

Supplementary Material: Definitions of the Means Objectives

This supplementary material provides definitions of the 14 means objectives that were identified as important in the built environment of inpatient stroke rehabilitation facilities. These means objectives and the relationships between them and the fundamental objectives are displayed in Supplementary Figure 1 below.

[Place Supplementary Figure 1 approximately here.]

Maximize the Adaptability of the Space

The adaptability of a space refers to its ability to change in response to new knowledge or requirements, both at the level of the clinical program and at the level of the patient, and to be “future proof” (this term was used a number of times by participants in the workshops). In this definition, ‘adaptability’ refers to changes that need to occur over the long-term (i.e., years or decades) and the mid-term (i.e., months or years), but not the short-term (i.e., hours or days). This concept of adaptability applies to both the fabric of the building (i.e. the overall layout and structure), and the internal fit-out of the building (i.e. the interior design, partitions, etc.). Mid- and long-term costs can be reduced if the building is designed from the outset to be able to adapt to changing requirements. This objective is a means to achieving the following fundamental objectives:

- **Maximize the responsiveness of space:** An adaptable space will be responsive to changing needs and requirements over the mid- and long-term.
- **Minimize cost:** Mid- and long-term costs are reduced if the building is designed from the outset to be able to adapt to changing requirements.

- **Incorporate and support adequate technology:** An adaptable space will accommodate for unprecedented knowledge growth and facilitate the introduction of new technologies.

Maximize the Versatility of the Space

The versatility of a space refers to its ability to change over the short-term (i.e., hours or days) in response to day-to-day changes in clinical programs or to meet the immediate needs of different people. In other words, the building should be customizable and have a “loose enough fit” (this term was used by participants in the workshops) so that it works for all users.

‘Versatility’ implies that the space should be customisable; **some spaces may incorporate cues as to what the space could (or should) be used for, while other spaces may have no cues at all.** Some spaces may be functionally agnostic, and some may be functionally suggestive, but what is important is that they are flexible enough to be used for different things at different times and to suit changing needs. This may involve defining the purpose of a space to a certain extent; it should still be recognisable as being for a certain type of activity, but it should not be so tightly defined that it can't be modified to meet changing needs. Regardless of how prescriptive these spaces are, they should always be ready to be activated by an individual or group. For example: a therapy room should be able to accommodate both individual and group therapy, or different forms of therapy; a consult room that is normally used by just a patient and clinician should be able to accommodate the patients' extended family if they happen to visit during the consultation time; and a communal lounge should be able to support both the patient who needs low stimulation and intimate conversations and the patient who needs high stimulation and lots of activities. This objective is a means to achieving the following fundamental objectives:

- **Maximize the responsiveness of space:** A versatile space will be responsive to changing needs and requirements over the short-term.
- **Minimize cost:** A versatile space can serve many functions, thereby decreasing the number of different types of spaces that may need to be included in the finished building and reducing upfront costs.
- **Minimize time:** A versatile space can be quickly changed to suit needs, thereby minimizing time spent finding or developing an alternative, suitable space.
- **Maximize opportunities for practice of physical function and cognitive function and effective sleep and rest:** A versatile space can be designed to suit changing clinical needs so that it can continue to create suitable opportunities for practicing physical and cognitive function. A versatile space can also be altered to remain conducive to sleep as patients' needs, sensitivities, and preferences change, or in response to seasonal changes (e.g., longer daylight hours).
- **Maximize safety for staff and patients and family/friends:** Having versatile patient rooms with moveable walls would allow patient beds and occupancy to be changed in response to infection control or behavioural needs, **or to provide a line of sight or more supervision for patients at risk of falling.**
- **Maximize personal control over the space:** A versatile space should allow for personal control, and a space that allows for personal control should be inherently more versatile. This is a bidirectional relationship. However, designers do need to ensure that both objectives are always being met as not all versatile spaces will automatically allow for personal control over the space.

Incorporate and Support Adequate Technology

A stroke rehabilitation facility should be designed to support the necessary technologies for administration and clinical practice, and the design should be flexible enough to adapt as these technologies evolve. In other words, the physical space needs to be designed to align with the technology. Many different forms of technology need to be considered including (but not limited to): Medical apparatuses, gym and therapy equipment, staff computers, public computers, staff and patients' personal devices (phones, tablets, laptops, etc.), pager systems, WiFi and mobile network signals, duress systems, and patient entertainment devices.

