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Routine Action Networks: An architectural study of spatial layouts and performativity in outpatient clinics

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Abstract

Social network analysis offers powerful ways to investigate personal relationships, however, to date little work has explored the more routinized, impersonal work processes present in bureaucratic organizations. Asking whether network analysis has insights to offer into routine work, this paper investigates a data set of direct observations of diagnostic care processes in ten outpatient clinics of two different hospitals. Instead of networks of agents, this study constructs so called action networks, tying together sequences of tasks into networks structures. Following the strong social networks tradition of considering contexts, this paper examines the architectural layout of a setting as key variable. Drawing in particular on ecological approaches to the study of networks by focusing on variability, it is hypothesized that the spatial configuration of clinics is associated with performativity, i.e., a more varied set of sequences to emerge within more open-plan layouts. Results indicate that this is the case, showing how different sets of routines emerge in different types of layout depending on their openness. Variability in routinization is also found between doctors, nurses and clerks, highlighting ecological niches. Network density as well as edge-weighted centralization turned out to be useful metrics for performativity. The work presented contributes to the study of bureaucratic organizations, making a case that social network methods can be fruitfully applied to impersonal, routinized and rule-driven relations.

Keywords

Network ecology; context; spatial layout; action network; routine dynamics; bureaucratic organization; outpatient clinic;

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Introduction

Understanding personalized relationships such as friendship ties, relations of trust or seeking of advice is at the heart of social network analysis. Inside organizations, the importance of personal relations is evident across settings, underlining the importance of affective and thereby strong ties in organizations (Krackhardt, 1992); or illustrating implications for group performance and leader reputation arising from friendship ties (Mehra et al., 2006), to name just a few prominent examples from extant research.

In contrast to personalized relationships, impersonal relations inside organizations such as those captured by the performance of routine tasks have to date attracted less attention from the social networks community.

Yet, routines play an important role in organizational life. In fact, a routinized view of organizations, where tasks have been proceduralized based on rules, roles and hierarchies has dominated the discourse on organizations for centuries: the archetypical Weberian bureaucracy (Lazega, 2020). In addition to this traditional form of organizing, where decisions are made through rules and rulers, a contrasting form of organizing has been described in the work of Lazega and others (Lazega, 2001, 2020; Lazega and Pattison, 1999; Lazega et al., 2011), i.e., collegiality, where decisions are made through deliberations among peers and relational infrastructures. Exactly because personal relationships and infrastructures matter so much in collegial organizations, the methodological and theoretical advances in social network analysis were instrumental in understanding these differently operating organizational forms according to Lazega.

This raises the question whether network analysis can also help us to understand bureaucratic organizations and routinized behaviour better.

Aiming for an initial answer to this question, this paper considers an organizational setting that is often associated with routine work and strict hierarchical structures: a hospital, and more specifically, outpatient clinics, where patients come in for scheduled appointments and particular diagnostic checks and examinations, which follow regular and repeated patterns. Patient care processes present particularly complex routines since they integrate actions by various professional groups, and as such have been considered prototypical in the past (Bucher and Langley, 2016; Pentland et al., 2020b). Healthcare settings are also renowned for their pronounced division of labour (Durkheim, 1893), as well as for hierarchies, silos and tribal working practices, especially between the different professional groups such as doctors and nurses (Braithwaite and Westbrook, 2005; Creswick et al., 2009). This type of bureaucratic and hierarchic organization offers an ideal setting to study routinized behaviour.

Instead of the personalized relationships of friendship, affection, trust or advice between human *actors* which typically form the foundation of social network analysis, this paper investigates the relationships between routine *actions* performed by healthcare workers (HCW) in outpatient clinics. By focusing on activities and their sequences, a procedural perspective is taken that brings the impersonal aspect of routine actions in bureaucratically organized settings to the forefront. This follows the work of Pentland and colleagues (Pentland et al., 2011; Pentland et al., 2017), who coined the term ‘action network’ (also called narrative network) – a network that is formed from routine tasks as vertices and their sequential order as directed edges.

Action networks are a relatively new approach, stemming from an interest in exploring organizational routines and process dynamics. To date only a few empirical cases exist, focusing on invoice processing in Norwegian organizations (Pentland et al., 2011), task schedules in videogame development (Goh and Pentland, 2018), and patient processes in dermatology clinics (Pentland et al., 2020a; Pentland et al., 2020b). In all those cases, routine action networks were created but mainly analysed visually. Analytic methods for action networks are developing rapidly yet to date have mostly focused on investigations of patterning such as motifs or clusters of action (Pentland and Kim, 2021), as well as sequence analysis (Mahringer and Pentland, 2021). Hence, our knowledge of action networks from a network analysis perspective is limited. Here, a quantitative network approach using tools and metrics of social network analysis is chosen to analyze routine tasks in healthcare organizations.

Actions are always embedded in a particular environment, similarly to how social networks have long been argued to be part of their surrounding social or organizational structures. The newly emerging field of network ecology examines “*how features of the social environment shape network structures by affecting the nature of interactions and relationships, and how those relationships, in turn, affect the social environment*” (McFarland et al., 2014, p.1089). The main innovation in network ecology according to McFarland et al. is considering the context in which networks are situated prominently and systematically. Yet, a clear lineage of ideas can be traced back to other scholars interested in social context. This was called foci by Feld, i.e. “*a social, psychological, legal or physical entity around which joint activities are organized (e.g., workplaces, voluntary organizations, (…) etc.)*” (Feld, 1981, p. 1016), but resonates with other theorists including White who argued that humans are controlled by their social surroundings, their “*grounding in material production and the constraints from physical space*” (White, 1992, p. 4).

It is exactly the constraints and opportunities of physical space that this paper brings into focus, as a means to capture the context in which routinized actions in bureaucratic organizations unfold. Physical space is understood here as the material structures of the workplace environment of healthcare workers in outpatient clinics, i.e., the architectural layout of the clinics and therefore the ordering of functional allocations. Architectural elements such as walls, partitions and ceilings demarcate extensions of space while doorways, corridors and staircases connect rooms to one another; furniture and fittings such as waiting room chairs, desks, computers, instrument tables, diagnostic machinery, examination tables etc. set the functionality of a room. All of this taken together describes the spatial configuration of a clinic.

Spatial configuration offers a meaningful way to analyze tie formation in personal relationships (Small and Adler, 2019); likewise, impersonal relations expressed through routine actions can be argued to depend on spatial structures, too (Koch and Steen, 2012).

An example of a routine in an outpatient clinic can exemplify this: a healthcare worker moving from the exam room to the waiting room to call and bring in the next patient for the examinations involves a sequence of actions: walking, talking to patient, walking, talking to another healthcare worker, documenting, and so on. This sequence is situated in a specific spatial layout – depending on locations of waiting room and exam room, a series of spaces will be traversed, resulting for example in longer or shorter walking distances, in fewer or more opportunities to encounter others, in smaller or larger incentives to bundle other activities and tasks along the way. It is easy to imagine how the same routine would play out differently in a highly partitioned workspace with long corridors, large distances and low levels of intervisibility between HCW workstations, waiting room and exam room versus a more open-plan layout with high intervisibility and proximity between key areas.

In this sense, the spatial configuration of a clinic is hypothesized to affect routine performance, specifically regarding the variability of routines. To explore this relationship, this paper uses a detailed configurational analysis of the spatial structure of ten different outpatient clinics across two hospitals alongside direct observations of healthcare worker routines performed by doctors, nurses and clerks to ask whether a more open clinic layout is associated with more varied routines.

Insights derived from this study have the potential to inform theories regarding the structuring of work in bureaucratic organizations. The findings highlight a way to explain routinized, patterned and rule-driven behaviour through both tools of social network analysis, but also in relation to spatial structure, as indeed it was found that more open layouts are associated with more routine variation. Thus, the paper offers a perspective to use network theories and methods to understand impersonal relations. It underlines the relevance of physical space as a context of human actions and contributes to the emerging field of network ecology by offering a perspective into the variability of behaviours.

Research Background

An Ecological Perspective on Context

It has already been argued that the context of a network can be of utmost importance in understanding human actions. Context can capture many different aspects and properties of the environment in which human actions unfold. Across the social networks community, a plethora of different approaches exist regarding what can count as context.

The most prominent type of context is the social environment, i.e., the social units in which individuals or groups of individuals are contained, such as schools, associations, communities, organizations, neighbourhoods, and so on. Sociologists would argue that social action is situated in those contexts. Examples of research in this tradition are studies of kinship networks within and across villages (Entwisle et al., 2007), or the investigation of social arrangements and social infrastructure within a police academy as an influence on tie formation (Conti and Doreian, 2010). This view of context made it into mainstream social networks research through the formalization efforts of scholars so that local social neighbourhoods (Pattison and Robins, 2002) as well as other contextual information such as actor affiliations and attributes (Lusher et al., 2013) can be included in network modelling.

