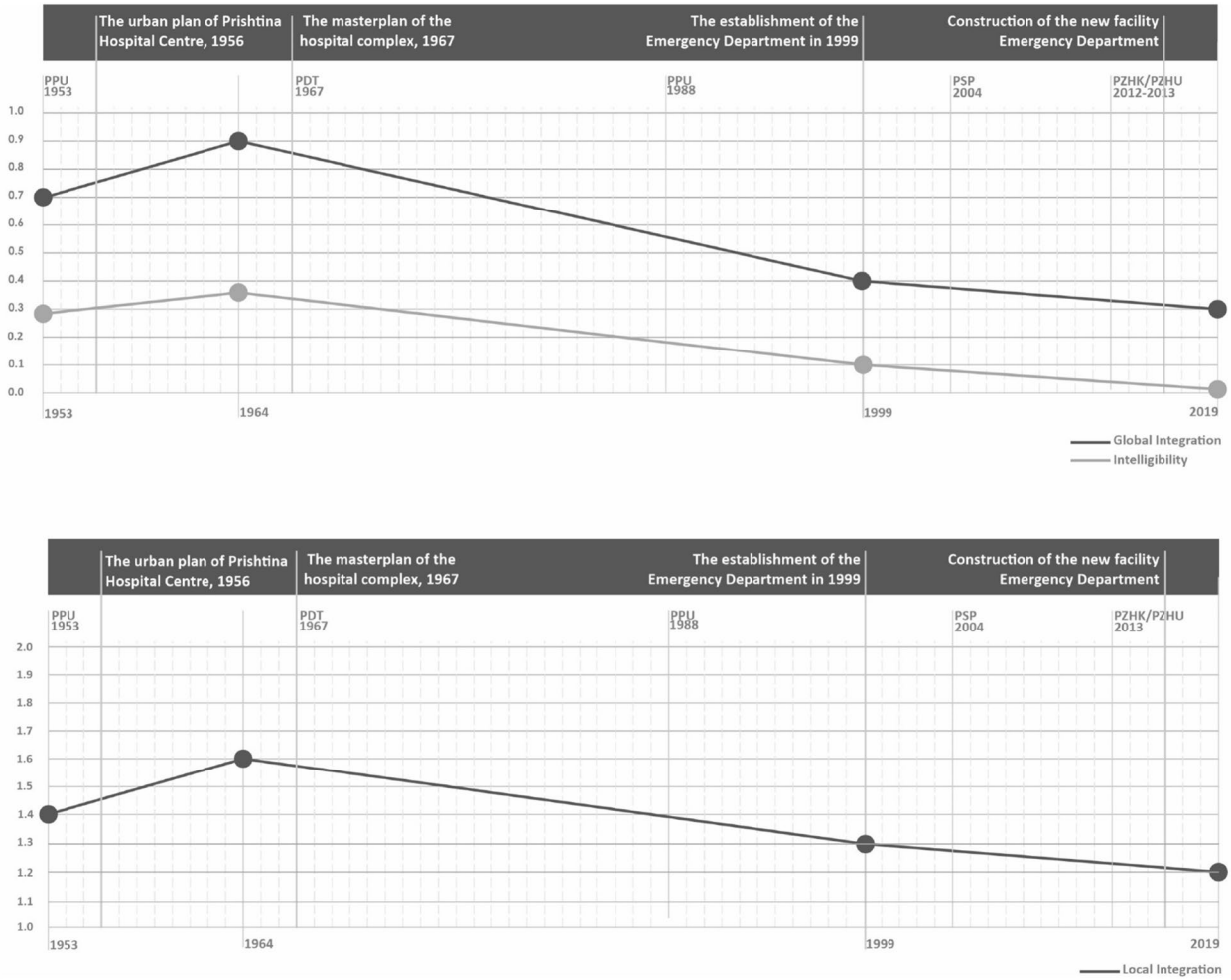


Fig. 10 Global and local accessibility and intelligibility of Prishtina over the years

the location of the hospital. The hospital is accessed through "Shkupi" street to the west, as part of the IC in a global level and “Muharrem Fejza" street to the north, which locally becomes more integrated than in 1999.

