Post-Occupancy Evaluation applied to the design of a complex hospital by means of the flow analysis

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Abstract: Design contributions to contemporary complex hospitals, based on the study of flows and the successive spatial readjustments they are subjected to, favor the preparation of architectural programs that are more capable of meeting the needs of their users. The Cancer Institute of the State of São Paulo (Instituto do Câncer do Estado de São Paulo – ICESP) is a large high-rise building, located in Brazil, in the metropolitan area of São Paulo, in a high-density urban region with a built area of approximately 82,500 m². The architectural aspects of this building that emerge from the Post-Occupancy Evaluation – POE approach, in terms of functionality, through the evaluation of its flows, aiming at identifying their impacts on patients and the work of the staff, are presented. It is hypothesized that the continuous application of POE can ensure that flows remain appropriate during the life cycle of this type of building, bringing benefits such as: a) the best addressing of users’ needs; b) the reduction of contamination cases deriving from the unwanted intersection of flows and c) the assurance that the means of circulation inside the building meet its daily need.

Keywords: Post-Occupancy Evaluation – POE, functionality, hospital facilities; flow of users.

1. Introduction

In today’s scenario, hospital buildings tend to lose their original functionality and new technologies render them obsolete quickly (Thomazoni, 2009). The study of operative flows in a hospital building, that is, of users, materials, equipment and corpses, in light of the successive spatial readjustments they are subjected to, helps to preserve the concept of humanization and elects the most appropriate design processes to better meet the expectations of users and generate safe and quality care.

As Voordt (2016) has pointed out, end-user satisfaction, enhancing productivity and stimulating innovation are highly prioritised; which values are prioritised depends on the organisational objectives, target group, available budget, position in the life cycle of design, construction and use and external context, in particular governmental policy. In Brazil, the operationalisation into concrete design choices and strategic management of buildings-in-use is still underdeveloped. In addition to this, the benefits arising from recent and new technologies, with impacts on the pre-established flows in the hospital
building, such as: the results of the implementation of the pneumatic mail system, the advances in Information Technology – IT and in the Information and Communication Technologies in Healthcare – ICTH, as well as in Telemedicine and Preventive Medicine, are irrefutable in the identification of improvements that affect the architectural aspects of this type of building.

2. Objective

The evaluation of verticalized hospitals on a regular basis, with a focus on functional aspects, can ensure that the flows of users, materials, equipment and corpses are kept appropriate, aiming at identifying their impacts on patients as well as on the staff and their work which may be directly or indirectly related to health care. This article highlights the relevance of the POE results with a focus on flows to improve the quality of the design process.

3. Methodology

As the research was conducted, the scarcity of literature on flows in contemporary complex hospital buildings in Brazil and around the world became apparent. Abroad and more recently, the approaches on hospitals correlate the POE to the analysis of the efficient control systems of the building. In the USA, the publications of The American Institute of Architects – AIA, the Washington State Hospital Association – WSHA and the Design & Health World Congress & Exhibition, an annual world congress that aims to increase the knowledge of the interdisciplinary science of design and health (International Academy of Design and Health, 2015), stand out. In Brazil, flows are studied conceptually and can be dealt with in events, congresses and issues of specialized magazines, but they frequently have neither mappings and drawings nor conclusions by architects themselves. The lack of accurate visual information can be identified as a major cause for the delay in the application of the technical findings to new designs (Kowaltowski, 2006).

An interview script was prepared containing ten questions about five different aspects: a) the integration of flows that are external to the hospital with the internal ones; b) whether the study of flows can contribute to the development of better hospital designs and to the changes and extensions of the building; c) the intersections of undesirable and desirable flows and of spontaneous occupations; d) the physical sectorization; e) the POE in the routine of hospital architecture firms and on the interdisciplinary contribution to new hospital designs.