A second type of context is the organizational context in which actors find themselves in. This means explicitly considering the working processes, task structures, organizational cultures and hierarchies all of which might influence how ties form. Exemplary research on organizational contexts include a study of the work processes of lawyers in a New England firm that showed generalised exchange arrangements (Lazega and Pattison, 1999). Another example showed that the structure of association between workers in the famous Bank Wiring Room study by Homans was derived from the division of labour (Pattison and Robins, 2002).

As another type of context, network scholars discussed the spatial environment in which actors form ties, which means focussing on the physical structures across different scales in which actors are embedded, often conceptualised as physical distances between actors, or as geographical clusters. Examples of this stream of work are the special issues in Social Networks on ‘Capturing Context’ (adams et al., 2012) and in Network Science entitled ‘Networks in Space and Time’ (De Benedictis et al., 2015), both of which present a wide range of approaches to studying spatial context. On a micro-scale, the distance between actors as an influence on tie formation was investigated repeatedly over time across different settings, for example in a pioneering study of friendship ties among residents in an apartment block (Festinger et al., 1950), or of communication frequencies of R&D engineers (Allen and Fustfeld, 1975). Scholars also highlighted that teachers with assigned classrooms in close propinquity talked to each other more often (Spillane et al., 2017); and that distances between co-workers in office buildings shape social network structures of face-to-face contact (Potter et al., 2015; Sailer and McCulloh, 2012).

Further approaches to investigating context include considering tie formation on one strata as the context for tie formation on another strata thereby rendering context as dynamic (Lazega, 2020).

In some ways this rich tradition of considering context showcases the relevance of context sensitive research, however, we might ask what makes the context approach of ecology distinct.

The Oxford Dictionary (OED, 2008) defines ecology as a branch of ecology dealing with relationships between living organisms and their environment. Network ecology is the science of using network theories, concepts and methods to investigate a wide range of different aspects of ecology, from relationships within and between species, to relationships between species and their environments, or even general properties of ecosystems (Borrett et al., 2014).

One characteristic of network ecology is placing a particular focus on interactions between species and their environment, possibly more so than on the species themselves (Jordán and Scheuring, 2004). It could be argued that network ecology considers the environment an essential and constitutive part of network relations and in doing so, might differ from other context related network approaches.

Another aspect of network ecology is worth highlighting here. Key concepts of ecology include ecological adaptation and the formation of niches (Borrett et al., 2014), i.e. the process by which species change to better fit to an environment thus creating patterns of variability.

It is those two aspects of network ecology that this paper will draw on, i.e., firstly, considering the environment as a constitutive element of networks, and secondly, studying adaptation and variability of networks within a given ecosystem. As already highlighted, architectural layouts will form the context variable under investigation in this paper, asking how the spatial configuration of an outpatient clinic relates to routine action network structures arising within it, specifically, to which degree variability in routine actions arises.

Routine Work in Organizations

Different approaches exist on how to understand routines. This paper brings together two main perspectives: drawing on the work of Lazega and classic organization theories of

Weber and Taylor, routines can be seen as a fundamental feature of the bureaucratic dimension of organizations, while the work of Feldman and Pentland highlights routines as performed actions.

Lazega (2020) argued that carrying out routine tasks alongside hierarchical coordination and impersonal interactions is a major characterization of bureaucratically structured organizations. The routinization and standardization of tasks into regular activities provides a crucial foundation for the operation of control, imposed by rules and exercised through subordination and supervision, as described in the classic description of organizational rationalization by Weber (1947). This is closely related to the ideas of scientific management and efficient working processes by Taylor (1911), first developed in manufacturing, but later also applied to working processes in hospitals, for example in time and motion studies, measuring the time nurses spent walking as a metric for efficiency (Pachilova and Sailer, Forthcoming; Thompson and Goldin, 1975).

In contrast to the impersonal routine work of the bureaucracy, Lazega sketched a theory of another ideal type of organizing, that of the collegial organization, built on non-routine, innovative work among peers, characterized by uncertain outcomes and high task variability. In addition to the obvious utility of describing bureaucracy versus collegiality as archetypical forms, the author proposed that every organization can be placed on a continuum between bureaucracy and collegiality. Pockets of collegiality may reside in bureaucratic organizations while collegial organizations may be managed in more or less bureaucratic ways.

This perspective of challenging traditional viewpoints and moving away from the view that routines are necessarily fixed and stable is shared by Feldman and Pentland who agreed that routines form a major feature of organizations, however they also maintained that routines are performed and as such entail agency and an inherent capability for change and dynamics. Routines have been defined by Feldman and Pentland as “*repetitive, recognizable patterns of interdependent actions, carried out by multiple actors*” (Feldman and Pentland, 2003, p.95). The authors identified two elements of a routine: the ostensive part, i.e., the objective, idealised version of a process and the performative part, i.e., the subjective enactment by different actors across space and time. As each actor performs a routine, out of their agency and self-reflection emerges variability in the patterning, which gives rise to changes in the prescribed and programmed sequence of a routine.

The variability of routines is particularly interesting to investigate from an ecological perspective, as it may be grounded in both exogenous factors (e.g. exceptional cases or circumstances) as well as endogenous ones (e.g. experience of actors) (Pentland et al., 2011). Feldman and Pentland (2003) theorized this explicitly in relation to variation and selective retention. They argued that the performativity of a routine provides variability as they are enacted slightly differently each time, depending on context, while successful enactments might be selectively retained and become essential part of the ostensive description of the organizational routine in the future.

As space and time matter for performativity, the context of an action is an integral part of the routine, as every enactment is always rooted in a specific organizational, spatial and temporal setting.

The Spatial Configuration of Buildings

One particular perspective on spatial settings is offered by Hillier and Hanson (1984), who argued that a building makes unconscious and abstract organising principles of society concrete and structures power, procedures and principles of engagement. The building layout plays a key role in providing mechanisms of encounter and avoidance: it modulates access, arranges people in relation to one another, either close by or far apart and engenders movement and encounter patterns between different groupings of people. Buildings, so Hillier continues to argue, are "*configurations of space designed to order in space at least some aspects of social relationships*" (Hillier, 1996, p.43). This approach, also known as space syntax, is a morphological theory of space. It takes the configurational qualities of physical space into account, i.e., how spatial elements (such as rooms, corridors or staircases) are put together to form a flowing, interconnected physical environment. This spatial network is meaningful in the context of work and organizational routines. Large open spaces, or those with many connections such as corridors, entrance lobbies or atria offer actors multiple opportunities for actions. It is an arena for the performative enactment of routines. Spaces that an actor can see or access immediately around them constitute awareness and create co-presence with others (Haq, 2003). Another quality of spatial networks creates consequences for action. Spaces in integrated locations, i.e. connecting important parts of the spatial network fabric form strategic thoroughfares and attract more intense movement flows (Hillier et al., 1996; Penn et al., 1999). This increases the likelihood of encountering others. Both of these opportunities, *co-presence* and *movement* can give rise to unplanned encounters and therefore, potentially produce variations in routines.

Traditionally, space syntax theory distinguished two types of ideal organizations: those where activities followed strict rule systems, so called strongly programmed organizations (court buildings, hospitals, etc.), versus those housing uncertain and emergent activities, so called weakly programmed organizations (offices, museums, etc.) (Hillier and Penn, 1991). Spatial configuration was mainly expected to inform activities in weakly programmed organizations, as the rules in strongly programmed ones would override spatial opportunity systems. This dichotomy between strongly and weakly programmed matches the description of bureaucratic versus collegial organizations offered by Lazega. As space was predicted to matter more in weakly programmed organizations according to Hillier and Penn, Lazega argued that social networks mattered more for collegial organizations.

More recent research in the space syntax domain however has begun challenging the strict labelling of organizations as strongly or weakly programmed. Sailer showed that strong programmes can exist in weak programme buildings, for instance attractors in offices, e.g. coffee machines that deviate movement flows away from configurational logic (Sailer, 2007), and likewise, weak programme elements can be found in buildings expected to be rule based, such as hospitals (Sailer et al., 2013). Yet again, this matches Lazega's argument of collegial organizations being run bureaucratically, and pockets of collegiality existing inside bureaucracies.

Against this background, the outpatient clinics of hospitals, a place where we would traditionally expect strict rules, routinized behaviours, strong programming and little relevance of social as well as spatial networks will be scrutinized in this paper.