After 1964, syntactic parameters decreased continuously up to the reference year of 1999 (Int_Rn 0.4 and Int_ R3 1.3), experiencing the lowest values of integration in 2019 (Int_Rn 0.3 and Int_R3 1.2) through the whole analyzed period 1953–2019. Similar decline in the intelligibility values appeared in 1999 $R^2 = 0.1$ (Fig. 9e) and in 2019 $R^2 = 0.06$ (Fig. 9f). This degradation may be due to lack of enforcement of laws and required planning standards. Construction after the war in 1999 transformed over 70% of the urban structure (PZHU 2012–2022).

The diagram (Fig. 10) shows the variation of syntactic values through the reference points of the time period 1953–2019, at the global and local levels. The values of accessibility of the city configuration show a linear decline over the years at both levels. Regression analyzes show a decline in intelligibility values over the years, meaning that the information from a local part of the city is insufficient for understanding the global structure. This can be attributed to the growth of a chaotically built environment in which illegal neighborhoods have penetrated to the city center.

Proximity of the hospital complex to reference facilities

Since the ED at the UCCK also serves as a reference department for primary care cases, the influence of city configurational changes in this relational system should be analyzed to determine the degree of spatial proximity of hospital entrances to the network of family medical centers distributed throughout the city. The paper considered the relationship between the hospital entrances and the Main Family Medicine Center (MFMC) by measuring the topological distance through the step depth parameter in the axial map generated for the 1999 and 2019 vehicle model (Fig. 11). All three hospital entrances

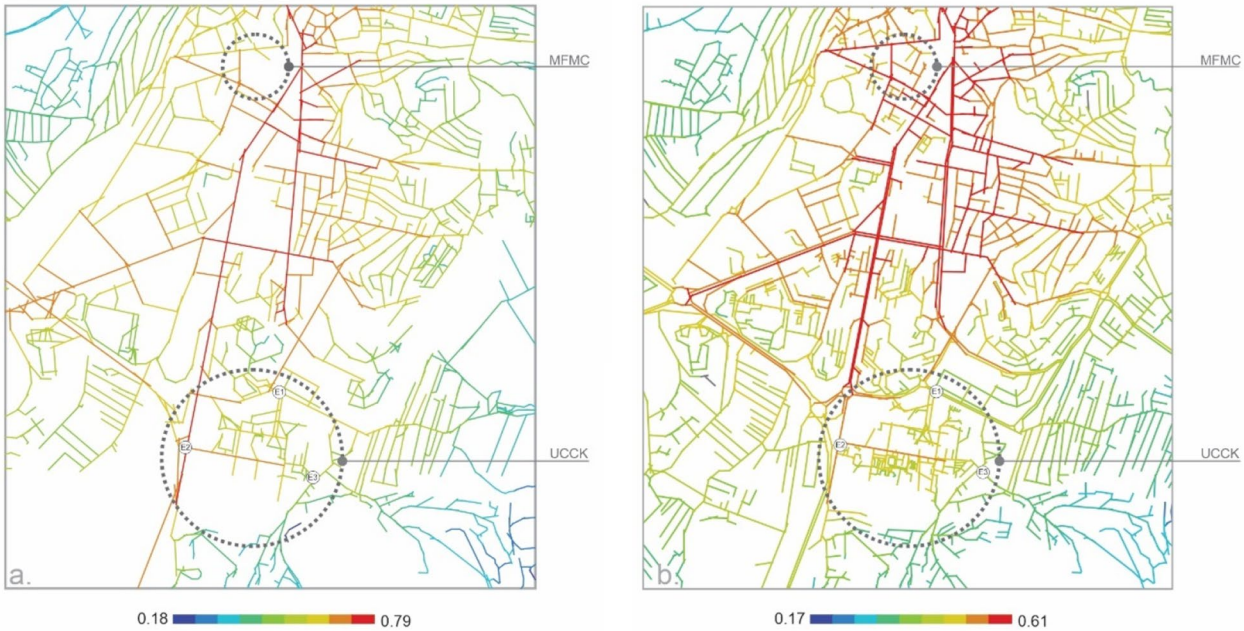


Fig. 11 The degree of proximity between UCCK and MFMC; 1999 (**a**), 2019 (**b**)

