Development of a tool for evaluating proximity requirements in the programming and design of a new hospital

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Abstract:
In the context of planning a new replacement hospital, proximity requirements between individual services are captured when developing a functional program (FP). Accommodating the list of requirements is daunting in an organization such as a university teaching hospital where services are complex, multiple and diverse by nature. Yet, the performance of a given design is directly conditioned by its ability to meet the objectives articulated within the FP. It is once the FP is interpreted by professionals and translated into a design that the feasibility of responding to these requirements can be evaluated. Ideally, this should consist of an efficient and systematic appraisal of the proposed design with regards to the program. The purpose of this paper is to develop a generic assessment tool capable of evaluating the level of fit between the proximities requested in a FP and a particular design. Once developed, this tool will be used to evaluate a specific architectural project in terms of its ability to accommodate the proximities. The tool will be assessed through the use of the pre-concept developed for the McGill University Health Centre (MUHC). This exercise could also potentially serve as a component in evaluating the pre-concept.

Key words: proximity requirements, functional program, planning tool.

1. Introduction

Planning for the new MUHC started in 1994 and preceded the administrative merger of five McGill University teaching hospitals in 1997. The activities leading up to the development and completion in 2002 of a Functional and Technical Program (FTP) included a broad-based consultation process in 1997, a number of Task Forces that addressed strategic and operational issues in 2000. This followed with the development of a Master Program in 2001 outlining strategic directions for the new facility.

The purpose of a Functional and Technical Program is to provide the most complete representation of the future complex through the utilization of narrative descriptions, numbers, and conceptual designs. It contains operating assumptions for each functional unit (i.e. staffing and hours of operation), an enumeration of the spatial areas (i.e. type, number, surface areas and proximity requirements) as well as a description of the construction and systems supporting these activities. This study extracted the information from the MUHC Functional Program (FP) pertaining to the proximities.

Proximity requirements are a sub-set of operating assumptions that describe the specific relationship needs between different functional units of a facility. Hospitals are complex facilities in terms of the sheer number of proximity requirements necessary for ensuring the functionality of numerous, diverse and highly interconnected activities. The optimization of these proximity requirements facilitates the attainment of desired operational efficiencies, as well as provides the conditions for the development of key synergies between the different missions (clinical, teaching and research) that constitute an academic teaching hospital.

In the case of the MUHC, the development of the FP was led by a health care consortium hired to manage the process. The FP was carried out by more than 800 participants involved in 73 different work groups, composed of health care professionals, physicians, administrators, patient representatives and volunteers. Through a series of meetings, the consultants garnered qualitative and quantitative information in order to develop the FP documents for the various workgroups.

Once finalized, the FP was handed over to a team of architects mandated to develop a preliminary architectural design (pre-concept). The pre-concept served as a communications tool for discussions on the MUHC project with various levels of government, community groups as well as internal stakeholders. It also provided valuable information in regards to the ability of the land to accommodate the planned activities within the constraints of an urban environment.

2. Objective

The objective of this exercise consists in developing a generic assessment tool capable of assessing the level of fit between the proximities requested in a FP and a particular design, as well as to identify specific recommendations for improving the tool. The MUHC FP was used for this exercise and in the evaluation of the pre-concept, in regards to the attainment of the proximity requirements outlined within the FP.

3. Data Sources

At the initial stage of this exploratory investigation, the "pre-research" phase, the identification of available information on the subject was explored. The decision was made to concentrate this phase on data analysis, in the belief that this would then provide the information necessary to better identify a particular field of research befitting this study. Ideally, in the future, a search for published articles describing the development of similar tools for assessing proximity requirements within a hospital design should be included. In addition, it is believed that this would provide an avenue for the validation of this exercise, for honing the research tool and for ascertaining the potential contribution of this study to a specific field of research. Therefore, for the purpose of this exercise, the only information used was derived from the MUHC FP narratives and the architectural pre-concept.

4. Methodology

The methodology consisted of three main steps: FP data extraction, pre-concept data extraction and data analysis. Upon initial review, 699 requests for proximity were identified within the FP and over 93 different adjectives, including schematic diagrams, used to describe them. The information was refined prior to developing a database that would be used to perform the analysis. Figure 1 schematically presents the process that was followed. The following sections explain in more detail the steps carried out.