Here are some illustrative examples of the relationship between technology and the built environment. 1) If the WiFi is strongest in, e.g. the corridors, then people will congregate there, causing an accessibility problem and fire hazard, and the spaces designed for congregation will not be used. The WiFi signal should be accessible in all areas. 2) The placement of nurses stations, and the presence of computers at these stations, can influence how frequently medical records are updated and can impact on staff travel times within the building. 3) Swipe card access to certain areas of the building can impact on accessibility and patients' personal control over the space, but may also need to be considered in some areas to ensure safety. The building should accommodate the technologies designed to maximize safety, e.g., equipment such as hoists can minimize the need for staff to manually handle patients. Adequate technology may also impact efficiency and effectiveness. This objective is a means to achieving the following fundamental objectives:

- **Maximize the responsiveness of space and Minimize cost and Minimize time:** There are many technological solutions designed to save time for staff, reduce costs, or make a

space more responsive to the needs of its inhabitants (e.g., smart rooms). The building should support inclusion of these evidence-based technologies to improve efficiency.

- **Maximize opportunities for practice of physical function and cognitive function and effective sleep and rest:** There are many new technologies (e.g., robotics, interactive computer games, VR, etc.) designed to assist in the practice of physical and cognitive functions. The building should support inclusion of these evidence-based technologies to improve the effectiveness of therapy. There are also technologies that exist to promote effective sleep and rest (e.g. lighting for circadian rhythms).
- **Maximize safety for staff and patients and family/friends:** The building should accommodate evidence-based technologies designed to maximize safety (e.g., duress systems, floor sensors, smoke alarms).
- **Minimize manual handling:** Adequate technology (e.g., hoists) can minimize the need for staff to manually handle patients.
- **Maximize the legibility of the space:** Technology such as touch-screen information kiosks, and apps that provide information about the facility can support wayfinding.

Include Multipurpose Circulation Spaces

The corridors, or circulation spaces, make up a large proportion of the overall floor space of a building and, in a rehabilitation facility, they naturally serve many functions to support clinical operations. Corridors are used as unofficial social spaces, hosting incidental and natural social interaction. They are used as storage spaces that allow equipment and wheelchairs to be stored close to patients (which then facilitates patients being independently mobile). They are used as unofficial therapy spaces, and may well be the first place where a patient walks by

themselves unassisted. The naturally multipurpose or versatile characteristic of corridors should be encouraged in rehabilitation facility design so that these spaces can continue to serve many functions, whilst still providing a means for safe, efficient circulation and travel. This objective is a means to achieving the following fundamental objectives:

- **Maximize opportunities for practice of physical function and cognitive function:**

Multipurpose corridors may encourage patients to emerge from their rooms and engage in incidental practice of physical and cognitive functions.

- **Maximize the versatility of the space:** Since circulation spaces make up a large proportion of the floorplan, multipurpose corridors can therefore be an economic use of space and can go a long way to ensuring that the facility as a whole has some element of versatility.

- **Maximize accessibility within the building:** Well-designed circulation spaces work to link key services and promote access throughout the building. Corridors should be wide enough to accommodate the many activities that naturally take place in these spaces so that the number of people and presence of equipment does not impact on safe transit throughout the facility.

Maximize Outdoor and Green Spaces

Outdoor space can be incorporated into the design of the building to provide views of nature from patients' rooms (especially from their beds), therapy areas, and communal areas. However, privacy also needs to be accommodated; the design should allow patients and staff to control the balance between views of the outdoors and privacy indoors. This objective is a means to achieving the following fundamental and means objectives:

- **Maximize opportunities for practice of physical function and cognitive function:**

Outdoor spaces provide more opportunities for practice of ‘real world’ physical function, and for social interaction. In addition, there is some evidence to suggest that nature itself is beneficial for brain repair.

- **Foster emotional well-being for staff and patients and family/friends:** Nature can be rejuvenating and relaxing, helping to combat stress for patients, staff, and visitors.
- **Maximize the versatility of the space:** Well-designed outdoor spaces can be incredibly versatile; they can be used by individuals or by large groups, and for many different types of activities.
- **Maximize integration with the community:** Outdoor spaces with public access can facilitate interaction with the community.