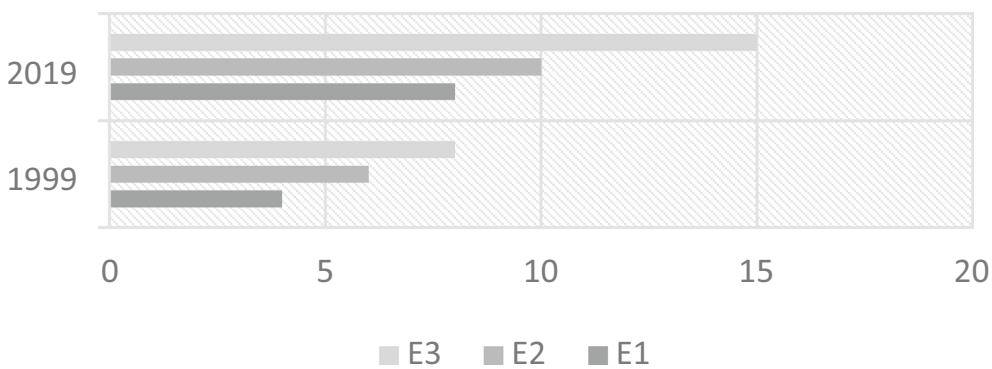


Fig. 12 Topological distances between hospital entrances and MFMC

have become topologically more distant over the years in relation to MFMC (Fig. 12), which is in line with the decrease in the city's average values of integration.

Accessibility of the hospital entrances from the city

The degree of accessibility of hospital entrances is considered an important indicator of hospital accessibility (Haq and Girotto 2003). Due to different means and ways of arrivals, different axial models should be considered (Simoncini et al. 2013). As ED users arrive by vehicle and, although less commonly on foot, vehicle (Fig. 13) and pedestrian (Fig. 14) axial models were created to assess hospital accessibility at global (Rn) and local (R3) levels. The measurements were performed at three reference points—three hospital entrances on a time scale of 1999–2019.

Syntactic analysis of different configurations estimated the period in which certain entries were more accessible. The accessibility potential of the hospital entrances was investigated by considering different ways of arrival. The global accessibility of the western entrance (E2) appeared to be higher compared to other two entrances (Table 3), both in 1999 (Int_Rn 0.73) and 2019 (Int_Rn 0.54), while locally (Table 4), the north (main) entrance (E1) is more accessible in both years (Int_R3 3.1 and Int_R3 2.85). Syntactic analyses indicate a tendency for E2 to remain dominant over E1for vehicles, while the latter for

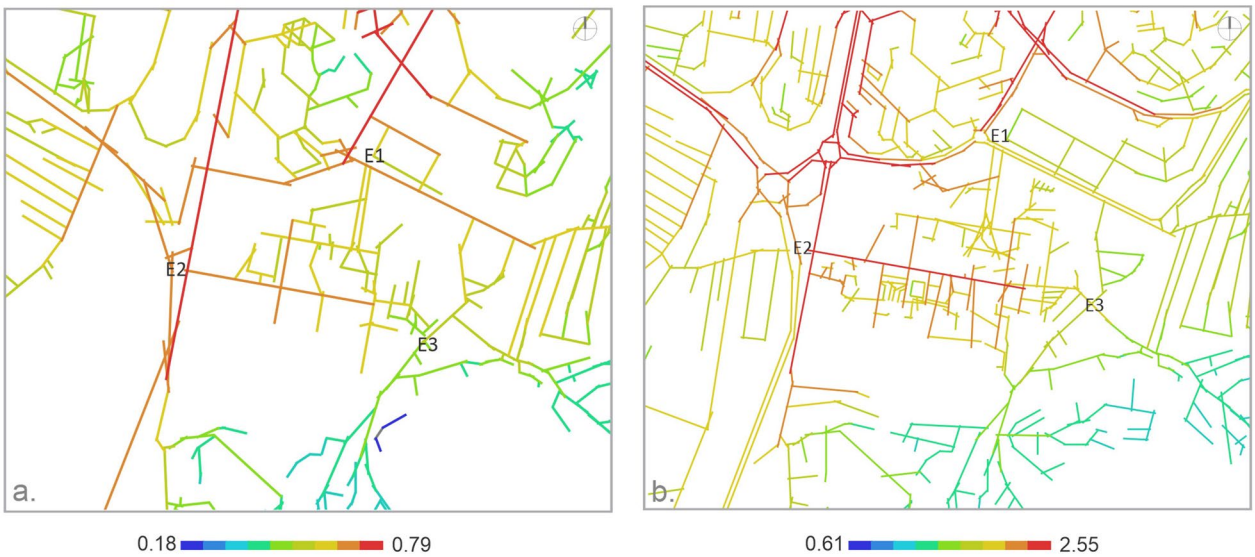


Fig. 13 Global accessibility value (Rn) of hospital entrances; 1999 (**a**), 2019 (**b**)