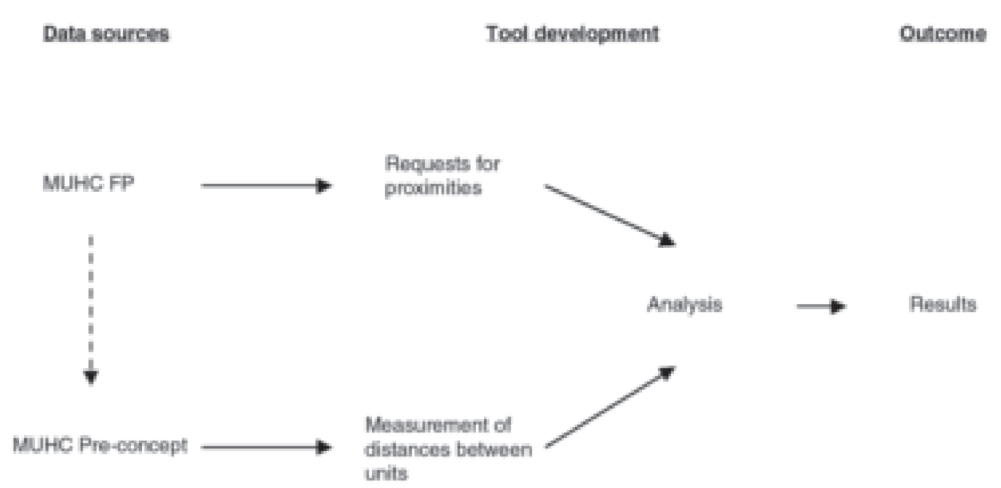
4.1 FP Data extraction

In the FP data extraction phase of the study, two major steps had to be completed: first, extraction and classification of the proximity qualifiers and second, classification of the units or services.

4.1.1 Proximity Qualifiers

The first step consisted of extracting and organizing the descriptors used as proximity qualifiers in each of the FP narratives. The 93 qualifiers

Figure 1 - Schematic of the methodology



identified were either in the form of diagrams with or without arrows, with or without supporting narratives, or just narratives. Some of the adjectives used were similar, such as near and nearby, whereas others were different for example direct versus immediate access. Proximities were not identified in all of the documents. The collection of this information was not performed systematically or consistently amongst the FP groups. Thus, the level of detail and type of information varied considerably from one FP narrative document to another. Table 1 provides examples of proximity

Table 1 - Examples of proximity qualifiers
Adjacent to
Direct adjacency
Contiguous
Primary adjacency, secondary adjacency
Lowest priority adjacency
Nearby
In same area
Timely and convenient access

qualifiers found in the FP. The adjectives found were then sorted alphabetically and grouped within the classification system described below. Table 2 presents the categories chosen for regrouping the adjectives and their definition. This was necessary in order to refine and reduce the different types and sheer number of qualifiers that were identified. The process for the classification of each request was based on a consensus amongst the workgroup members who analyzed the proximity requests found in the FP. An urban analogy was used to categorize the proximities, describing them within specified and limited boundaries.

The selection of terms, commonly used, introduced a concrete notion of actual distances between two points that are easily understood by most people. This helped to avoid employing categories such as close, near, or far which are more open to subjective interpretations. Furthermore, it lends readily to the campus style concept commonly used to describe the project and relates to an intellectual city composed of different missions bringing together resources and services for a specific purpose.

Table 2 - Definition of Proximity Categories			
Level	**Category**	**Definition**	**Health Care Context**
A	Neighbour	A person who lives near or next to another	A service directly beside another service or department
B	Neighbourhood	A district	Pavilion / Service grouping
C	City	A large and important town	Campus / Site

4.1.2 Units

Upon classification, this information was used to form a basis for the creation of the proximity database. However, each of the requesting units was first coded in order to ensure they were all captured. The "units" consist of the different service areas or departments found within the FP space program. In some cases this involved the creation of additional numerical units in order to indicate a proximity request generated from a sub-unit within a unit. For example the FP for the cancer centre is composed of three different sub-units, chemotherapy/infusion unit, outpatient clinic, and oncology day hospital. The addition of a code was necessary for these sub-units because they specifically requested a particular proximity in relation to another unit; yet they were grouped as a single unit in the Cancer Centre FP. In this text, unit or service is used interchangeably.