Routine Variation in Outpatient Clinics in Relation to Spatial Configuration

Bringing all the different strands together, organizational routines and spatial configuration will be explored using a data set of care processes in outpatient clinics across two different hospitals.

Following Pentland and Feldman, the performativity of routines, i.e., the degree to which routines are varied and enacted differently within a given setting is focused on. There is a typical ostensive process of how care is delivered in an outpatient clinic: a doctor calls a patient from the waiting area into the exam room, documents their condition and symptoms, undertakes an examination, diagnoses an issue, potentially in communication with a colleague, documents, talks to the patient and discusses a treatment plan, while nurses assist in the process and clerks support the administrative elements of care. However, routines are also performative, as discussed above and vary according to different contextual parameters.

Inspired by the "*deceptively simple question: What makes a pattern of action more or less varied over time?*" (Goh and Pentland, 2021, p.1918), here it is asked whether it may be the structure of the spatial layout that makes patterns more or less varied. But why would we expect variations in the first place?

Following Hillier and colleagues, two different spatial mechanisms affecting the potential variability in routine actions might be at play drawing on space syntax theory: co-presence and movement as introduced above.

Firstly, local visibility and large viewsheds, i.e., all spaces immediately perceived by an actor from where they are situated whilst performing an action bring opportunities for the variability of routines due to co-presence. A larger number of co-present other actors in the surrounding spaces could lead to an actor proactively deviating from their ostensive routine, for example by seeing a colleague who might be knowledgeable in a specific field and seeking their advice. An actor engaged in a routine might also be interrupted by others as an effect of intervisibility and co-presence. This process of recruiting others into an action or being recruited has been systematically linked to patterns of visibility and co-presence in space syntax literature (Backhouse and Drew, 1992).

Secondly, the theory has suggested that highly integrated areas attract higher intensities of movement flows, and with more frequent movement, chances for co-presence and encounter are yet again increased, once more potentially leading to variations in routines due to recruitment. This is a slightly different spatial mechanism as highly integrated spaces do not necessarily rely on immediate, local properties of the spatial network such as large viewsheds but more so on their global strategic location with overall shortest paths to everywhere else in the spatial network (e.g., central corridors).

In summary, more open layouts with higher degrees of local and global visibility are expected to offer more opportunities for deviations from an ostensive routine due to a higher number of encounters and distractions arising from higher levels of co-presence and movement. It is therefore hypothesized that open layouts, expressed both in terms of local visibility as well as strategic access, host more varied, i.e., more performative routines.

Evidencing a link between routine variability and spatial layout would add a new angle to existing routine dynamics theory by offering explanations for variability that are not just grounded in organizational characteristics or process management but highlight the importance of the spatial context in which actions unfold. It would also add nuance to spatial theories in showcasing the impact of spatial layouts on human actions inside strongly programmed, rule-driven and routinized bureaucracies, where still spatial mechanisms are thought to be less relevant.

Method and Materials

Case Studies

Two different hospitals were studied for this paper. Hospital A is situated in the southern part of the Netherlands in the province Limburg in the outskirts of a small town. It was newly built in 2010 following an extensive consultation and redesign of care processes, including the introduction of a new electronic patient record system, integrating technology with space to provide effective patient care. The hospital delivers 350,000 outpatient treatments every year, in addition to 17,000 inpatient admissions. The four main floors cover a total of 112.000 sqm. Figure 1 shows a floor plan of the lower two floors of the hospital where the out-patient clinics are located. The main spatial design feature of the outpatient clinics in hospital A is an open-plan back-of-house space, arranged next to a series of enclosed examination rooms and accessible to healthcare workers only, where many work processes of documenting, talking with colleagues, walking etc. occur.

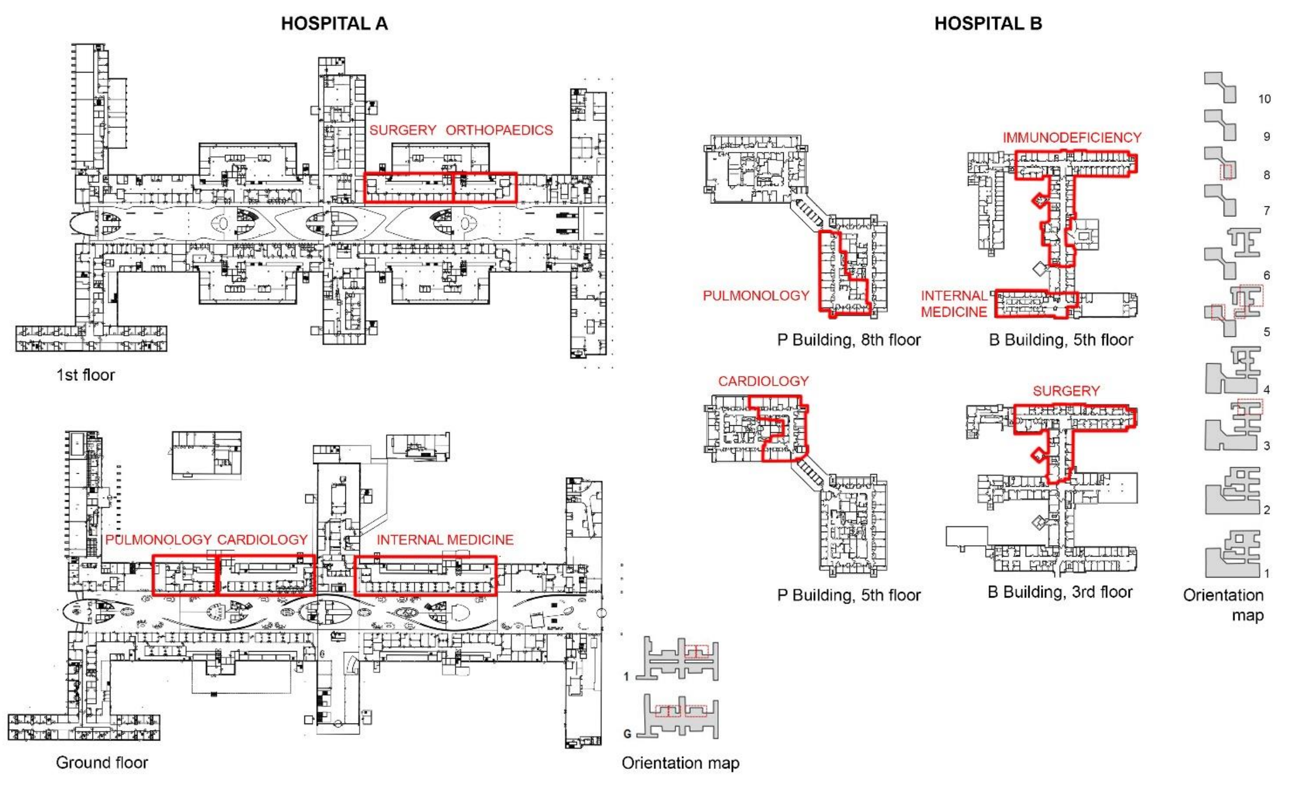

Fig. 1: Floorplans of hospital A and hospital B including location of the studied clinics.

Hospital B in contrast, is situated in the down-town area of a large Canadian city. It was originally built in the early 20th century and extended and refurbished in phases up until 1988. It serves 380,000 patients in outpatient clinics and inpatient wards every year. The hospital is arranged in a 10-storey tower on a relatively small plot of land and a slightly smaller total size than hospital A of approximately 100.000 sqm (see figure 1). The design of hospital B is characterised by a typical corridor and closed room layout with many partitions and most clinics arranged in L, T or U-shaped corridor systems.

The two cases were selected in a two-step process. Hospital B initiated a research project in 2012 since they were interested in a systematic study of their clinic layouts due to upcoming further development and refurbishment plans. In the process of looking for best practice examples elsewhere, they found hospital A as an exemplary case and wished for their care processes to be compared to hospital A. Five out-patient clinics were selected in each of the hospitals with a focus on choosing similar medical fields where possible. In both hospitals, the clinics for cardiology, pulmonology, surgery and internal medicine were selected. In hospital A, orthopaedics was chosen in addition and in hospital B immunodeficiency.

Procedures of informed consent and data anonymization were followed, and the boards of both hospitals gave their ethical approval for the study. Preliminary findings from the project are reported elsewhere (Pachilova and Sailer, 2013; Sailer et al., 2013).