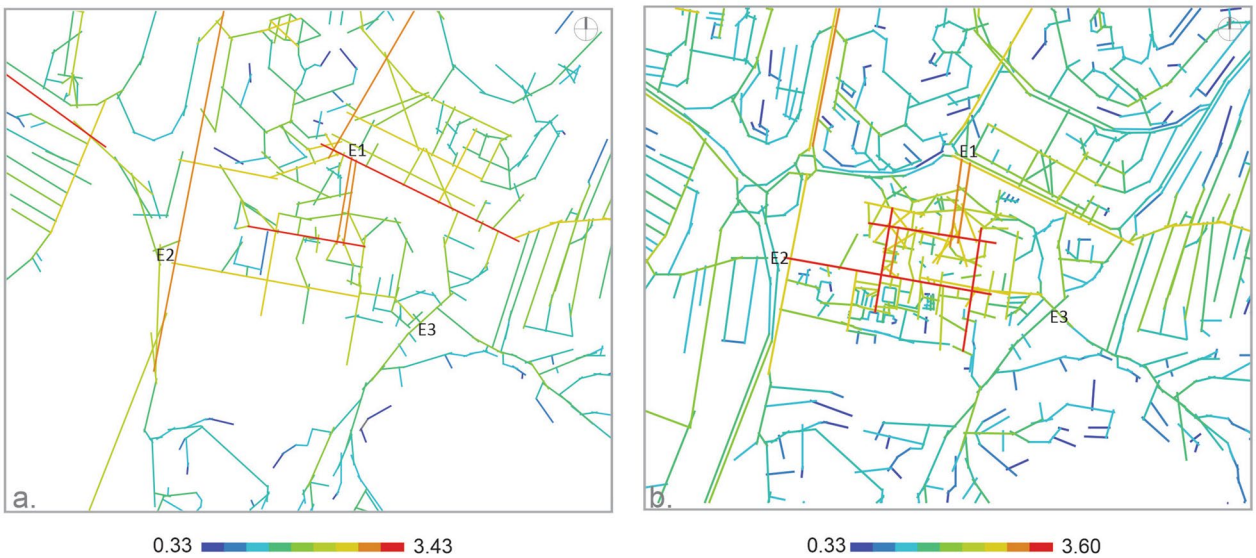


Fig. 14 Local accessibility value (R3) of hospital entrances; 1999 (**a**), 2019 (**b**)

Table 3 Global accessibility values (Rn) of Prishtina

Map/year	Hospital entrances	Int. Rn of entrances	Int. Rn of entrances in relation to the whole system
2019	E1	0.48	m/h
	E2	0.54	m/h
	E3	0.45	m/h
1999	E1	0.66	m/h
	E2	0.73	h
	E3	0.55	m

h high, *m/h* medium high, *m* medium, *l* low

Table 4 Local accessibility values (R3) of Prishtina

Map/year	Hospital entrances	Int. R3 of entrances	Int. R3 of entrances in relation to the whole system
2019	E1	2.85	m/h
	E2	2.5	m/h
	E3	1.89	m
1999	E1	3.1	h
	E2	2.9	m/h
	E3	2	m