Maximize Personal Control Over the Space

Patients, staff, and visitors should be able to execute personal choices in regards to their environment. There are dichotomies of needs that exist in stroke rehabilitation that need to be accommodated. Relaxing and restorative spaces are needed to allow people to de-stress or contemplate, but patients may also need stimulating and energising spaces to create opportunities for practicing cognitive function and to combat boredom. Similarly, there needs to be private or intimate spaces (both aurally and visually private) so that patients can be alone or just with loved ones, and there needs to be social or communal spaces that encourage social interaction and facilitate incidental peer-to-peer learning (which is emphasised in education settings). In addition, stroke can happen at any age, so it's important that patients can create age-appropriate spaces. Maximizing patient, staff, and visitor's control over the space allows them to create the

appropriate balance between these dichotomies and to change this balance from day to day or hour to hour. This objective is a means to achieving the following fundamental objectives:

- **Maximize opportunities for practice of physical function and cognitive function:**
Having personal control allows patients, staff, and visitors to change the space to suit clinical needs. In addition, a sense of agency may be key to motivating patients to practice physical and cognitive function.
- **Foster emotional well-being for staff and patients and family/friends:** Having personal control allows patients, staff, and visitors to change the space to suit their emotional and well-being needs. It also allows patients and visitors to introduce a level of normality, familiarity, or homeliness to their environment. In addition, having control introduces a sense of agency, which can be uplifting and empowering.
- **Maximize the versatility of the space:** A space that allows for personal control, i.e., that allows individuals to make their stamp on it and to change it to suit their needs, is inherently more versatile.

Maximize Integration With the Community

A stroke rehabilitation building should maximize the facility's integration with the wider community. The facility should be conveniently situated in relation to the existing community and in close proximity to associated health services. A rehabilitation facility that is integrated into the community should also contribute to the neighbourhood and become “more than just a hospital”, providing benefit to staff, patients, visitors, and the general public. Including public spaces within the facility (e.g., cafés, gardens, even the hydrotherapy pool) will encourage people in the community to use these spaces, and **will introduce a sense of normalcy and a home-**

like atmosphere for patients. The street level of the building in particular should incorporate porous public space, and design consideration should be given to the identity of the building and how it contributes to the community. This objective is a means to achieving the following fundamental objectives:

- **Minimize time:** Integration in the community may minimize travel time for staff, patients, and visitors to get to the facility (i.e., easily accessible by car or public transport). This may minimize the time to transport patients from associated health services. The ease of the journey to and from the building is also important once a patient is discharged as they may be required to travel daily to attend therapy as an outpatient.
- **Maximize opportunities for practice of cognitive function:** Public spaces provide opportunities for both incidental and programmed practice of cognitive functions. An accessible location will encourage family and friends to visit, which may provide opportunities for social interaction and practicing cognitive function. In addition, having access to ‘normal’ facilities such as cafés provides opportunities for therapeutic practice of skills required in everyday life; an occupational therapist may work with a patient to go to the café and order a coffee and thereby practice the necessary cognitive functions.
- **Foster emotional well-being for staff and patients and family/friends:** Being integrated into the community introduces some level of normalcy for patients (and staff and visitors). It allows them to observe or participate in some aspects of normal life, with a comforting reminder of home, and introduces ready-made communal or social spaces. Access to public spaces within the hospital introduce a break in a patient's routine, combat boredom, and encourage social interaction. An accessible location may also

encourage family and friends to visit, which may benefit the emotional well-being of patients.

Maximize Aesthetics

Our definition of ‘aesthetics’ refers to the beauty or attractiveness of the building, views, interior design, and any artwork in the space. This beauty or attractiveness may be visual, or it may be associated with one or more of the other senses (sound, smell, touch, taste). Aesthetics should be maximized in all areas of the facility including the patients' rooms, staff areas, therapy areas, communal spaces, and corridors/circulation spaces. This objective is a means to achieving the following fundamental and means objectives:

- **Foster emotional well-being for staff and patients and family/friends:** A better aesthetic may work to make users feel more positive.
- **Maximize integration with the community:** An aesthetically pleasing environment may act as a ‘draw-card’ and encourage people from the wider community to appreciate and integrate with the rehabilitation facility building (thereby potentially decreasing isolation for the patients and helping to foster their emotional well-being).

