Sustainable healthcare facilities: Reconciling bed capacity and local needs

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Received 13 May 2016; received in revised form 25 October 2016; accepted 20 January 2017

Abstract

Healthcare facilities throughout Europe are constantly changing to support efforts to provide efficient healthcare services with decreasing resources. Recent changes include larger and more specialist hospitals to achieve economies of scale. This approach has yet to be proven to sustainably respond to the demands, and efficiently satisfy the users' needs. The evidence that supports larger healthcare facilities as more cost effective is limited and contradictory as wider sustainability issues need to be given greater consideration. This information paper presents the findings of a comprehensive literature review that addresses aspects that can lead to sustainable small healthcare facilities. It also establishes sustainable-related factors, including economics and energy efficiency, which could be employed to evaluate the viability of healthcare facilities. A typical small-scale facility provides a case study that contextualises these factors, captures their interdependencies, and explores the viability and sustainability of small hospitals. The findings from the work suggest that small facilities can be viable and more comprehensive research that provides a balanced view of economies of scale is required to support future healthcare design policies, where large and more specialised hospitals may no longer be environmentally, technologically, socially and economically sustainable.

Keywords: Healthcare facilities; Sustainability; Refurbishment; Bed capacity; Economies of scale

1. Introduction

During the last 15 years, many healthcare services in Europe have become more concentrated within larger and specialist hospitals with the intention of improving cost-effectiveness, reducing acute care beds, creating sufficient throughput that ensures high quality of care and offers more sustainable healthcare provision (Mossialos and Le Grand, 1999; Kroneman and Siegers, 2004). The consequence is the closure of many smaller (i.e. less than 150 beds) hospitals, as highlighted by Azevedo and Mateus (2014). Although concentration strategies can have positive impacts on the quality of patient care (FSH, 2015), they can also have negative impacts on the delivery of sustainable healthcare provision. Several researchers (Hindle et al., 2004; Rull, 2011) have recorded those negative impacts for the outcome of such. McKee et al. (2002) argued that concentrating services in strategic areas within

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Peer review under responsibility of The Gulf Organisation for Research and Development.

http://dx.doi.org/10.1016/j.ijsbe.2017.01.003

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larger units has significant shortcomings which need to be
given attention. Furthermore, Szczesny and Ernst (2006)
demonstrated that in some instances such concentration
strategies may have led to fall in the cost effectiveness of
basic and regular care hospital services. In particular, evi-
dence from research appears to suggest that capping hospi-
tal budgets and regulating the distribution of hospital beds
has yet to be proven as a successful sustainable healthcare
strategy on its own.

Typically, a great proportion of hospital costs is associ-
ated with the buildings and fixed costs (Mossialos and Le
Grand, 1999). McKee et al. (2002) have suggested that
many policy makers in healthcare delivery consider that
‘bigger hospitals are not necessarily better’. In their favour,
bigger hospitals are often considered to be more efficient
than smaller ones, even if both are operated at full capac-
dity, due to the economies of scale (Posnett, 2002;
Doherty, 2011) if measured in monetary terms. While large
hospitals may lead to improved efficiencies within the site,
this is not the only factor that has to be considered in evalu-
ating its viability. The argument here is that having a
smaller number of beds does not preclude the opportunity
of being a sustainable healthcare facility. International
research has demonstrated that very large hospitals rarely
result in lower costs or better patient outcomes
(Reinhardt, 1996; Aiken and Sloane, 2002; Bengt, 2008;
Murray et al., 2008; Aiken et al., 2012). Also, Azevedo
and Mateus (2014) argued that beyond a certain size, effi-
ciency reduces due to hospitals increasing diseconomies
of scale, thus leaving the debate open on the optimum size
of sustainable healthcare facilities. The challenge is to deli-
ver a more comprehensive lens to support future analysis of
healthcare design policies where large hospitals may no
longer be physically, technologically, socially and econom-
ically sustainable. This information paper reports the
results of an investigation into aspects that can lead to
improved sustainability in small healthcare facilities to pro-
vide essential inputs for the comprehensive lens.