h high, *m/h* medium high, *m* medium, *l* low

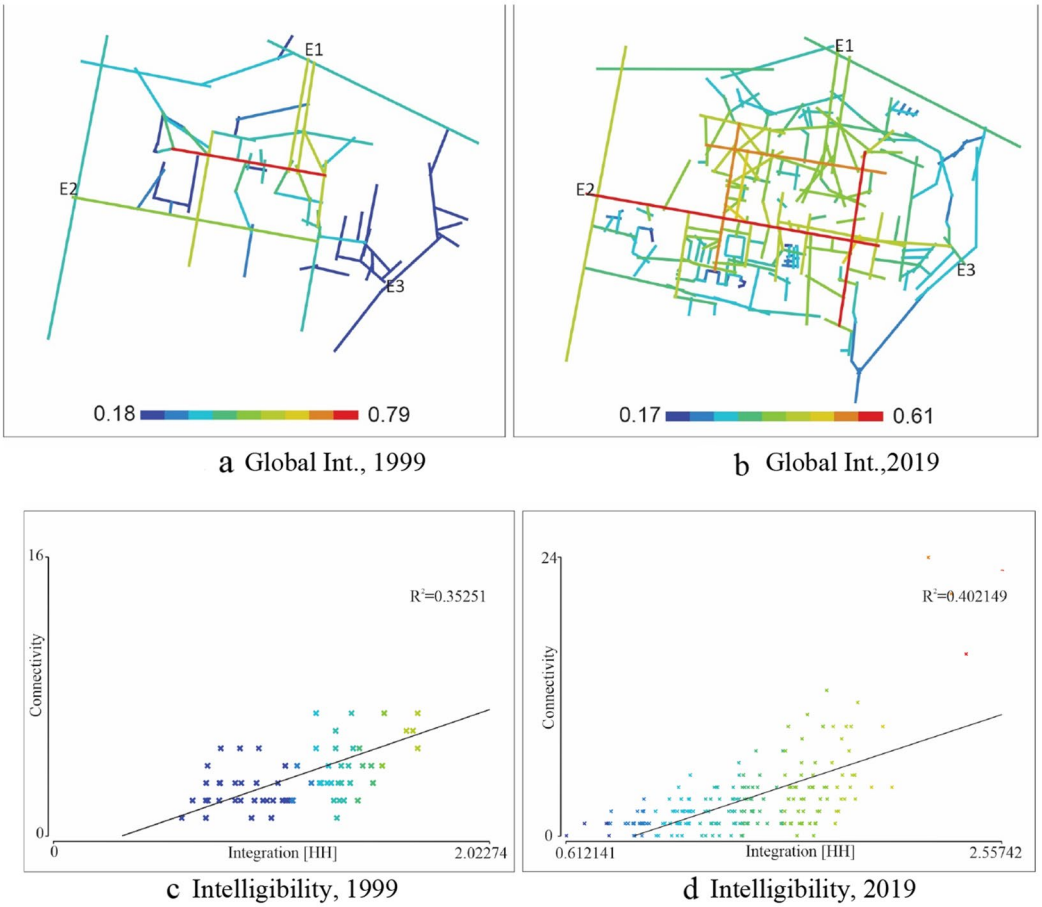


Fig. 15 Global accessibility and intelligibility values of UCCK in 1999 and 2019

pedestrians. This is consistent with the results of a previous research (Meka and Ferati 2021) conducted at UCCK through observation—gate count, with the largest pedestrian flow resulting from the north side of the complex.

The change in the accessibility values of hospital entrances over the years, both globally and locally, was evaluated by determining the interval to which they belong in the depthmap attribute summary and are rated as high, medium high, medium and low values of syntactic attributes for the entire system. The assessment of the spatial accessibility in relation to the whole system shows a decline in the degree of accessibility of the hospital entrances over the years. The E2 entrance was more accessible to vehicles (Table 3) in 1999 than in 2019, while the E1 entrance for pedestrians (Table 4), consistent with the decline in the city's syntactic values over the years. It was also observed that the accessibility of hospital entrances from the city decreases while the topological distances between hospital and reference facilities increase. This can increase the length of the patient's journey, impair navigation and, in some cases, cause disruption to both vehicle and pedestrian movements.

Meso: the hospital

Accessibility and legibility of the hospital

In order to examine the degree of accessibility and legibility within the hospital complex, a diachronic and synchronic configurational analysis of the UCCK road network on the maps of 1999 and 2019, the period after the establishment of the ED, was carried out. The syntactic model of the axial lines was used, through which the global average values of syntactic parameter integration and intelligibility for the campus as a whole were measured. The spatial accessibility assessment on the 1999 hospital map (Fig. 15a) shows that the most integrated road is located in the central part of the campus. In 2019 (Fig. 15b), the transformation of the spatial configuration of the hospital changed the shape of the IC and the hierarchy of the road network due to the increase in the number of constituent roads towards the south axis and transversal roads.

Table 5 Syntactic properties of UCCK

UCCK/years	Connectivity	Integration Rn	Intelligibility
1999	3.43	1.12	0.35
2019	3.88	1.39	0.4

Although the data (Table 5) show a slight increase in syntactic values from 1999 to 2019, however, the relationship between the parts and the whole of the spatial configuration of the campus shows a relatively low level of intelligibility in both years ($R^2=0.35$ and $R^2=0.4$), confirmed through the method of mental maps of K. Lynch, showing that the participants "face difficulties grasping the image of UCCK" (Meka and Ferati 2021). Low intelligibility values indicate an inefficient layout that creates opportunities for disorientation and the appearance of other informal roads to shorten topological distances. This is mainly due to the lack of a master plan during the development of the hospital complex in the last two decades.