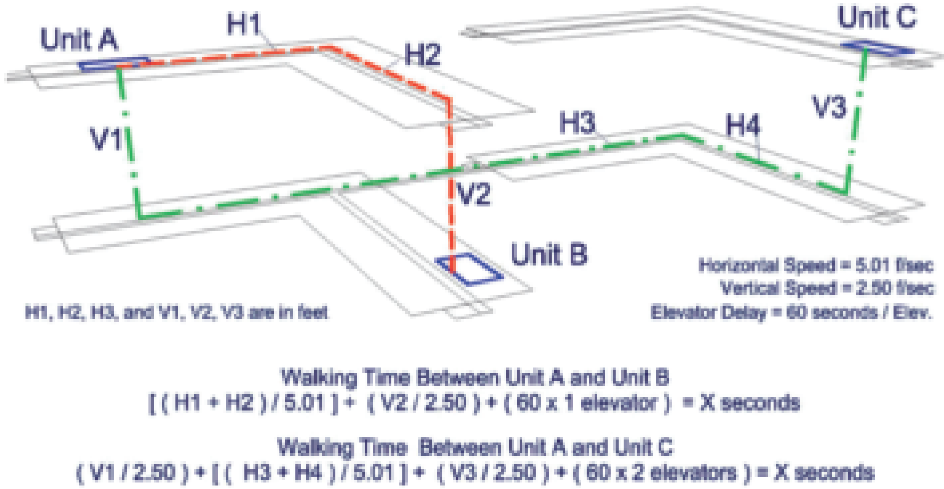
4.2 Pre-concept Data Extraction

The next step was to extract the information contained in the architectural pre-concept. The pre-concept is an optional step sometimes performed prior to the design phase. The architectural pre-concept for the MUHC was executed for three reasons. First, to verify the degree to which the proximity requirements called for in the FP could be met in a complex of this size and within the constraints of a three-dimensional environment. Second, to address for the first time the ability of the selected site to meet the requirements contained in the FP for the new MUHC complex, especially regarding the urban planning considerations. Finally, the pre-concept provides an illustration of the future complex, a tool necessary to negotiating zoning changes, as well as to supporting communication initiatives with the public at large.

The pre-concept architectural plans were created with an AutoCAD software, which allowed for the measurement of the compatibility between the FP proximity requests and the suggested proximities in the pre-concept. Within these plans, an identification label was placed at the geographic centre on each floor and for each service identified. Distances between all of these labels were then measured using a computer program written in AutoLISP. This program retains and compares the parameters of each label in terms of the service, the floor it is located on, the area of the building it is located in, and the spatial positioning of its geographic centre (x and y coordinates).

Data output from the AutoLISP program was then input into a database in text format where each line of information corresponded to a distance between two services. The pre-concept yielded 18,721 couples (a pair of units requiring proximity to each other). This data was then imported into an Access table, from which an analysis of travel distances between services and an analysis of the proximity requests were conducted. Time was used instead of distance, based on the assumption that people have a better sense of time measurement than an ability to evaluate distance travelled. Also, this provided a common denominator for vertical and horizontal displacement. Next, an experiment was conducted to estimate a person's average horizontal walking speed. The results of this exercise set the speed at an average of 5.01 feet per second and constituted the

Figure 2 - Visual representation of the measurement method



first element of time travel that was established. A second element factored into the equation assumed that the vertical travel speed was half of the horizontal travel speed and placed it at 2.5 feet per second. The third element took into consideration the number of elevators necessary for travelling between two services. Therefore, horizontal travel was considered to be the speed of a normal person walking and vertical travel was considered to be elevator speed.

Other parameters could have also been introduced into the time travel calculations but would have involved further investigation for their inclusion in this study. For example, factors that impede travel such as obstacles in corridors, traffic, and chance meetings would increase overall travel time of an individual. Also, alternatives to horizontal or vertical travel such as mechanical sidewalks or stairs were excluded from the study. Nonetheless, the same formula throughout to ensure consistency in the handling of the data.