2. Aim

This paper aims to identify sustainable-related factors of
healthcare facilities and explore the viability and sustain-
ability of small hospitals. The paper is structured as fol-
loows: first, healthcare facility bed capacity is discussed in
relation to efficiencies and economies of scale; and then
sustainable-related factors are identified against different
dimensions of sustainability. The discussion employs a
detailed case study that could challenge conventional views
on the optimum size and on the ability to change of health-
care facilities that have informed their design and manage-
ment so far. The findings from the research contribute to
the existing knowledge through: original insights that chal-
lenge current healthcare facility planning trends; and the-
ory building that will support a long-term health and
social care integrated delivery system.

3. Methodology

The paper is mainly based on evidence found in litera-
ture with a detailed case study being used to explore the
viability and sustainability of small healthcare facilities.
The research methodology comprises the following two
stages.

1) A comprehensive literature review of key aspects
relating to: how optimum size is determined; and
what constitutes a sustainable healthcare facility.
The output from the review was synthesised into an
audit pro-forma.
2) A systematic sustainability appraisal of a case study
small healthcare facility in Italy using the audit pro-
forma generated through the literature.

The scope of the review and the details of the selected
cause study along with the procedure for its analysis are
addressed in the sub-sections hereunder.

3.1. Literature review

International online and offline publications were exam-
ined to gather comprehensive information on the on-going
debate on bed capacity as a health service provision indica-
tor. The juxtaposition between efficiency and sustainability
and between economies of scale and local needs subtends
to the identification of the key factors for sustainable
healthcare facilities. The state-of-the-art in Europe and in
the UK illustrates the variability in hospital bed capacity,
and particularly between existing and newly designed
healthcare facilities. In particular two elements emerged:
efficiency and economies of scale. Besides, definitions of
sustainability embrace multiple dimensions, far beyond
the economic and environmental, which need to be given
due consideration.

The literature was organised and presented in two
stages: the first confirmed that there is limited and contra-
dictory evidence on an optimum scale that could determine
sustainability in healthcare facilities and the number of
beds should be considered against different aspects; the sec-
ond provided a classification of 52 sustainable-related fac-
tors that are relevant to the environmental, technological,
social and economic dimensions of sustainability.

The purpose of the literature review was to suggest a
systematic organisation of different aspects (i.e. factors)
that build up the set of criteria proposed for each of the
above four dimensions. Those factors are expected to vary
according to the local needs, thus they were synthesised in
the audit pro-forma in Table 3 and used to explore the viab-
ility and sustainability of a small case study.

3.2. Case study

A 130 bed Istituto di Ricerca e Cura a Carattere Scien-
tifico (IRCCS) in Italy served as a sustainability appraisal
case study through the generated audit pro-forma. Although selected as ‘the researcher had access to a situation previously inaccessible to empirical study’ (Yin, 2014), this case is highly representative of the existing healthcare facilities in Italy, and of other European countries. Only 15 per cent of the healthcare buildings in Italy were built after 1991; 20 per cent between 1971 and 1990; and 65 per cent before 1970, of which 15 per cent before 1900 and 20 per cent between 1900 and 1940 (Commissione Parlamentare di Inchiesta, 2013). In 2010, among 634 public healthcare facilities, 33 per cent have less than 120 beds; 40 per cent have between 120 and 400 beds; and only 16 per cent have over 600 beds (Ministero della Salute, 2012). The case was identified as combining typical elements of the majority of alike hospital buildings and having undergone an extensive debate to determine its fitness-for-purpose over the future, thus being ‘instrumental’ (Stake, 1995) to provide insights on viability of small hospitals. Creswell (2013) and Hyett et al. (2014) praised the positive insights that ‘case study research’ can offer to the body of knowledge when quality and rigour of data collection is maintained.