The relation between hospital entrances and hospital IC

Analyses of these relationships were carried out on the vehicle (Fig. 16) and pedestrian (Fig. 17) model on the time scale of 1999 and 2019. For the assessment of proximity, the following grade levels were used: high (integrated), medium (moderately integrated) and low (segregated). For the vehicle model, a high value of the degree of proximity was found between E2 and the hospital IC, both in 1999 and 2019, while low levels for E1 and E3 (Table 6). For the pedestrian model, analyses show that E2 in 1999 appeared with low levels, while these values increased to high in 2019 as E2 became part of the

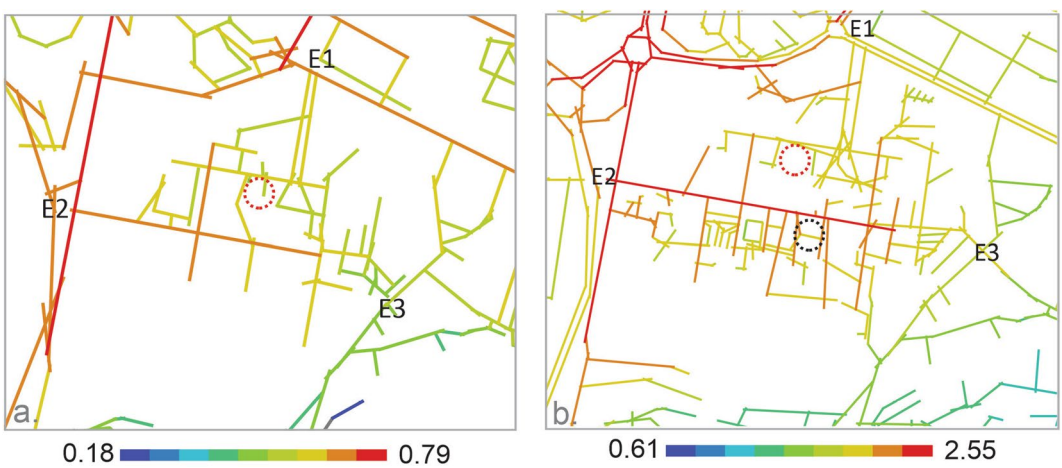


Fig. 16 Relation of the hospital IC with the hospital and ED entrances in a global level Rn; 1999 (**a**), 2019 (**b**); Circled in red—ED1, in black—ED2

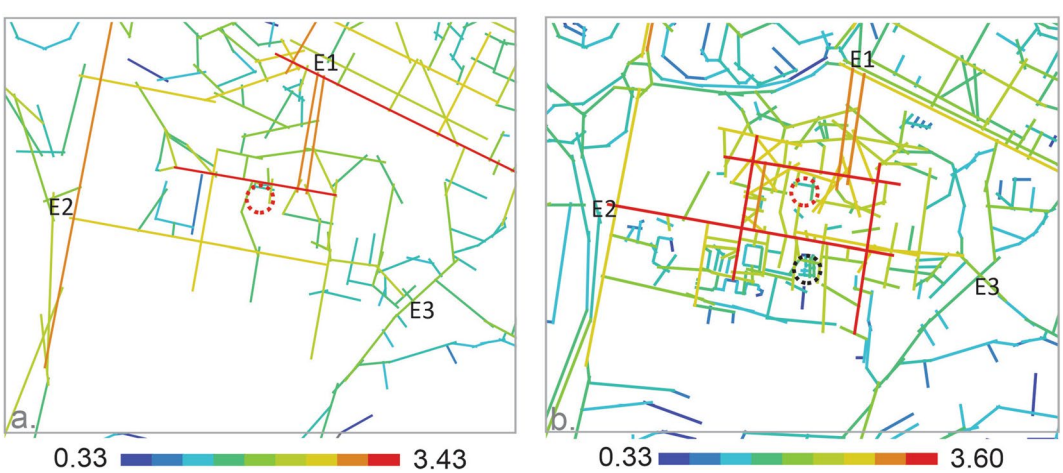


Fig. 17 Relation of the hospital IC with the hospital and ED entrances in a local level R3; 1999 (**a**), 2019 (**b**); Circled in red—ED1, in black—ED2