Figure 2 is a visual representation of how the measurements between the couples were calculated. Two examples help to illustrate the process adopted. The tags H1, H2, H3, and H4 represent horizontal travel, while V1, V2, and V3 represent the vertical travel paths. The travel path between Unit A and Unit B is represented by the hyphenated line and involves 1 horizontal path (H1 and H2) and 1 vertical travel path (V2). The travel path between Unit A and Unit C is made up of 1 vertical path (V1), followed by two consecutive horizontal paths (H3 and H4), and ends with a second vertical path (V3).

4.3 Data Analysis

This section describes the data analysis conducted subsequent to the completion of the two steps (FP proximity requests and pre-concept analysis) described above.

From the original data set of 699 requests from the FP, 70 requests were eliminated for the purpose of this analysis because they were placed within the same functional area in the pre-concept. For example, in the oncology ambulatory cluster, the oncology day hospital requested proximity with the chemotherapy/infusion centre. In the FP, these are listed as two distinct entities that were placed in the same functional area in the pre-concept, therefore had the same tag. Of note is that in another design, these two units might not necessarily be located in the same area and that a more refined design would enable us to identify the exact location of both units in the design. The time travel measurement between these two points would have been equal to zero, since they were both identified in the pre-concept by the same label or tag. A number of requests were also eliminated from the analysis since they were not specifically dealt with in the pre-concept and therefore could not be tagged or labelled in the pre-concept (i.e. helicopter pad). Data analysis for this study was done on 629 requests for proximities in the FP and identified in the pre-concept. This is a consequence of the pre-concept not having achieved the same level of detail expressed in the FP.

In order to simplify the presentation of results, the FP units were grouped according to families of similar hospital functions. The families used to regroup the different hospital functions are:

- Administration - includes senior administra tion, foundation, auxiliary
- Ambulatory - includes outpatient clinics, day hospitals, emergency
- Clinical support - includes pharmacy, clinical laboratories
- Diagnostic and treatment - includes imaging, operating suites
- General support - includes housekeeping, security, installation maintenance
- Inpatient - includes wards, ICU
- Public spaces - includes amenities, patient resource centre
- Research, and teaching - includes faculty offices, conference centre, library

Table 3, below, describes the distribution of proximity requests by hospital function or families. The numbers highlighted in grey represent couples where both members come from the same family. For instance 26 couples from the ambulatory family requested proximities between themselves. To illustrate such a couple is the proximity request between the cardiology/pulmonary ambulatory cluster and the emergency department. All the numbers that appear below the grey boxes forming a staircase are requests between units belonging to different functional families. For instance, 54 requests involved one member of the couple belonging to the inpatient family (wards or ICU) and the other belonging to the diagnostic and treatment family (Imaging or operating rooms).

Proximity requests involving functions that were from the same functional family represented 19.1% of the total requests. The most frequent couples requesting proximities belonged to the diagnostic/treatment family with the ambulatory family (13.0%) followed by diagnostic/treatment and inpatient families (8.6%), and teaching family and ambulatory family (8.4%).

Table 3 - Distribution of proximity requests by hospital function

	Administration	Ambulatory	Clinical support	Diagnostic & Treatment	General support	Inpatient	Public spaces	Research	Teaching
Administration	9								
Ambulatory	13	26							
Clinical support	1	27	8						
Diagnostic & Treatment	1	82	27	33					
General support	5	10	8	3	16				
Inpatient	8	26	33	54	10	11			
Public spaces	17	20	8	3	9	1	6		
Research		0		2				0	
Teaching	8	53	10	32	1	22	1	14	11

Number of cases = 629

The data set from the FP, once matched with the pre-concept data, enabled extraction of travel times for all of the couples requesting proximity. Table 4 presents a summary of the findings relating to travel time.

Table 4 - Summary of travel time data

Number of couples	629
Average travel time	3.01 minutes
Minimum average travel time	0.47 minutes
Maximum average travel time	8.29 minutes
Standard deviation	1.47 minutes

Overall, the average travel time between a couple is 3.01 minutes. The range is fairly large, with a minimum average travel time observed of 0.47 minutes, and a maximum average of 8.29 minutes. The standard deviation calculated for the data set was 1.47 minutes. An example of the minimum was the request between the vascular surgery clinic and the outpatient pharmacy satellite (0.47 minutes) whereas the maximum was observed for the request between the printing service and the inpatient wards (8.29 minutes).