The reinforced concrete building was originally developed in 1935 and subsequently refurbished in 2007. The data collection started in 2010 after the refurbishment project handover and contains information related to the first year occupancy and service run of the hospital. On-site direct observations and un-structured interviews were conducted: the former to provide contextual evidence, and the latter to allow tailoring of the interviews to the different stakeholders and their experience (Denzin and Lincoln, 2011; Yin, 2014). The interviews used the audit pro-forma and targeted respondents from three categories: the Estates and facilities team; patients; and visitors. Questions were spontaneously asked with the scope to gather the participants’ perspective; nevertheless the type of questions was sub-divided into two levels: (1) the general discussion around each of the four dimensions identified through the literature review; and (2) the specific 13 factors that may be relevant to each dimension. The interviews were transcribed, coded with NVivo® per themes and interrogated on the 52 key factors identified in the literature review and included in the audit pro-forma, which Hsieh and Shannon (2005) defined ‘directed content analysis’. Findings from the interviews were complemented with important archival records such as project layout drawings and organisational registers, which captured the scale and rationale of the adopted design solution for the case hospital.

4. Healthcare facility bed capacity: state-of-the-art in Europe and the UK

In many European countries, both in the renovation of existing facilities and in the construction of completely new ones for efficient and effective service provision, concentration of hospital services is leading to an increase in the number of inpatient beds (Posnett, 2002). Table 1 summarises three examples of large hospitals in different geographical areas within the European boundaries: the New Erasmus University Medical Centre in The Netherlands; the New Karolinska Solna University Hospital in Sweden; and La Fe University Hospital in Spain.

While two out of the three above facilities are new design on new selected sites, the New Erasmus is the result of expansion and innovation on an existing centrally located urban area. The New Karolinska Solna is the result of a complex merger of two already large hospitals in a new city district. Yet, all the three projects, which respond to local needs, were driven by mutual key issues: centralisation of highly specialised services in new suburban health sites; dismantlement/decommissioning of small urban health sites; reorganisation and expansion of existing health sites; rebalancing of health service provision; shortening of average Length of Stay (LoS); increasing of whole-life health checks and chronic conditions; and growth of e-health service provision (European Commission, 2014a).

In the UK, the situation does not appear to be much different, with brand new super-facilities recently completed or heading towards completion over the next years, of which Table 2 offers three examples, and always more frequent hospital mergers.

A recent report on the effect of the size of acute healthcare providers in England (many of which operate a range of sites often including outreach centres and community hospitals) on their performance found no clear evidence that smaller hospitals consistently perform worse (Monitor, 2014). The average smallest total bed capacity identified in the report by Monitor was of 435 units per single-site provider, as not all the indicators were available at hospital level. This confirms that English hospital bed capacity can be smaller than 435 beds per acute facility.

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Construction period</th>
<th>Construction cost</th>
<th>Gross area (m²)</th>
<th>Inpatient beds</th>
<th>Staff employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Erasmus University Medical Centre</td>
<td>Rotterdam (Netherlands)</td>
<td>2009–2017</td>
<td>–</td>
<td>203,000</td>
<td>864</td>
<td>9,000</td>
</tr>
<tr>
<td>New Karolinska Solna University Hospital</td>
<td>Stockholm (Sweden)</td>
<td>2010–2018</td>
<td>SEK 14.5 bn</td>
<td>330,000</td>
<td>830</td>
<td>8,750</td>
</tr>
<tr>
<td>La Fe University Hospital</td>
<td>Valencia (Spain)</td>
<td>2002–2010</td>
<td>£842 mil</td>
<td>170,000</td>
<td>1,109</td>
<td>–</td>
</tr>
</tbody>
</table>

Source: EGM Architecten, White Architects, and AIDHOS Arquitec.
far from the figures provided as examples in Table 2 and the trend towards economies of scale that have already started to affect the financial sustainability of smaller hospitals (Monitor, 2014).

Construction period, construction cost, gross area and staff employed are all parameters that can play an important role in the decision to build a new healthcare facility; choice of physical location; planning for transport and accessibility; transfer of existing staff or selection of new one; and other planning and operational judgements. Although in many countries (e.g. Finland, Germany and Italy) bed capacity has been used as ‘preferred unit for planning hospital care’ (Rechel et al., 2010), this shall not be retained as a key driver for sustainable healthcare facilities. Considerations on existing and new design facilities have been discussed in a recent study in which two Italian hospitals with over 550 beds did not achieve a ‘sufficient global environmental score’ (Buffoli et al., 2014) support the initial assumption of this paper that a more comprehensive point of view is required to support future healthcare design policies.