Direct Observation of Activities

Twelve different healthcare workers (six doctors, three nurses, three clerks) were shadowed in each clinic for a target period of one and a half hours and the sequence, duration and location of each activity was logged on a pre-programmed hand-held device. Observers were trained in advance to achieve inter-rater reliability. Activities were easily classified as most involved clearly distinguishable bodily actions (such as talking, walking, documenting, etc.). Observations focused on clinic opening hours, i.e., when healthcare workers interacted with patients. The majority of observations took place between 9am-noon and 2-4pm. Lunch hours (12-2pm) were observed less due to fewer appointments. On average, a single observation sequence lasted for 82 minutes. Since some healthcare workers had to leave the clinic unexpectedly in the middle of the observation, another healthcare worker of the same category was chosen to continue the observation. In total 127 healthcare workers (64 doctors, 33 nurses and 30 clerks) were shadowed in the two hospitals.

A total of 34 detailed activities, defined previously with clinical input, were distinguished in the observations, as highlighted in table 1. All activities were grouped into nine broader categories of tasks: patient care, communicate, document, support, walk, break, wait, off unit and custom (for any other undefined activity).

Due to the nature of work in outpatient clinics as well as the timing of the observation to include only clinic hours, a focus is provided on routine tasks, i.e., the repetitive, recognisable patterns of all the processes involved in seeing patients during diagnostic appointments. Naturally, certain activities expected to occur in any organization will appear underrepresented. For example, only three scheduled meetings occurred during our observation times, as they normally would not have taken place during clinic hours, where healthcare workers focused on patient-related activities. Likewise, activities occurring elsewhere in the hospital but outside of the outpatient clinics, such as care for patients in wards, imaging, operating, laboratory work, going to lunch, etc. are not represented by the data.

CATEGORY	ACTIVITY	COUNT	%
Patient care	Care for patient	547	6.6
	Escort Patient	95	1.2
	Phone with patient	89	1.1
	Talk to family	65	0.8
	Talk with patient	706	8.6
Communicate	Phone	278	3.4
	Scheduled meeting	3	0.0
	Talk with other HCW external	63	0.8
	Talk with other HCW internal	1658	20.1
	Unscheduled meeting	12	0.1
Document	Chart review	185	2.2
	Computer	350	4.2
	Data entry	57	0.7
	Document management	266	3.2
	E-Chart review	597	7.2
	Electronic charting	265	3.2
	Paper charting	179	2.2
Support	Clean	100	1.2
	Completions	46	0.6
	Copy or fax	115	1.4
	Get / drop equipment	43	0.5
	Get / drop linen	17	0.2
	Get / drop supplies	386	4.7
	Prepare slate	72	0.9
	Registration	40	0.5
	Scheduling	16	0.2
	Supply chain management	11	0.1
	Slate review	75	0.9
Walk	Look for caregiver	16	0.2
	Walk	1715	20.8
Break	Break	52	0.6
Wait	Waiting delay	58	0.7
Off unit	Off unit	19	0.2
Custom	Custom	42	0.5
	TOTAL	**8238**	**100.0**

Table 1: Overview of detailed activities observed.

In Hospital A, 5348 distinct activities were observed with a total observation time of more than 90 hours, while in Hospital B, 2890 distinct activities were observed with a total observation time of more than 85 hours.

Constructing Action Networks

In this paper only the sequence of activities is used for further analysis. Each performed activity such as care for a patient, walk, talk to another healthcare worker, etc. counts as a vertex of an action network, while an edge between two activities is created if one activity follows the other in an observed sequence. Due to the focused observations coinciding with clinic hours, it is reasonable to assume that all observed activities are part of the routine work of examinations. Figure 2 exemplifies the principle of constructing an action network from the order of routinized activities of one healthcare worker. As a result, networks are directed and might include loops (if an activity is repeated, for example in a different location). If an activity follows another activity more than once, an edge weight is created based on count data. Edges are then weighted by the frequency of one activity following another with the highest frequency in the network normalised as 1 and all other edge weights therefore ranging between 0 and 1.

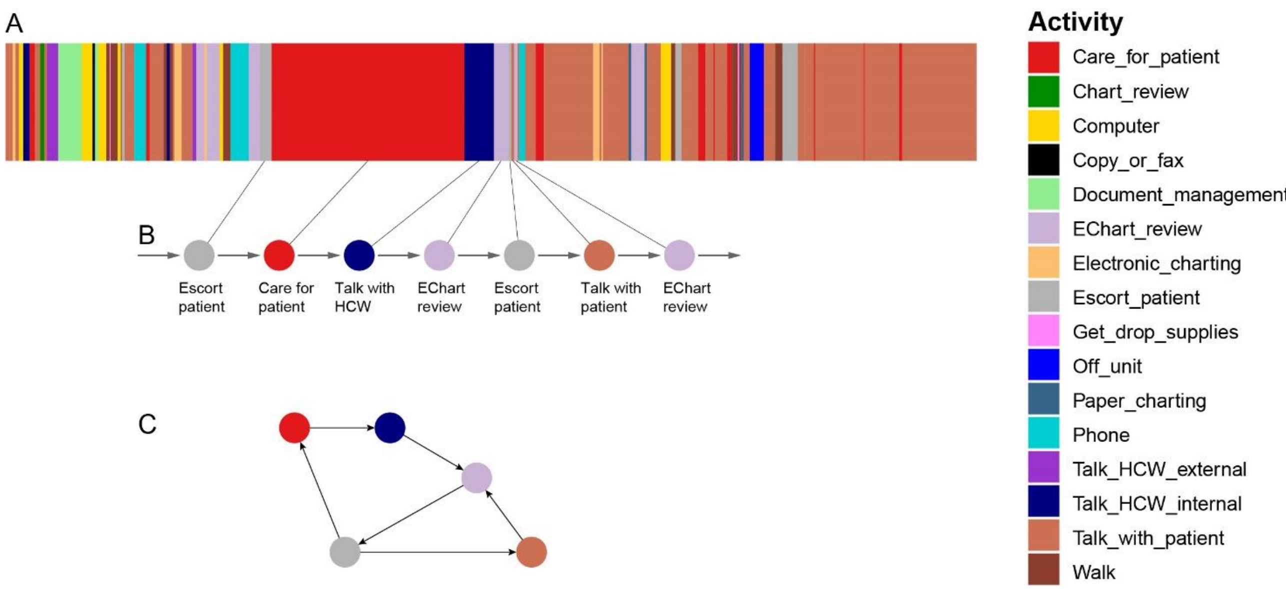

Fig. 2: Sample of a one-hour activity sequence of a cardiology nurse in hospital A (a) with a subsection of the sequence shown as vertices (b), and the resulting network of this subsection (c).

To construct action networks, the R application ThreadNet was used (Pentland, 2019). ThreadNet requires sequential data as an input. Each new observed healthcare worker was treated as a new thread, so that activities were tied together only within the routine of a specific actor. Thus, the beginning and end of a sequence corresponds to the beginning and end of an observation of one particular healthcare worker. Initially, all activities performed in a clinic were considered in creating an action network by clinic (n=10). Differentiating action networks not just by clinic (n=10), but also by role (doctor, nurse, clerk), creates an additional sample with observable variations in network structure. This resulted in three different networks per clinic with the exception of two clinics in hospital B, where the job of nurses was undertaken by clerks, therefore leading to a total sample size of n=28 for role-related action networks.

Network related metrics were calculated in R using the package igraph (Csardi and Nepusz, 2006).

Space Syntax Layout Analysis

The architectural layout of the clinics is investigated by a space syntax analysis. It is a quantitative method based on graph theory, whereby spatial elements are considered vertices and visual or accessible connections form edges. Different representations of what counts as a spatial element are used in this field, however, this paper follows the conventions of a so called 'visibility graph' (Turner et al., 2001), a representation based on small scale locations in a floor plan tied together by visibility relations. This means imposing a regular grid that splits the building floor plan into grid points (here: 0.6x0.6m), which is approximately the area a human body would take up in space including personal space around them. From the centre of each grid point, an isovist (also referred to as viewshed) is created, which is the visible area seen from that particular vantage point (Benedikt, 1979). By connecting all visible grid points to this vantage point (see figure 3) and repeating this step for all possible grid points acting as a vantage point, a visibility graph is constructed, where each grid point is a vertex, and a visible connection is an edge. This visibility graph highlights what can be seen from a particular point in space, as well as shortest paths of visibility from any point to any other point in the clinic.