Table 5 presents the same data set but in terms of the requested proximity levels.
Requests of couples wanting to be neighbours made up 58.7% (n=369) of all requests, with a third (33.3%) of couples wishing to be in the same neighbourhood. Only 7.9% of couples requesting proximity stated that they should be located on the same campus. This likely underestimates the number of level C proximity requests because many participants may have assumed that their service would be located on the same campus. Therefore they may not have felt the need to express a proximity request. The table also shows that the averages per level of proximity follows the logic that A travel time is smaller than B, and B is smaller than C. It is important to note that the analysis did not reveal an important difference between the averages of the three different levels.
The modest difference between the three levels of proximity could be explained by the following:

1. When the users were asked to express their proximity requirements, the interpretation of the terms may have been inconsistent. *or*
2. The architects may have relied more heavily upon their experience rather than following the FP narratives in a strict manner. *or*
3. This may have been in response to other project constraints, (e.g. costs) when developing the pre-concept.

Mining this information further the distribution of average travel time between the levels of proximity was examined. In order to explore this distribution the average times were categorized into intervals of 0.25 minutes (15 seconds). Figures 3, 4 and 5 illustrate the distribution of the proximity requests by level.

	Level A - Neighbour	**Level B - Neighbourhood**	**Level C - City**
Number of requests	369	210	50
Average travel time	2.91	3.09	3.43
Median travel time	2.69	2.99	3.13
Minimum observed	0.47	0.61	1.46
Maximum observed	7.82	8.29	7.89
Standard deviation	1.48	1.46	1.34