Table 6 The degree of spatial proximity of the hospital IC to hospital and ED entrances

UCCK/years	Integration core/models	Relation of the hospital IC with the hospital and ED entrances				
		Hospital entrances			ED1 entrances	ED2 entrances
		E 1	E2	E3	W	W
1999	Vehicular	(–)	(++)	(–)	(–)	n/a
	Pedestrian	(++)	(–)	(–)	(++)	n/a
2019	Vehicular	(–)	(++)	(–)	(–)	(++)
	Pedestrian	(+)	(++)	(–)	(++)	(++)

++ high, + medium, – low, *w* walk in entrance

hospital's most integrated road**.** The degree of proximity of this relationship for E1, in both years, is rated as moderate. Therefore, due to hospital configurational changes, syntactic analyses of recent years show the tendency of E2 to gain primacy over E1 for pedestrians, due to its highest proximity values with hospital IC. But the fact that E2 showed greater potential for vehicle accessibility from the city, while E1 for pedestrians, and given their relationship to the hospital's accessibility core, indicates a disruption in the continuity of pedestrian movement from the city to the hospital.

Micro: Emergency Department

The study took advantage of the simultaneous presence of two emergency facilities (ED1 and ED2) in different locations to investigate the impact of ED position on the continuity of patient's movement. Furthermore, it investigated how the configurational value of the ED position changes when the hospital spatial structure is analysed as detached from or connected to the city.

The relation of ED entrances with the hospital IC

According to Peponis and Zimring (1996), integration core is considered as a spatial node of the system and attention should be paid to its relationship with the main destinations. The relationship of the hospital entrance with the hospital IC was evaluated by measuring the value of integration at the global level (Rn) with axial map. The paper focuses on examining the flow of self-presenting visitors to ED walk- in entrance as they are greater in number and mostly unfamiliar with the hospital environment. The degree of proximity was assessed through axial maps of 1999 and 2019 on the vehicle (Fig. 16) and pedestrian (Fig. 17) model by assessing whether ED walk-in entrance is part of the hospital IC, moderately integrated or segregated (Table 6). In 1999, ED1 entrance appears segregated for the vehicle model, while for pedestrian (Fig. 14), as part of the most integrated road of the hospital campus. In 2019, the hospital accessibility core is expanded and its shape becomes convex, allowing the ED1 entrance, for both models, to remain in the same relationship as in 1999. If the location of ED2 is considered, it clearly offers better relationship with the hospital IC for both models, but only better vehicular access from the city, since it is directly connected to the most accessible entrance for vehicular movement (E2). Nevertheless, ED2 is not able to ensure the continuity of pedestrian movement, since, despite its high connection with the IC, the latter has a moderate relationship (Table 6) with E1, as the most accessible entrance for pedestrian movement. These relationships, explored on separately derived hospital maps, show that the configuration value of the ED entry varies depending on whether the hospital is detached (Fig. 18a) or connected (Fig. 18b) to the city. Namely, the value of the most integrated road in the northern part, where ED1 is located, is lower compared to the value when the hospital is connected to the city.

Proximity values between ED and hospital entrances

The degree of spatial proximity of ED entrances to the hospital entrances is considered an important requirement ACEM (2014). Regarding the vehicle model, ED2 offers easier access, with lower topological distance of only 2 step depth with E2 (Table 7). According to ACEM (2014), a clear and direct movement route should be provided between the walk-in ED entrance and the main hospital entrance. In this sense, ED1 provides better pedestrian access from the northern part of the complex in both years, with only 2 step depth to E1, while ED2 in 2019, although from the configurational analysis appears as part of the hospital IC, is unable to ensure continuity of movement for pedestrians due to the higher topological distance of 6 step depth with E1, thereby obstructing the navigation process in the hospital environment.