Maximize Indoor Environmental Quality

‘Indoor environment’ refers to air quality, light levels, access to natural light, ceiling heights, sound levels, views of the outdoors, and orientation to the sun. In addition to these general requirements, the indoor environment should be designed to suit the specific needs of patients with brain injury, who may have sensory or perceptual differences. Indoor environmental quality should be maximized in all areas of the facility including the patients'

rooms, staff areas, therapy areas, communal spaces, and corridors/circulation spaces. This objective is a means to achieving the following fundamental objectives:

- **Maximize opportunities for practice of physical function and cognitive function and effective sleep and rest:** Appropriate lighting and noise levels at night are essential to ensure good sleep and therefore good clinical outcomes for patients. Noise levels during therapy are also important so that the patient and staff can effectively communicate and concentrate.
- **Foster emotional well-being for staff and patients and family/friends:** A good indoor environment is integral for physical comfort and therefore emotional well-being.
- **Maximize safety for staff and patients and family/friends:** Air quality is of obvious importance in terms of infection control, and light and sound levels are important for staff attention and concentration (reduce medical errors) and for general occupational health and safety.

Maximizing the Legibility of the Space

A 'legible' space is easy to navigate and understand. Legibility of space, or wayfinding, is not just about signage, it is also about being able to predict, or anticipate how a space is laid out. Environmental cues (e.g., staircases and reception desks) can help people understand where to go and what different areas are for. Information provision is another key component of a legible space; patients and visitors need to be provided with information prior to their visit and upon arrival to facilitate their understanding of the space. The aim is for a stroke rehabilitation facility to have intuitive wayfinding, but, importantly, it must be intuitive for patients who have had a stroke and who may have cognitive impairments. Consideration should also be given to

people with low literacy, people who do not speak English, and people with visual or other sensory impairments.

The entry to the rehabilitation facility can be a key component in ensuring the legibility of the entire facility. The arrival or entrance to a building forms the first impression of the building and is therefore very important and memorable. The entry should provide a clear demarcation that introduces the rehabilitation space as a different type of space, it should also create a sense of safety, and it should clearly indicate what different spaces are for. This objective is a means to achieving the following fundamental objectives:

- **Minimize cost and Minimize time:** Patients and visitors who feel disorientated or lost will ask staff for directions, which impacts on staff time (and therefore costs).
Disorientated patients may take longer to get to therapy and so therefore may leave therapists waiting (again impacting on staff time and costs).
- **Maximize opportunities for practice of physical function and cognitive function:**
Being oriented enough to move about yourself creates opportunities for practice of physical and cognitive function, and it allows people to access existing opportunities for physical and cognitive function. Legible spaces also mean less time finding your way and getting lost, therefore leaving more time for incidental and deliberate practice.
- **Foster emotional well-being for staff and patients and family/friends:** Good wayfinding can reduce stress in a foreign environment and is especially important for people have a cognitive or physical impairment or who are experiencing fatigue. Getting lost or disorientated and having to walk further can sap energy and impact on pain levels.
- **Maximize safety for staff and patients and family/friends:** Legible spaces can help patients and visitors orient themselves, which is important for emergency evacuation.

Maximize Accessibility Within the Building

A rehabilitation building should be designed so that all staff, patients, and visitors can independently access the necessary parts of the facility in a timely fashion. There are a number of considerations that need to be taken into account in order to make a rehab building accessible including colocation of facilities, journey time within the building, access to services, and disability access.

Patient should not need to rely on staff in order to gain access to outdoor spaces, communal spaces, public on-site services (e.g. cafés), and therapy spaces. These spaces should be in a central location and circulation between these spaces and the wards should be designed to encourage patients to access these spaces independently (e.g., wall rails, minimize distances, no locked doors, etc.). Importantly, entry to these spaces should not be limited to the 9-5 working day. Rather than being organized around staff working hours, services such as cafés need to remain open and operational at times that coincide with the facility's visiting hours (e.g., evenings and weekends), otherwise they become inaccessible at the times at which patients and visitors would most benefit from them. Importantly, it is essential that people with a disability can independently access all areas of the facility – this includes people who use a wheelchair or other mobility aids, and people who have a visual or other sensory impairment.