Figure 3 - Distribution of average travel time - Proximity Level A

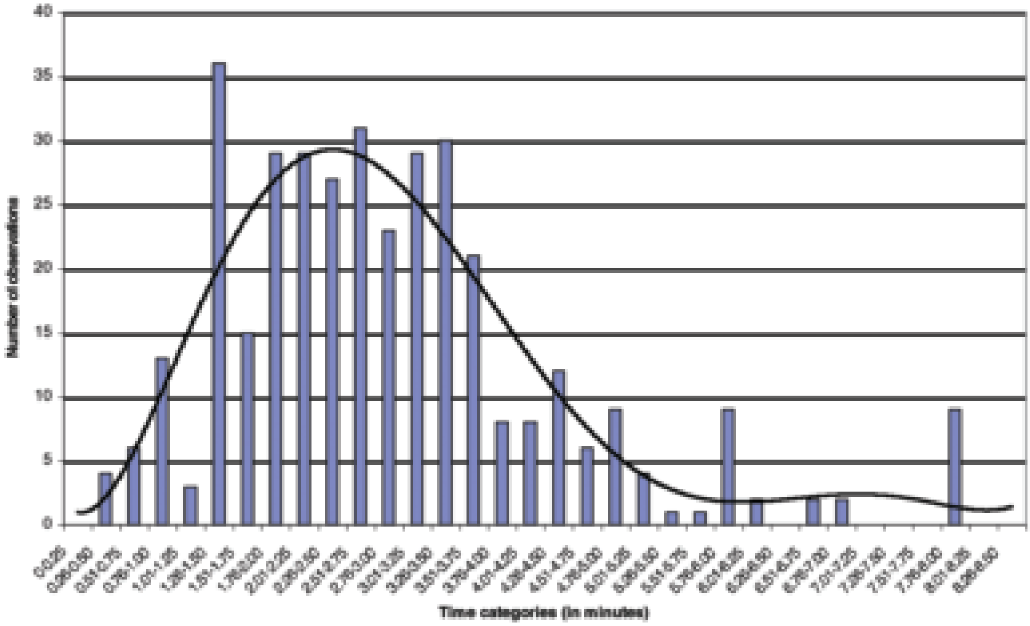


Figure 4 - Distribution of average travel time - Proximity Level B

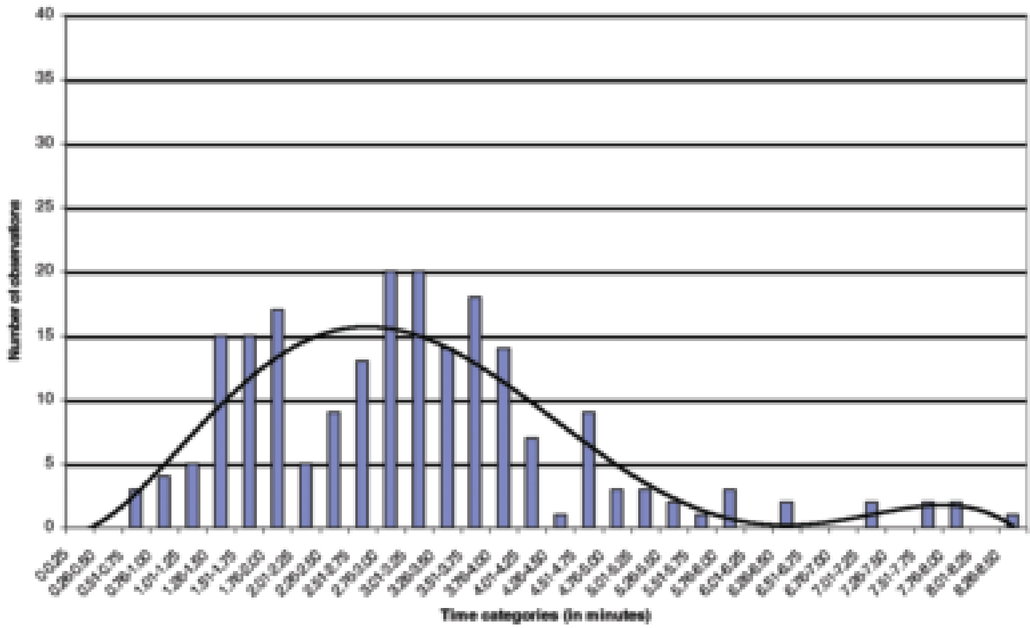
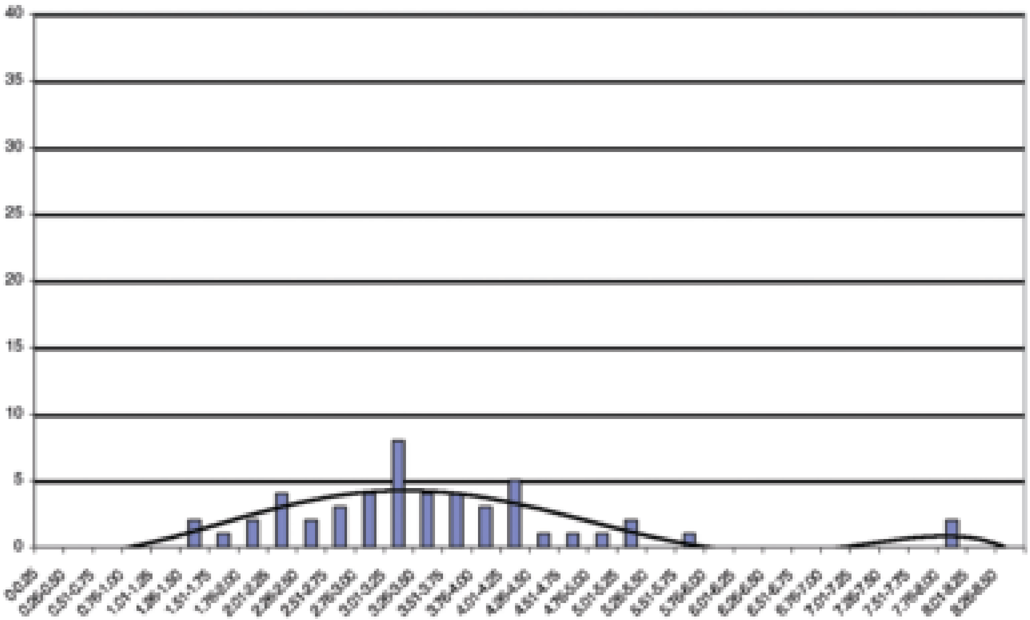


Figure 5 - Distribution of average travel time - Proximity Level C



After comparing the three previous tables, there was an expectation that the figures would distinguish the distribution of average travel time between the different proximity levels (A, B, C). However, upon examination it became apparent that any conclusions based on this information were limited at this stage of the tool's development. This may be due to the treatment (categorization) of the information retrieved from the FP and the subsequent translation of this information by the architects in the development of the pre-concept. Notwithstanding, these figures point to areas for potential improvement of the tool as well as interesting information for assessment.