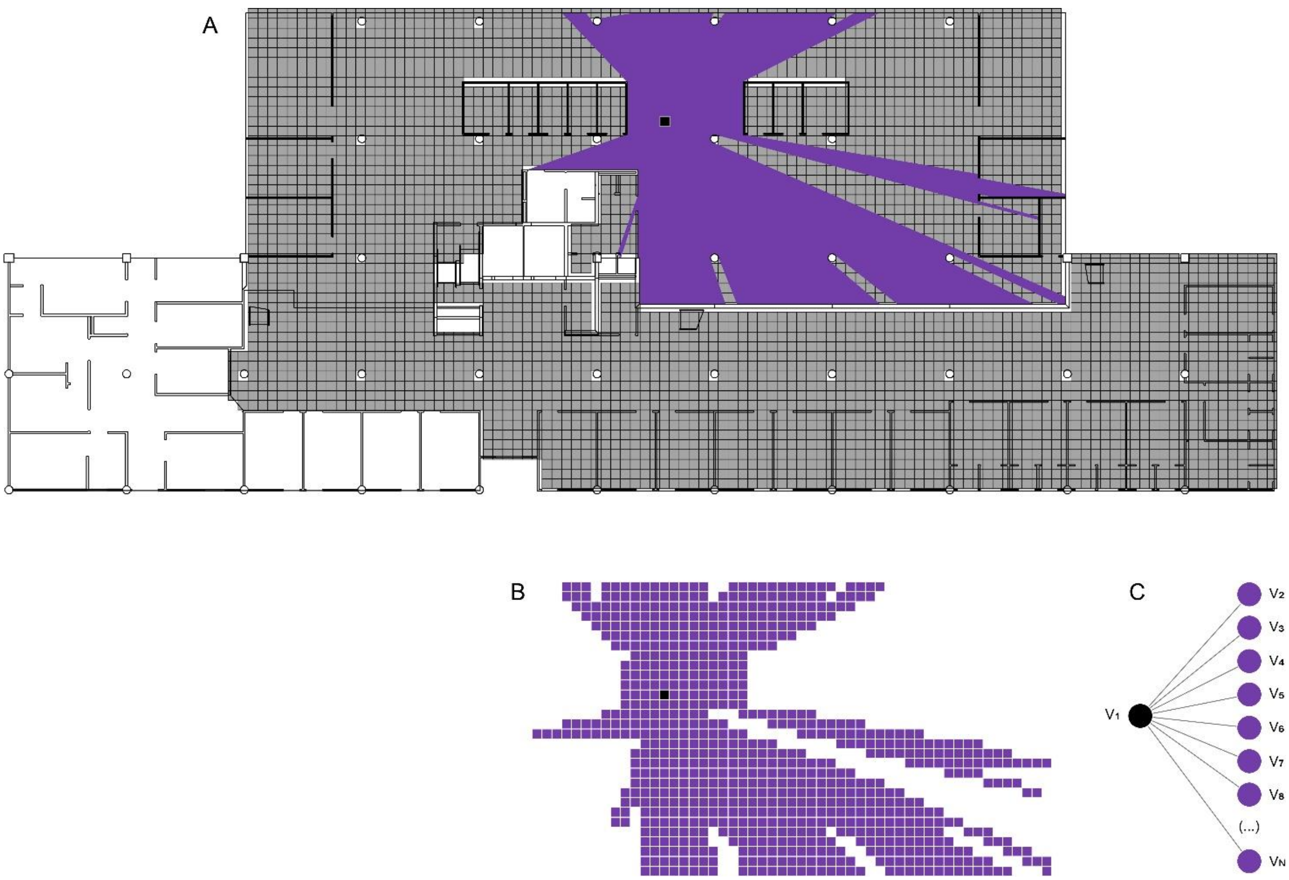

Fig. 3: Construction of a visibility graph: a) floor plan of a clinic (Cardiology in hospital A), split into a 0.6x0.6m grid with grid points shown in grey and overlaid with an isovist (in purple) from one particular vantage point V1 (grid point shown in black); b) all grid points visible from vantage point V1; c) vantage point V1 is connected to all directly visible grid points V2 to Vn in a graph.

Metrics

To analyse action networks, a focus was placed on network level metrics in order to describe and compare each of the action networks against each other. Metrics include:

<u>Network density</u>, i.e., the number of edges in an action network divided by the total number of possible edges, given the number of vertices; output ranges from 0 to 1.

<u>Degree centralization</u>, i.e., the variability in the degree values (number of edges) of vertices as a percentage of that of a perfect star network of the same size; output ranges from 0 to 1.

Edge-weighted degree centralization, i.e., the variability in the edge-weighted degree values of vertices (edge-weighted degree denotes the sum of all edge weights for each vertex) as a percentage of that of a perfect star network of the same size, where all edges have maximum values; output ranges from 0 to 1.

To quantify the qualities of the architectural layouts of the ten clinics, the following space syntax related metrics of interest were calculated:

Connectivity, i.e., the number of other grid points in direct visibility of a spatial vertex (this denotes the size of an isovist, i.e., its viewshed and is conceptually related to degree centrality), calculated for each grid point and aggregated as mean value for the clinic space as a whole.

Mean depth, i.e., the average path length in the spatial network (steps of depth) from a particular vantage point to all other points in the graph, aggregated again as mean value for the clinic space as a whole; this describes how often you have to ‘look around the corner’ to visibly access all possible areas in a space.

Assumptions

The investigation is interested in understanding variations in routines and how the spatial layout of clinics, in particular their openness and degrees of intervisibility are associated with variability. Routines can either by routinized, thus more ostensive, or varied, thus focusing more on performative elements.

Structural network effects for density, degree centralization and edge-weighted degree centralization are considered as follows:

A higher density in a routine action network shows a higher number of ties given the number of nodes. This means a variation in routines, since one action potentially leads to a higher number of possibly following actions, hence a more varied routine. As density is calculated as a single metric for the whole network, it does not discriminate between particular sequences varying more than others; hence it captures overall variability.

Degree centralization considers the distribution of degree values in the network. A higher centralization value means that the network is more star-like and hierarchical. A perfect star structure would mean that one action, say vertex V_1, bridges between all others, or in the case presented here using sequential data, that V_1 is either following every action, or preceding every action, while at the same time vertices V_{2-n} are not connected among themselves directly. Hence with a lower value for degree centralization, degree is distributed more equally among different actions, and the importance and positional advantage of individual actions is less pronounced. Compared to density, this is a slightly different way to express variability or lack thereof in that it focuses on the absence or presence of ideally a single key action tying routines together.

Finally, a higher metric of edge-weighted degree centralization highlights action networks that are more star-like and hierarchical, and in addition have relatively heavy weighted edges leading to central nodes. If a sequence of actions is recurring, edge weight is added. If a routine is heavily routinized and certain short sequences appear again and again, more edge-weight is added in relation to other edges that occur less frequently. This means edge-weighted centralization exacerbates the effect of a hierarchy of routines in comparison to unweighted centralization, which captures only the presence or absence of edges but not their weight. For the sequential data presented in this paper it seems well suited to express a particularly localised effect of routinization through recurring motifs.

In summary, while density captures overall variability and performativity, centralization highlights intermediary steps in routines due to the sequential nature of the data, i.e., activities that link one activity to another and thus become highly central due to their function as bridges. Walking is an obvious candidate for such an intermediary task, which is why it will receive special attention in the analysis to come.

Results: Routine Variation and Spatial Context by Clinic

Overview

Descriptive statistics for the routine action networks for the ten different outpatient clinics are presented in table 2 while figure 4 illustrates their sociograms. The sociograms show some patterning in that walking and talking with other healthcare workers internally take relative prominent positions in each network, highlighted by large degree centralities and high edge weights. However, variations are obvious, too, for example in the Internal Medicine clinic in hospital A, where talking with patients and electronic chart reviewing have higher degree centrality than walking and talking with other healthcare workers.