For the understanding of the healthcare design of contemporary and complex high-rise hospital buildings through the POE approach, as to its operative flows, an evaluation of a case study on the Cancer Institute of the State of São Paulo – ICESP (in Portuguese) was performed. The evaluation was supported by the analysis of the existing literature, the study of the main Brazilian legislative and normative requirements, interviews with eight experts of interdisciplinary backgrounds and with architects that are specialists in hospital architecture, as well with fifteen ICESP’s healthcare professionals.

For the application of the POE to the case study, regarding the analysis of flows and their functionality, the main Brazilian normative reference is the ANVISA RDC 50 (National Health Surveillance Agency, 2002) which deals with the technical regulation for the planning, programming, development and evaluation of the design of Health Care Facilities. This regulation presents the sectorization of health care buildings divided into eight functional units, which favors the analysis of the flows involved: (1) Outpatient and Day Hospital Services; (2) Immediate Care; (3) Inpatient Services; (4) Diagnostic Support and Therapy; (5) Technical Support; (6) Education and Research; (7) Administrative Support; (8) Logistical Support.
Critical areas ("environments where the risk of the transmission of infectious agents is greater, in which risky procedures are performed with or without patients or where immunocompromised patients are present" (National Health Surveillance Agency, 2002, p. 63)) impacts on flow aspects in environments such as the kitchen, operating rooms, central sterile supply storage and laundry area (Karman, 1995, p. 109). Among the design recommendations on the intersection of contaminated material flows, several precautions can be eliminated with the confinement and the protection of contaminated materials at their source, i.e., with the correct packaging technique and with safe transportation. Under these conditions, the intersection of laundry carts, clean clothes carts, trash carts, food carts, dirty material carts and sterilized material carts is acceptable, allowing the elimination of routes, doors, walls and resources used to prevent the transfer of potentially pathogenic contaminants.

3.1. The case study

The case study is a contemporary complex hospital specialized in cancer treatment that provides about 54,000 medical services a month. The building is located in the metropolitan region of São Paulo, Brazil, in a high-density urban area, with a 440 bed-capacity and it has been in operation for six years. The building has a built area of approximately 82,500 m², 28 floors (112 meters high), one of highest hospitals in the world. Its vertical typology has a system of three vertical blocks interconnected horizontally: the main one, where health care services take place and the two lateral ones, for the circulation of patients, companions and visitors. On each floor, care teams are located and circulate in the Core of the building while patients, companions and visitors reach the main tower through the two lateral blocks (Figure 1).

![Figure 1: Core and user flow on floor plan. (source: Thomazoni, 2016)](image)

Although different authors may adopt different sectorizations for healthcare buildings, the analysis of user, material, equipment, and corpse flows in the building, that is the focus of this case study, was carried out according to the eight functional units defined by National Health Surveillance Agency (2002).
As shown in Figure 2, the functional organization is arranged in such a way that activities requiring a high turnover of users are placed on lower floors while those of low turnover are placed on higher ones.

### 3.2. The methodological procedures

The methods and techniques applied and selected with a focus on people, environments and the institution took into account their aim, time, the limitations of data collection in a healthcare building, the systematization and analysis of data, the availability of financial and human resources and the access to information. In order to do that, the most appropriate tools from the theoretical and methodological framework used in researches in the area of Post-Occupancy Evaluation were applied. According to Ornstein et al. (2009), the use of POE tools for new buildings and the remodelling of existing ones help to constantly update master plans of occupation, especially in the case of large and complex buildings, such as healthcare facilities.