One element highlighted by these figures was the existence of outliers for each of the proximity levels (i.e. A, B, C). For example, in Figure 3 the number of couples with an average travel time of 7.75 to 8 minutes, is clearly identified. This information could be exploited by identifying the couples represented in this interval so as to determine means to improve travel time.

Another interesting aspect was the distribution of the proximity levels according to member affiliation to clinical versus non-clinical functions. The clinical function category grouped the inpatient, ambulatory, diagnostic/treatment, and clinical support functions. The remaining functions were considered to be non-clinical, or not directly related to patients. Thus we created three categories of clinical "presence" that were attached to the 629 couples: C2 - couple with 2 clinical functions, C1 - couple with 1 clinical function, and C0 - couple with no clinical function.

Table 6 shows the distribution of number of requests and average time travelled by level of proximity.

Overall, couples made up of 2 clinical functions (C2) and 1 clinical function (C1) had a lower average travel time than did the couples with no clinical services (C0).

Table 6 - Average travel time by clinical presence

Clinical presence		Level of proximity A	B	C	Total
C2 - Couple with 2 clinical services	Average time	2,46	2,69	2,88	2,57
	Number	187	121	19	327
C1 - Couple with 1 clinical service	Average time	2,84	3,17	3,66	3,01
	Number	131	54	21	206
C0 - Couple with no clinical service	Average time	4,70	4,37	4,00	4,50
	Number	51	35	10	96

Couples with no clinical services had a higher average travel time when they had requested a high proximity level (level A - 4.70 minutes) in comparison to when they had requested a lower level of proximity (level B - 4.37 minutes, level C - 4.00 minutes).

Interpretation of results must be done cautiously due to the low number of cases in the C0 category as well as in the level C category. Nonetheless, the data may shed light on how the architects processed the information from the FP in developing the pre-concept. Intuitively and based on their experience, they may have started by placing the clinical components and then the non-clinical components in the design. It also may indicate that proximities are not the only factor in developing an architectural concept.

4. Conclusion

The objective of developing a generic assessment tool, as described throughout this paper, was met. In particular, the tool has the ability to sort FP proximity requests by level of importance from the FP and translates this information into distances between units in the pre-concept. This enabled a systematic calculation of the average travel time between units. In addition, this initial phase has enabled us to better identify future exploration in the literature to identify existing fields of research. The added valued of this exercise is that it has proven helpful in identifying issues that need to be carefully considered at the FP stage of a project. This also will enhance the tool's ability to evaluate an architectural design. As well, the exercise has resulted in the identification of future opportunities to expand the evaluation capacity of the tool and are described below. Finally, this analysis provided an opportunity to consider potential "gaps" in the information provided in the FP.

That being said, the tool requires further refinement. The following recommendations highlight key factors that would help improve upon this initial work.

6. Recommendations

• The use of a predefined framework for the identification of proximity qualifiers was not employed throughout the FP process. A systematic classification of this information with the users in FP groups would eliminate the need for developing one after the fact. A standardized framework that classifies levels of proximity in a consistent manner would increase the validity of the scale developed from a "softer" data source through the identification of the proximity qualifiers.

• The tool can be used for identification of proximity outliers in formulating recommendations for professionals for improvement when future iterations or revisions to the project design are made.

• The assessment tool could serve to measure the impact of design decisions or modifications. For example, in subsequent designs a decision could be made to optimize the particular travel times for the A-level requests in exchange for one greater than the average travel time for the C-level requests. This analysis could also be performed when mechanical forms of transportation are introduced or enhanced within the design (e.g. moving sidewalks, rapid elevators, increased number of elevators) evaluating it in terms of improved achievement of proximity requests as specified by FP participants.

• The adoption of travel time can be used as a standard measurement to validate the intent on the part of the user requesting the proximity. For example, for user X, does a 3.5-minute travel time to unit Y meet his/her expectations for a requested proximity.

• The effect of alternatives to transport, such as information technology and automation, should also be incorporated into the diagnostic tool. This capacity would enable the tool to evaluate the introduction of new technologies that may not exist currently but may be necessary in future hospital designs.

References

Kurt Salmon Associates. Functional Program - McGill University Health Centre. March 2002.

Lemay, Bobrow and Associates, in collaboration with NBBJ. Architectural pre-concept - McGill University Health