Accessibility can be improved by removing physical barriers wherever possible, including avoiding changing levels/floors, and collocating key rehabilitation services such as the gym, occupational therapy, and other allied health services. Designing for colocation requires a weighing of priorities; it's impossible to have all sections of the facility next to each other. Time should be spent in the design phase to map out usage patterns and travel times, and to discover

the ‘core’ spaces and how they interact. This information can then be used to ensure that the facility's layout supports the service of care. This objective is a means to achieving the following fundamental objectives:

- **Minimize cost and Minimize time:** It is detrimental to both time and cost if staff have to travel long distances between patient rooms, porter patients to therapy, or wait for patients to get to therapy. **The use of a single, remote therapy area may not be the right approach.** Large wards with all majority single patient rooms may need to hire more nurses in order to ensure appropriate observation of patients, which is costly for the facility.
- **Maximize opportunities for practice of physical function and cognitive function:** Having independent access to more spaces in the rehabilitation facility may give patients more opportunity to engage in incidental practice, or self-motivated deliberate practice. Therapy sessions with the physiotherapist, occupational therapist, or speech therapist are often scheduled for consecutive, short periods during the day, and travelling long distances between these sessions may cut into the patient's therapy time and so decrease their opportunities for deliberate practice of physical or cognitive functions. It could be argued that having to travel some distance to therapy may provide patients with an opportunity for incidental physical practice en route, but if the distance is too large then patients will need to be portered to therapy and so any possibility of incidental practice is removed.
- **Foster emotional well-being for patients:** Arduous travel times within the building may make patients feel more incapable and reliant as they may need to depend more on staff

to get from a to b. Being able to get to rehab by themselves may help patients to feel more agency and independence.

- **Maximize safety for staff and patients and family/friends:** Accessibility within a building is obviously important for emergency evacuation, and good sightlines may improve patient safety. However, there may also be a negative relationship between accessibility and safety; unhindered patient and visitor access within the rehabilitation facility may increase the risk of fall or injury for patients, and it may also make the facility more vulnerable to theft and other petty crimes. The benefits and risks of accessibility must be weighed during the design process. Many of the risks associated with accessibility may be alleviated by ensuring that the design facilitates good sightlines and integration with the community (both of which increase human observation throughout the space).
- **Maximize the legibility of the space:** People need to be able to access areas in order to familiarise themselves with those spaces. Accessible spaces with obvious, tangible functions can be easier to understand and navigate.

Minimize Manual Handling

Stroke rehabilitation facilities should be designed to minimize the amount of manual handling that staff need to do when lifting or moving patients or equipment by hand. This is a fundamental occupational health and safety issue. Suitable technologies (e.g., hoists, trollies, etc.) should be included (see ‘incorporate and support adequate technology’ above), but other design choices will also be important in minimizing manual handling (e.g., railings and corridor width). Storage spaces for equipment should be easily accessible (i.e., at appropriate heights and

close to patient areas); and distances between key facilities and services (e.g., bed and toilet) should be minimized. In addition, the design should be flexible enough to adapt as new manual handling solutions are developed. This objective is a means to achieving the following fundamental objectives:

- **Maximize safety for staff and patients:** Less manual handling should mean fewer injuries for staff and patients.

Maximize Sightlines

The design of stroke rehabilitation facilities should allow people to easily see across key spaces. However, the objective of maximizing sightlines needs to be weighed up against the need for private spaces. This conflict could be addressed by ensuring that patients, staff, and visitors can exercise personal control over the space. This objective is a means to:

- **Maximize safety for patients:** Good sightlines allow staff to readily observe a number of patients simultaneously. This may be a means to reducing falls risk without restricting patients' physical activity.
- **Maximize the legibility of the space:** Being able to see your destination, or your starting point, makes the space more legible and predictable. **Clear orientation for patients, plus welcoming and accessible views of spaces, will help motivate patients to move around the facility, contributing to their sense of autonomy and help foster independent movement and incidental practice throughout a facility.**

Meet Hospital Safety Guidelines

Stroke rehabilitation facilities should meet or exceed the building safety requirements or guidelines as laid down by the appropriate governing agency. These guidelines should stipulate, among other things, fire safety measures (e.g., number and placement of fire extinguishers, fire exit signage, etc.), balcony railing height, security cameras and monitoring, duress systems, etc.

Although much of these guidelines may be the same as for any public building, some alterations may need to be made for a stroke rehabilitation setting (e.g., larger holding spaces to accommodate more people in wheelchairs in the case of fire). This objective is a means to achieving the following fundamental objectives:

- **Maximize safety for staff and patients and family/friends:** Standard building safety guidelines are required to insure the minimum safety standards are met for a public building.