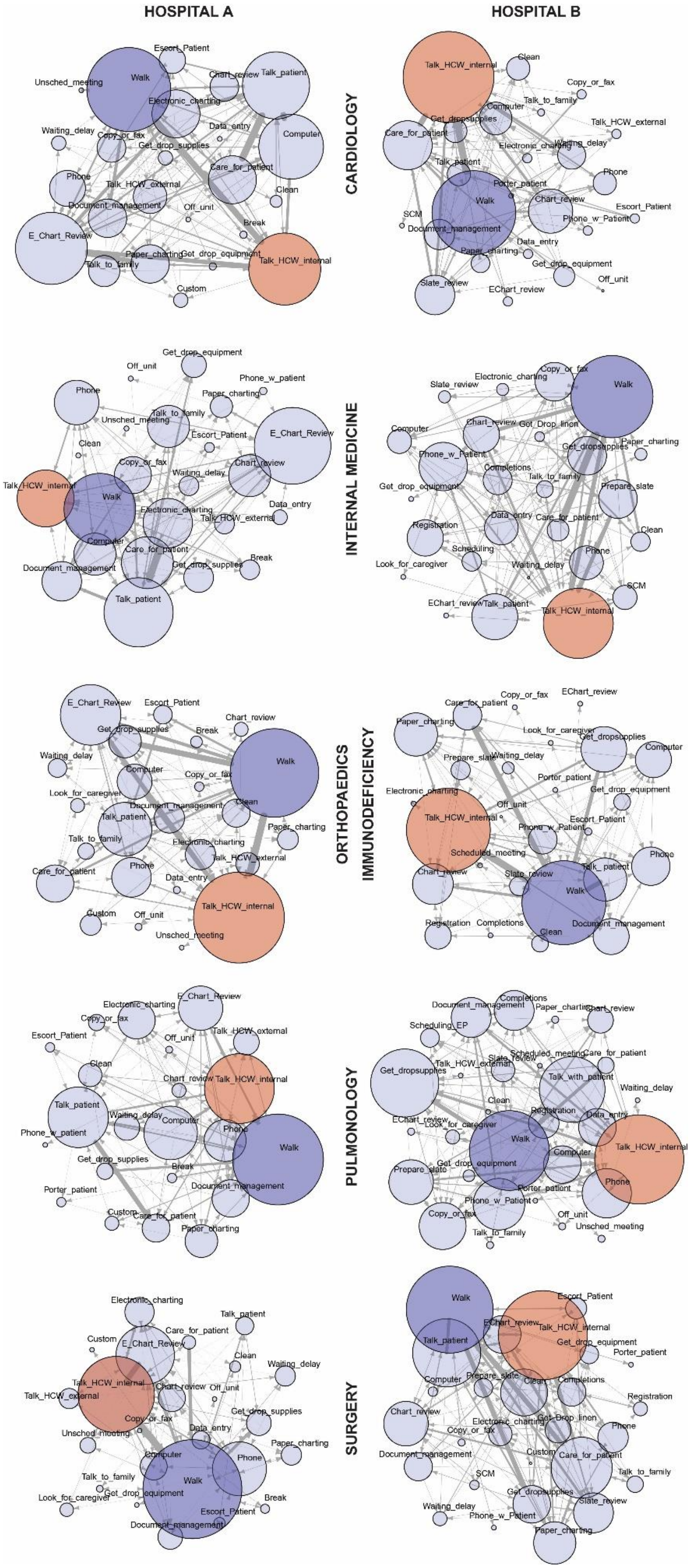
HOSPITAL A
HOSPITAL B
CARDIOLOGY
INTERNAL MEDICINE
ORTHOPAEDICS
IMMUNODEFICIENCY
PULMONOLOGY
SURGERY

Fig. 4: Sociograms of all ten outpatient clinics with vertices sized according to degree centrality and edges according to edge weights. The two prominent activities of walking and talking with internal HCW are highlighted in blue and red.

The networks are comparable in their number of vertices (see table 2), i.e., how many of the different pre-defined activities actually occurred in each clinic context. The number of edges shows a higher degree of variation, ranging from 132 edges to 181 edges, i.e., the number of possible combinations of what follows on from a particular activity. As a result, network densities vary. Clinics in hospital A tend to have a higher action network density than clinics in hospital B. A t-test produces highly significant results ($p<0.0080^{**}$, t-ratio=3.4), which shows that clinics in hospital A have more performative routines, as a higher density signifies that there are more variations in what follows what in healthcare worker routines. The two centralization related network metrics do not produce significant differences between the two sites.

	Action network metrics					Spatial metrics	
Clinic	**No of vertices**	**No of edges**	**Density**	**Degree Centralization**	**Edge-weighted Degree centralization**	**Connectivity**	**Mean Depth**
Cardiology [A]	24	167	0.30	0.48	0.20	491	2.19
Internal Medicine [A]	24	163	0.30	0.40	0.17	453	2.26
Orthopaedics [A]	24	153	0.28	0.60	0.26	445	2.29
Pulmonology [A]	22	144	0.31	0.65	0.22	486	2.33
Surgery [A]	25	137	0.23	0.72	0.21	447	2.26
Cardiology [B]	25	132	0.22	0.62	0.29	140	2.99
Internal Medicine [B]	26	149	0.23	0.47	0.25	163	3.13
Immunodeficiency [B]	26	138	0.21	0.51	0.22	114	2.85
Pulmonology [B]	29	181	0.22	0.47	0.23	124	3.13
Surgery [B]	27	177	0.25	0.50	0.24	161	3.21

Table 2: Network metrics for the action networks (number of vertices, number of edges, density, degree centralization, edge-weighted degree centralization) as well as spatial visibility graph metrics (connectivity and mean depth) of each clinic.

The relation to spatial layout

Single factor linear regressions were conducted for both spatial metrics against all action network related metrics to test whether the openness of the spatial layout of a clinic is associated with greater variability in routine actions. Results are reported in table 3.

		Action network metrics		
		Density	**Degree Centralization**	**Edge-weighted Degree centralization**
Spatial metrics	**Connectivity**	0.67**	0.07	-0.24
	Mean Depth	-0.49*	-0.08	0.25

Table 3: Linear regression results reporting association between spatial metrics and action network metrics; R square values are shown; p-values <0.05 are marked by * and p<0.01 by **; insignificant results are greyed out.

Results indicate that density is associated with spatial layout variables: it is higher in clinics with larger connectivity, and higher in clinics with lower mean depth. This confirms the hypothesis that large local viewsheds (connectivity) and shorter path lengths (mean depth) are associated with a larger degree of overall variation in action sequences. In more open and highly visible layouts there is more choice of which action follows on from another action. The size effects of the correlations highlight that immediate visibility as expressed in connectivity (R^2=0.67) plays a more important role than path lengths shown by mean depth (R^2=-0.49).

In contrast, unweighted or edge-weighted degree centralization did not produce significant results and seem to be unrelated to spatial effects.

Due to the nature of the action networks representing sequences, walking and talking to other healthcare workers with their frequent occurrence (20.8% and 20.1%) as well as their high degree centralities take on intermediary roles, thus gluing other routine actions together. Both activities are crucial in structuring the routine action networks. In addition, walking has a key relationship with a spatial layout, as it is the most clearly spatialised action.

Therefore, the question arises whether the above relationship between routine variability and spatial configuration only holds due to the prominence of walking. In order to analyze this further, the above regressions were repeated after removing the vertex walking from the routine action networks and thereby also removing all links that lead from and to walking. This follows theorisation in the action routine literature arguing that vertex removal highlights that an action is no longer undertaken and therefore also does not offer paths from and to other actions any more thus removing “*possible ways of getting things done*” (Goh and Pentland, 2019, p. 1904).

Remove walking

Results from the linear regressions models excluding walking from the routine action networks are presented in table 4.

		Action network metrics – no walking		
		Density	**Degree Centralization**	**Edge-weighted Degree centralization**
Spatial metrics	**Connectivity**	0.46*	-0.04	-0.74**
	Mean Depth	-0.31	0.01	0.76**

Table 4: Linear regression results reporting association between spatial metrics and the metrics for the reduced action network (walking excluded); R square values are shown; p-values <0.05 are marked by * and p<0.01 by **; insignificant results are greyed out.

As before, degree centralization did not result in any significant correlations. For density, the association with space weakens, to the degree that only connectivity is still significant, yet with a lower effect size (R^2=0.46). The density of a network does not change much when one vertex is removed, even if it is a central one, so this is somewhat expected.

In contrast, edge-weighted centralization returns strong and significant associations with both aspects of spatial structure. Lower connectivity, i.e., smaller local viewsheds and larger mean depth, i.e., longer path lengths in the visibility network are associated with higher edge-weighted degree centralization, hence more partitioned and segregated spatial layouts are associated with star-like and hierarchical routine action networks when walking is removed.

The assumption that the spatial layout only matters because of the prominence of walking did not hold. If anything, the relation is more pronounced, yet it also shifts from a focus of overall variability (density) to localised variability (edge-weighted centralization). When walking is removed as an action from the network, actions are only tied together if they can occur in the same location. Hence a network without walking highlights localised routines in specific places of the clinic setting.

It is also of interest that the t-test between the two sites A and B which did not produce significant results for edge-weighted centralization before, now yields strong differences (p<0.0013**, t-ratio=4.8) between hospital A, which shows lower edge-weighted centralization values (ranging from 0.17 to 0.21) and hospital B with clearly higher ones (from 0.26 to 0.36).

Results: Routine Variation and Spatial Context by Role

In a final step of analysis, routine action networks are split by the roles of the three groups of professionals working in the outpatient clinics – doctors, nurses and clerks – in order to understand how the single spatial context of a clinic may host different routine action network structures. Spatial metrics were again regressed against action network metrics including all 28 routine action networks by role this time.