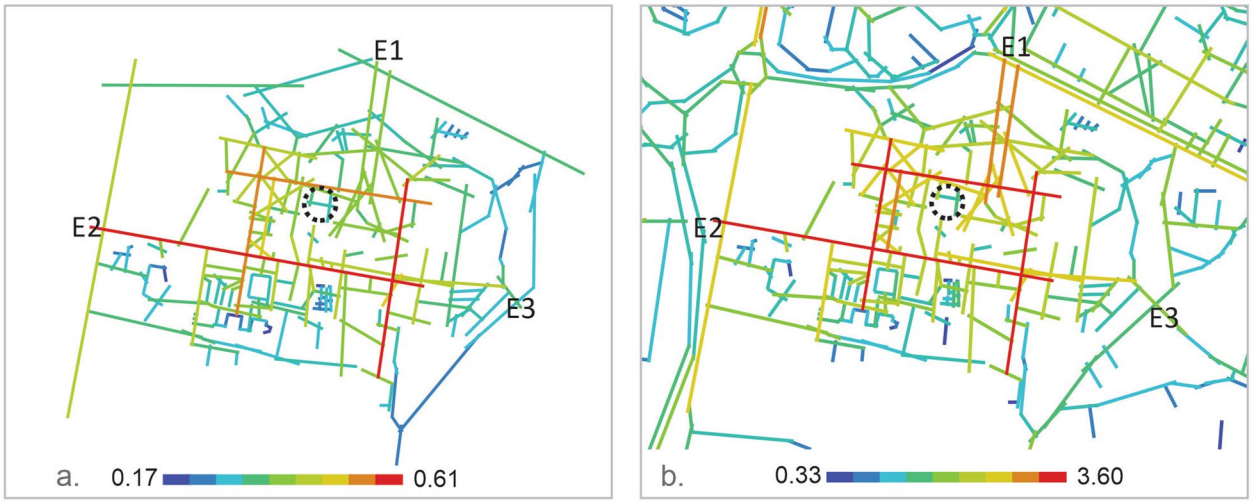


Fig. 18 UCCK spatial structure detached (**a**) and connected (**b**) to the city

Table 7 The degree of spatial proximity of ED entrances to hospital entrances

	ED walk in entrance		Topological distances between ED entrance and hospital entrances (step depth)					
			ED1			ED2		
			E1	E2	E3	E1	E2	E3
1999	Models	Vehicular	2	4	5			
		Pedestrian	2	3	5			
2019		Vehicular	2	4	5	6	2	6
		Pedestrian	2	3	4	6	2	5

E1, E2, E3 hospital entrances

Conclusion

Through the configurational theory of architecture, this study quantitatively investigated the changes of the spatial configuration through the levels of the patient's journey toward ED, at different spatial scales and different time periods and determined its impact on ED accessibility. For this purpose, the study developed a methodological framework of spatial requirements and indicators related to syntactic attributes of space. The research was conducted at the UCCK in the city of Prishtina. The paper revealed that the city has developed segregated both globally and locally, becoming less accessible and less intelligible over the years, which coincides with the period of partial implementation of urban plans due to political and social circumstances. These developments are reflected both in the decrease of accessibility of hospital entrances from the city and in the increase of the topological distances between the hospital and reference facilities. This is manifested in the length of the patient's journey, difficulty in navigation, and in some cases in the disruption of the continuity of movement, both for vehicles and for pedestrians. Due to hospital configurational changes, syntactic analyses of recent hospital configurations clearly reflect the tendency of hospital entrances to change their primacy depending on their relationship with the core of the hospital spatial structure. Discontinuity occurred when the hospital entrances with accessibility potential for a certain way of arrival from the city were segregated in relation to the most accessible hospital roads for the same category of users. The paper also found that any change in ED location affects the continuity of the patient's movement due to its relations with the hospital IC and topological distance to hospital entrances. These changes present difficulties, both due to the greater distance, as well as for the process of navigation through the hospital environment. In addition, research show that the configurational value of the ED entrance varies depending on whether the hospital is detached from or connected to the city. This gives meaning to the idea that ED accessibility should be explored as part of system of territory-hospital-ED relation. The variable configurational value of ED entrance confirms its

relative position in the system of relations. The outcome supports the assumption that the effects of configurational changes across components of the patient journey are interrelated and reflected in the continuity of movement toward ED. Research results could prompt designers and decision-makers in rethinking ways to explore ED accessibility through the levels of patient journey. The configurational approach and the developed methodological framework could serve as a complementary method in the processes of ED planning strategy.

Abbreviations

UCCK	University Clinical Center of Kosovo
ED	Emergency Department
ED1	Current Emergency Department at UCCK
ED2	New Emergency Department at UCCK
E1, E2, E3	UCCK entrances
IC	Integration core

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Competing interests
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