For the case study, in a four-month period in 2014, through weekly visits, the following POE tools and techniques were applied: a) survey of the occupation history; b) study of the sectorization by functional units; c) study of the architectural designs; d) reconnaissance visits; e) technical visits/walkthroughs and wayfinding; f) checklist application; g) visual records; h) organizational chart analysis for the definition of interviewees; i) 15 semi-structured interviews with key personnel; j) observation of user, equipment, material and corpse flows. The research involved twenty-one ICESP users, encompassing eight functional units. The semi-structured interviews with key people addressed the viewpoints of cancer patients, since it was not possible to have contact with patients themselves.
The following people were interviewed: Director of Building Infrastructure and Clinical Engineering; Architect; Building Infrastructure Manager; Building Engineering Manager; Director of Operations and IT (Information Technology); Outpatient Functional Unit and Day Hospital Manager; Diagnosis and Therapy Functional Unit Manager; Directors’ Medical Assistant; Infectious Diseases Medical Coordinator; Infectious Diseases Nurse; Ambulatory Coordinator; Director of Education and Research; Administrative Director; Surgery Center Nurse Manager and Director of the Emergency Department.

4. The new and recent technologies

In Brazil, among the recent technological developments with effects on pre-established flows in hospital buildings, it is possible to mention the implementation of the pneumatic mail, advances in IT, ICTH and Telemedicine. The pneumatic mail system changes and systematically unburdens the flows of materials, allowing the optimization of its internal logistics. The purpose of the automatic multi-station system is to link several sectors through tubes connected to stations and terminals, which, by vacuum and compressed air, enable the safe transit of materials, such as documents, samples for pathological analysis, blood bags and others. The efficient transport of these items implies a reduction in circulation by care teams and otherwise inside the building, creating greater speed, efficiency and safety.

For those in charge of IT, the digital mapping of the processes that are carried out in the health care institutions increasingly enables them to strictly control the flows of users, materials, equipment and corpses in the hospital building. Among the digital systems, it is possible to mention the digital signage, which shows the paths to be followed by patients and the environments to which they must go, decreasing erroneous foot traffic and enabling users to improve their wayfinding capability. In addition, the intelligent use of vertical transport systems for elevators can lead the passenger to the most convenient elevator, reducing waiting times and the number of stops.

According to the Massachusetts Institute of Technology (1992), three criteria determine the navigability of a space: a) whether the navigator can discover or infer his present location; b) whether a route to the destination can be found; and c) how well the navigator can accumulate wayfinding experience in the space. Among the ICTH advances, it is possible to mention the implementation of digital simulation centers for the practice of health care procedures and the computerization of medical records with the creation of the Electronic Patient Record – EPR. Among its contents, the EPR has the patient identification, the evolution of his or her treatment, the preparation and the diagnostic decision-support system, which reduces the occurrence of errors, providing greater patient safety. The evolution of the ICTH with the implementation of the EPR brings positive results for health care professionals, patients, managers and other groups involved in healthcare services. The EPR makes it possible for the automatic sharing of information with other professionals and institutions that are taking care of the patient. This enables the continuity of a comprehensive healthcare in the institution, between institutions and within a region (city, state or country). As to the flows of users, materials and equipment in the hospital environment, the EPR precludes the logistics of the daily flow of inbound and outbound physical records. In addition, it reduces the control processes of those records, which can be checked by the members of the team wherever they are. Therefore, preventing them from having to travel to do their job, which is something that alters their flows, ICTH provides them with some extra time, which can be used to take care of a greater number of patients.

According to the ATA (American Telemedicine Association, 2014), the main international organization to speak for the use of advanced remote medical technologies, Telemedicine combines cost reductions
with the expansion of medical activities and it is also important in the remote updating of exam results 
and in the promotion of technical discussions.

Defined as the set of technologies and applications that enable the remote performance of medical 
activities, Telemedicine has been applied in hospitals and health care institutions that seek the help of 
leading institutions for consultation and the exchange of information and as a way of offering continuous 
care for the prevention, diagnosis and treatment of diseases. It has also been applied in the discussion of 
clinical cases, diagnostic aid, care of patients with chronic diseases, the elderly and high-risk pregnancies. 
Telemedicine helps to reduce the burden on hospitals, reducing their internal flows and giving priority to 
cases that require immediate hospitalization.