Linear regressions for the whole data set obtained no significant results, possibly also due to the nature of the data which means that each spatial context of a clinic is inhabited by three different action networks (doctors, nurses, clerks). In most cases, the range of density across the different professions within a single clinic context is considerable, as shown in figure 5 for Cardiology in hospital B. This means that within a single spatial context, distinct routines can play out with varying degrees of ostensivity (low density) or performativity (high density) for each professional role.

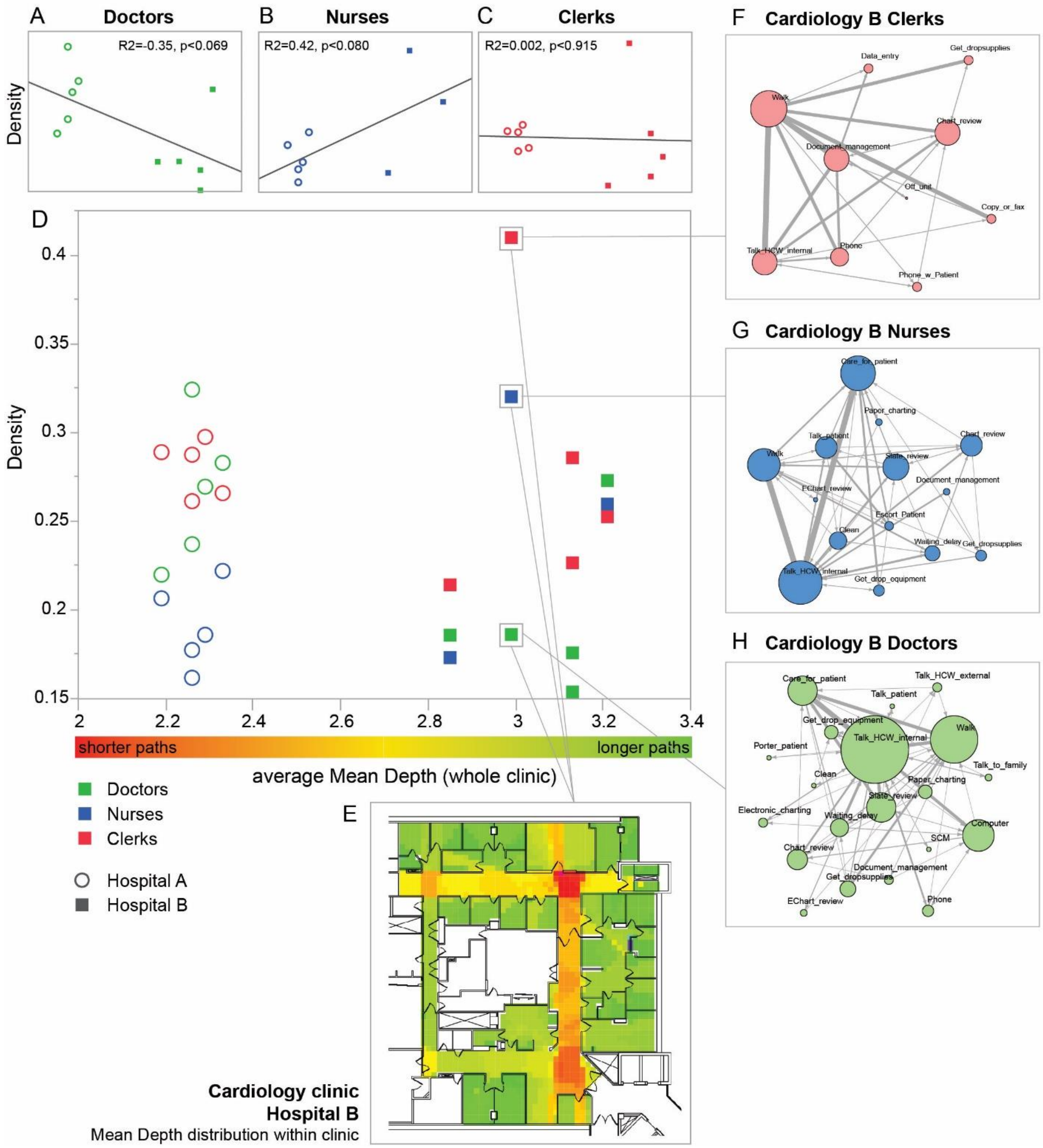

Fig. 5: Scatterplot correlating average mean depth with network density for all 28 action networks by role (d) alongside separate scatterplots for only doctors (a), nurses (b) and clerks (c). Sociograms (f-h) as well as a spatial configuration diagram (e) for the Cardiology clinic in hospital B are shown, too.

It was also investigated whether splitting the data set by role would reveal any spatial rationales for the distribution of action network density and therefore in effect for the variation in density for each of the three professional groups. Results are shown in figure 5a-c.

No significant results are obtained for routine action networks of doctors (fig. 5a), nurses (fig. 5b) or clerks (fig. 5c), however the regression lines point towards a negative trend for doctors and a positive trend for nurses. If results were significant this might mean more routinized patterns for doctors in segregated clinics (as expected) yet more variation for nurses in segregated clinics (rather surprisingly). However, with no significance achieved due to the small sample size, further research will have to confirm any spatial effect and whether indeed higher mean depth (i.e., longer paths) might create different opportunity structures for nurses and doctors: towards more routinization for doctors and towards more variation for nurses. With the results available here, this assertion is not possible and the observed variability in routine action network structures shown for the different professions might have non-spatial reasons but is interesting, nevertheless.

Discussion

It is worth reflecting further on several themes that the above presented results motivate: the nuanced nature of variability, the role of spatial configuration, the importance of walking, and the process of adaptation.

The nuanced nature of variability metrics

Variability in routine action networks is not straightforward to capture with standard social network metrics. In the first place, not many metrics exist that describe the whole network structure in a single variable. Some of the used metrics appeared less relevant overall such as centralization, which did not yield significant results in the regressions while edge-weighted centralization did.

Weighing centralization with edges discriminates more in cases where high degree and heavy edge weights overlap to create a strong reliance on individual actions within a routine procedure. This is particularly pertinent to the nature of the data presented here, which transformed sequences into network structures; thus, prominent actions in tandem with prominent short sequences or motifs represent repetitive routines. The more those motifs feature, and the more single actions stand out as intermediary tasks, the more this gets reflected in high values of edge-weighted centralization.

Density was found to be another successful indicator of the overall variability of routines. Where density increases, there is more variance of which routine action can possibly follow from what, thereby perfectly describing how performative actions are on the whole without focusing too much on intermediary tasks. Density is a metric that is not often investigated in social network analysis with the exception of studies of egocentric networks (see for instance: Marsden, 1993), but here it provides a fruitful perspective.

The role of spatial configuration

Spatial configuration was shown to be associated with routine variability. It cannot be fully ruled out however that other organizational or contextual factors impacted routine variability. For example, it could be the case that the two hospitals differed in how rule-based they functioned in the first place, or how strictly ostensive routines were defined.

With additional background knowledge on the wider organizational context of hospitals A and B, this concern can be alleviated. Hospital A underwent a strategic reorganization at the same time as the hospital building was designed. Hospital managers were keen to modernize not only the physical space but also how technology was integrated and how care was delivered. Therefore, many common assumptions were questioned, for example whether each doctor required their own personalized exam room, or whether patients really needed to see a doctor first before undergoing scans and imaging, as this meant separate appointments and more complicated work processes. Through detailed consultation and with input from senior clinicians, care processes were redesigned. Their implementation in everyday practice turned them into a valid way of thinking and acting based on shared norms. As a result of this history of process optimization and rationalization, we would expect clinics in hospital A to show more ostensive routines compared to B.

In reality though, clinics in A showed more routine variability than B, which brings us back to the spatial layout. It could be argued that the open and overall integrated spatial configuration of clinics in A made routine action networks more varied and less hierarchical.

It is worth going into more detail on the architectural mechanisms at play and how this relates to extant architectural knowledge, linking back explicitly to the theory section.

The main difference between an open-plan and a corridor layout lies in two aspects linked to everyday life: firstly, the relevance of seeing and being seen, which modulates and normalizes behaviours especially those on the front stage (Goffman, 1959) but also expresses co-presence, proximity and immediacy of personal exchange; and secondly the ease with which others can be reached and called upon for advice. The former is expressed in immediate local visibility, or viewshed sizes (connectivity), while the latter is highlighted by path lengths (mean depth). This was theorized earlier as the difference between the spatial orchestration of co-presence and movement. In this sense, spatial configuration can be considered an opportunity structure of nuanced levels of access to others, either immediate access by direct lines of sight, or mediated access through movement. What the findings highlighted is an increased performativity of routines in clinics with larger viewsheds and shorter paths, evidenced by higher action network density, i.e., more variability in what follows from one particular action. The potential presence of other people seems to make routines more performative due to recruitment opportunities but also distractions. Larger viewsheds seemed particularly pertinent in this context, highlighting the importance of immediate co-presence for variability.