5. Results

In terms of the results, the processing of the data collected through the POE tools enabled the analysis of 
the operative flows involved in the case study. Flows were studied according to four categories (users, 
materials, equipment and corpses) and their direction. Fourteen subcategories of flows were mapped as 
it can be seen in Figure 3. The analysis was conducted for each floor and functional unit and it contains: 
the photographic survey, design considerations on functional aspects and flows as well as the diagnosis 
and flow map (Figure 4). The dotted lines represent two-way flows while solid lines represent the one-
way ones on the floor plans.

![Figure 3](image)

Figure 3: Classification of the operative flows in the case study. (Source: Thomazoni, 2016)

Based on interviews with ICESP professionals, from the users’ point of view, the following 
considerations are presented: a) Healthcare-related professionals unanimously considered the centralized 
location for care services appropriate, since it allows immediate interaction for decision making about 
patients, while these and their companions should take the peripheral routes; b) Management quality 
came up as the conditioning aspect of the flows in the building; the adaptation of processes with changes 
in flows, but without physical alterations favoured the continuity of care, such as: the implantation of 
dedicated elevators and non-exclusive ones that generated more use flexibility, the implementation of a 
valet service in an area where vehicles are boarded and disembarked and the outsourcing of several 
services (laundry, pharmacy, maintenance shop and kitchen); c) The two different situations of 
sectorization and flows are arranged with one or two circulation corridors, according to the care provided 
by each functional unit; on outpatient floors, two circulation rings are established so as to separate 
doctors from patients, preventing the latter to approach the former out of their offices. The other 
healthcare functional units present a single corridor for user circulation (see Figure 5).
From the point of view of experts, out of the aspects set at the time of the design of the building, vertical terms, more important than the proximity between similar functional units is the efficiency of upright transportation, assigning units that generate more circulation to lower floors. It can be noted that
activities that require less circulation are found on higher floor while those requiring more foot traffic are in operation on lower ones.

According to design specialists, the constitution of the main tower in two wings with the central core allows physical readjustments to be performed with the isolation of either one of them. The Core has dedicated, but nonexclusive, elevator use and its location affords easy access by care teams and otherwise, without intersecting points with patients and companions. As to restrictive aspects, the constitution of the building by interconnected towers highlights the disintegration between them, which, on plan, limits its versatility and the core-centered care impels patients to follow long paths.

Regarding the external environment, being the building a skyscraper situated in a high-density region, user circulation is intense and causes traffic jams in the neighboring areas, making access to the building difficult for both drivers and pedestrians. Especially on the ground floor, the excessive flow of users produces overcrowding at peak hours in the lobby, elevator lines in the lateral towers and teeming circulation areas, with the resulting undesirable intersection of users, especially of patients, companions and visitors, which brings also to light the inefficiency of the vertical transport.

Advances in IT and ICTH applied to healthcare buildings reduce physical circulations and save time. The digital mapping of all the processes that are carried out in the building increasingly helps in the strict control of the flows of users, materials, equipment and corpses in its interior. The contextual changes are relevant as much as the increase in the number of services provided to patients is associated with the improvement of medical techniques and IT, such as the time reduction in radiation therapy, nuclear medicine therapy, microsurgery and robotics surgery. As a result, there is a growth in patient turnover within the building.

As for the interview script applied, three approaches considered the mapping of flows supported by graphic tools in the analysis. As a result, the six following aspects were predominant:

a) The study of external flows should be considered in light of the potential of the building site;

b) The architectural design should create the conditions for expansion in accordance with a Master Plan;

c) Flows derive from the sectorization whose core activities should be near and also provided with nearby circulations;

d) Among the problems caused by unwanted intersections, the main ones are those involving the risk of contamination and overcrowding resulting from the overuse of the physical capacity;

e) Among the positive intersections, the ones that facilitate activities and travels, offer shortcuts, afford changes and expansions, give the building the characteristic of versatility and improve wayfinding can be mentioned;

f) In Brazil, the interdisciplinary research associated with environmental psychology, design and POE is part of the academic environment and, for all respondents, the study of flows is essential to make the hospital architecture more efficient and user-friendly.

The POE applied to this high-rise health-care building allowed to consider that, although it is assumed that patients have to travel shorter distances in a hospital environment, this premise is only valid for the horizontal circulation. In the vertical circulation, sectorization is performed according to patient necessity of circulation on each functional unit, that is, functional units with more patient turnover should be
located on lower floors. The centralized location of the healthcare staff on the floor plan affords immediate decision making about the patient’s health and brings benefits for all.

The improvement of wayfinding, with contributions to a prompt health care assistance, helps in finding, guiding, choosing the path, and the identification of the user’s destination. The efficient wayfinding system sets users on the right path, preventing losses to their care. For Barbosa (2015), it is possible to propose a matrix to evaluate accessibility to the building based on wayfinding elements, such as circulations, decision points at intersections and others that enable the user to play his part with greater ease, safety and independence, considering the analysis of their flows. Based on the aforementioned aspects, which result from the analysis and application of the POE tools, it is possible to promote the understanding of the occurrence of the different operative flows in the hospital environment through the creation of a graphic tool. As consequence, the study of flows can give support to new architectural design programs and readjustments in pre-existing hospital buildings, contributing to fill the void in the area of design process on the subject, and making hospital architecture more efficient and user-friendly.

6. Discussions

In Brazil, the association of hospitals in a network with divisions according to complexity levels gives the user the possibility of receiving care in different units (clinics, polyclinics, etc.), which implies the progressive relief of hospital use. Other typologies of hospital buildings designed for patients who are subjected to low-risk and short-stay procedures, such as day hospitals have also come up (BROSS, 2006). The healthcare system, along with Telemedicine, promotes a new internal arrangement for the building and, as a result, the undesirable intersections of flows in ordinary hospital buildings are likely to become somewhat less common.

The choice of a unique vertical hospital building is due to the problems that derive from the complexity of its flows. The unavailability of large sites in high-density urban areas makes verticalization the optimal solution to complex healthcare facilities as long as its horizontal expansion is restricted. Implanted in a small area, the ways to access the building are few, limiting the diversity of flows that lead to its exterior. In addition, the adaptability within the building makes the enlargement of some of its sectors possible while causing the reduction of others. The vertical typology guides the sectorization of the hospital building by the overlapping of its sectors, and not by their proximity in accordance with a functional organization, which places activities involving the circulation of fewer users on higher floors. The choice of a new complex hospital building for this POE is justified as it brings, from its conception, the physical consequences of new and latest technologies incorporation in architectural design. A follow-up would be interesting, on investigation of the changes of flows in this hospital building along its life-span.

For similar case studies, from the results of this POE case study, it is possible to consider that normative contents point towards the most modern physical rearrangements for contemporary complex hospitals, enabling the exclusion of routes and the indiscriminate use of elevators. The study of operative flows in hospital buildings is of interest to the multidisciplinary teams involved in the course of its operation. Whenever possible, the implementation of management resources should precede physical alterations. Flows depend on the healthcare system of each country and cultural factors. As examples of flow conditioning by the healthcare system, it is possible to mention the layout with or without locker room dividers in Intensive Care Units and the presence of one or two corridors in surgery centers for the transport of both clean and dirty materials. Cultural factors are also flow determinants. One example is the presence or absence of a hotel area for companions connected to the hospital complex. Another one
that should be mentioned is the corpse itinerary, which can follow different service or healthcare routes, with impacts on the layout of the building.

A broader research on the subject, adding international experiences certainly would contribute with the results, as that can indicate new approaches that consider cultural diversity and different health-care systems. Besides, further similar studies, using a larger sample of similar hospitals would greatly collaborate to the improvement of the proposed methodology, which aims at a better architectural design quality and at giving support to designers and hospital management teams.

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References