This supports existing research on the relevance of larger viewsheds in healthcare settings, which were shown to affect increased levels of communication among care teams as well as quality of care provided while healthcare workers go about their routine work (Pachilova and Sailer, 2020).

Following the theory of strongly and weakly programmed buildings (Hillier and Penn, 1991), we would not necessarily expect configuration to predict rule-driven behaviours in so called 'conservative' organizations. Therefore, the fact that not only emergent, non-routine and collegiate behaviours can be explained through the spatial logic of building configuration, but also the routinized, patterned, rule-driven and more bureaucratic aspects of work organization is note-worthy. This adds to our understand of bureaucratic organizations as more or less routinized and rationalized with 'pockets of collegiality' (Lazega, 2020) even found within routine procedures.

The importance of walking as an action

Following on from the above architectural sensemaking, the importance of walking as an intermediary action is worth reflecting on further.

Walking is particularly key in routine action networks as shown; it is needed especially when immediate visibility does not offer many opportunities, for example for consulting with colleagues, or asking for advice.

When walking as an action is removed from routine action networks, the impact of spatial configuration as a predictor of overall variability as captured by density weakens somewhat, since correlations show lower coefficients or no significance anymore. The fact that connectivity is still associated with action network density yet again highlights the importance of immediate visibility and co-presence to enable performativity and engender variability.

In addition, removing walking makes a significant difference to the hierarchy of actions in observed routine action networks, since spatial configuration is now a strong and significant predictor of edge-weighted centralization. It seems that the localised perspective that the removing of walking engenders fits well with what edge-weighted centralization captures as a metric.

For edge-weighted centralization, differences between the two sites are now more pronounced, as the highly significant t-test highlighted. Hospital B showed a much more hierarchical structuring of routines than A with differences between the sites exacerbated by the removal of walking. When walking as intermediary action and ‘glue’ in the routine procedures is missing, this is replaced by a variety of actions in A, e.g., talking with other healthcare workers, charting, document review, being on the phone, patient care, or talking with patients. The localisation effect of removing walking did not seem to make too much of a difference to clinics in A. As a result, clinics in A have lower or similar edge-weighted centralization values in their action networks without the presence of walking, possibly as a result of the overall spatial integration of the layout and the inherent proximities of the open-plan, so that spatial opportunities are still available in direct line of sight. Hence, walking is not needed immediately and the action network remains reasonably balanced.

In contrast, the absence of walking is not buffered in the same way in the clinics in hospital B. Without walking, healthcare workers are thrown back to what their immediate surroundings offer: due to the partitioned layout, other healthcare workers are normally not in direct line of sight, therefore not available for ‘recruitment’ (Backhouse and Drew, 1992) in the same way as in hospital A. Hence, a strong reliance in the walking-less action network of clinics in B is placed on talking with patients for example. This makes the network more hierarchical, less variable, less dynamic, and arguable less resilient. It can be summarized that walking is really important in the routine action network of clinics in hospital B. This goes to show that space is not just relevant as a descriptor of physical distance but highlights built-in immediate opportunities for performativity arising from configuration (Small and Adler, 2019).

Adaptation and Ecological Niches

Finally, results can be interpreted to fit the principles of adaptation and ecological niches. Action network structures seemed aligned with their spatial context, i.e., higher degrees of routinization were generally associated with more segregated spaces. The process of selective retention (Feldman and Pentland, 2003) might be at play here. Following the discussion above on the role of spatial configuration, space has been argued to form a 'field of probabilistic encounter' (Hillier et al., 1987) making certain patterns more likely than others. Of course, healthcare workers can equally choose to interact frequently in segregated locations in a layout, yet this would cost additional effort, and as such is less pertinent, all other things being equal. Spatial structures might therefore create particular affordances for selective retention of activity patterns that are well suited to their environment.

Additionally, niches emerge, as the same spatial context hosted a variety of ostensive and performative routines for the different professions. Exact effects could not be established, at least not in relation to spatial variables. Yet, differences in the spatialised behaviours and positioning of doctors and nurses has been found in previous studies, for example highlighting how doctors were found in highly visible spaces, whereas nurses positioned themselves in spaces visible from patient beds (Lu and Zimring, 2011). Therefore, the potential variability in routines found between doctors and nurses might offer relevant future research opportunities.

Conclusions

This paper has set out to investigate the variation of routine tasks in bureaucratic, hierarchical organizations. Diagnostic care processes in outpatient clinics during clinic hours were investigated in relation and as a response to the physical layout of the clinics, i.e., their built-in opportunity structures of 1) seeing others in the immediate environment as well as 2) reaching others easily through short path lengths in the spatial network.

It was found that open-plan clinics with their high levels of visibility and short path lengths showed a larger degree of overall variation in routine task performance, whereas partitioned clinics performed in more routinized ways. Removing the action of walking from the routine action networks highlighted how walking glues routines together, particularly in segregated, partitioned environments.

The main contribution of this paper lies in offering an approach to study routine actions and their spatial embedding through the means of network analysis. Investigating routines as networks of action alongside the spatial configuration in which these actions unfold provides an opportunity to explore variability of actions with the help of network methods in a setting traditionally considered bureaucratic and thus less amenable to social network approaches. This can add to the study of the organization of work.

In addition, the paper identified relevant metrics from the standard toolbox of the social network analysis domain to capture the performativity of routine actions (density, edge-weighted centralisation). By highlighting the relevance of spatial structure, the paper adds an exciting new angle of context dependency to the routine dynamics literature. Furthermore, the exploration of niches, selective retention and adaptation contributes to the emerging field of network ecology, showcasing how those aspects might be captured empirically by borrowing the idea of variability from the routine dynamics literature.

As every piece of research this paper has multiple limitations. The most obvious one is the complex case study design, varying every possible factor between the two settings (national care regime, organizational culture, spatial context), which is less than ideal for a comparative study. Future studies could aim for more tightly controlled context variables, or in contrast, capture differences more systematically so that they can be operationalized and included in more complex multilevel modelling. Combining the study of routine action networks with the study of collegiate personal networks of advice within the same setting would be fascinating.

In addition, walking was captured as a generic activity. Distinguishing between different destinations of walking (similarly to how communicating was differentiated according to whom someone was talking to) might bring up new results. It could also be interesting to deepen the insights on the role of walking by removing walking not as a vertex including all its edges but instead to stitch together the preceding and subsequent actions of walking, thus removing the need for walking as an intermediary step. In a way that would assume a ‘space-less’ space, or one in which physical properties do not matter and where dimensions and distances are meaningless to bring people together, or tie actions together. In this theoretical scenario, it could be expected that differences between hospitals A and B might disappear and that spatial layout variables might matter less for variability, as the partitioned layout could not unfold such a strong effect anymore. Follow-on research could explore this further.

Two more avenues for future research seem fruitful: firstly, the ostensivity of initial routine definitions could be studied more in depth, for example by conducting qualitative interviews with healthcare workers to capture their understanding of routines, how they would describe their ostensive routines and what motivates potential deviations and performativity.

Secondly, variations could be explored even further to build on the theme of ecological adaptation, for instance by creating day shift networks, morning / afternoon clinic networks, or even individual healthcare worker action networks to understand to what degree these routines are repetitive, rule-driven, hence bureaucratic, or to what degree they are imbued with personality of the actors, building on possible collegiality and community spirit forming during shifts. Considering actor-level attributes (gender, experience, tenure, detailed role) would add to this. This would allow an investigation into individual or collective agency versus the concept of top-down imposed rules that are the same for everyone in theory. Such a study might build on the concept of relational turnover, whereby an organizational structure and pecking order was shown to remain stable despite turnover of individuals filling certain roles, yet role relationships and relational structures were more volatile (Lazega et al., 2011). Asking how much the networks of routine actions might differ from one day or shift to another also challenges architectural theory. Hillier suggests that space acts at the level of collective patterns of action and not on individual levels of behaviour (Hillier, 1996), so we might ask at what point of stratification would the importance of space break?

To conclude, the data presented in this paper makes a first step towards detailed, architecturally informed insights into bureaucratic routine-driven organizing by using social network methods on non-social networks of action. As such this opens up further opportunities to theorize the continuum between bureaucracy and collegiality, between impersonal and personal relationships.

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