Historically, most hospitals were of small bed capacity and attached to monasteries, thus disseminated across the surroundings (McKee and Healy, 2002). With the advance of medicine, specialities were introduced and hospitals expanded, trying to accommodate increasing change in service provision and use of technology. Nevertheless, European countries are still rich in small and medium size healthcare facilities (Nolte et al., 2014; Liaropoulos et al., 2016), often not in use or partially in use, but which require maintenance and account for healthcare expenditure. Recent research reported a great degree of variation in average hospital bed capacity, ranging from less than 125 beds in Greece (Liaropoulos et al., 2016) to 227 beds in France and 400 beds in Germany (Nolte et al., 2014). A EU Observatory on Health Systems and Policies report (Thomson et al., 2014) stated that ‘19 countries sped up the existing process of restructuring the hospital sector, mainly through closures and mergers’. This is leading to ‘centralised capacity planning approaches’ (Nolte et al., 2014) and to larger facilities becoming more common in Europe, in the effort to concentrate acute service provision to implement hospital performance and efficiency. Nevertheless, centralisation of services may come with additional challenges, as seen in October 2016 at Leicester’s Glenfield Children’s Heart Centre in the UK, which NHS England is currently planning to stop operating, thus not always leading to sustainability if a lens other than efficiency (e.g. accessibility) is applied.

5. Bed capacity: efficiency versus sustainability

Historically, bed capacity has been considered as a health service provision indicator (Rechel et al., 2010). Yet it has not been proven that it can be a suitable element against which is possible to assess hospital sustainability. According to Carr and Feldstein (1967) a large bed capacity is not necessarily and not the only way to reach sustainability in a healthcare building. It may be a way to lead to economic efficiency, but ‘after a point’ any further increase in size does not result in cost-reduction of providing care; determining that point when ‘diminishing returns’ set in is often not addressed in the analysis that informs policy on healthcare provision.

Efficiency does not guarantee sustainability (Arrow et al., 2004), other than in relation to clinical outcomes and volume of activity, as ‘there are an infinite number of efficient time paths, only some of which are sustainable’ (Bishop, 1993). In economics, the concept of efficiency is used to generally describe a system that works well, quickly and without waste, where resources are optimally allocated to produce the desired outputs. It is linked to a performing system, over a time path, thus meaning that being sustainable at the present time does not guarantee being sustainable at future time (Stavins et al., 2003; Arrow et al., 2004). In healthcare facility design, the concept of efficiency has been extensively debated in relation to energy control and cost management (Scher, 2005; Linna et al., 2006; Pavlas et al., 2006; Preyra and Pink, 2006; Magnusen and Nyland, 2008; O’Neill et al., 2008). Palmer and Torgerson (1999) have looked into definitions of efficiency as a means ‘to measure whether healthcare resources are being used to get the best value for money’ and ‘to increase health outcomes produced’. The relationship between efficiency and hospital size measured in number of beds is linear if ‘variable returns to scale’ are taken into assumption, when all hospital units do not operate at optimum scale (Tiemann and Schreyögg, 2009). External factors relating to market competition, capital and regulatory constraints, and mergers and exits can impact frameworks to measure efficiency.

Posnett (2002) reported that average costs begin to increase in hospitals of 300–600 or more beds, in a chapter of the European Observatory on Healthcare Systems Series. This is supported by the more recent work of

Table 2

Three UK examples of large hospitals.

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Construction period</th>
<th>Construction cost</th>
<th>Gross area (m²)</th>
<th>Inpatient beds</th>
<th>Staff employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Queen Elizabeth Hospital</td>
<td>Birmingham</td>
<td>2005–2011</td>
<td>£545 mil</td>
<td>137,000</td>
<td>1,215</td>
<td>8,000</td>
</tr>
<tr>
<td>New Royal London Hospital</td>
<td>London</td>
<td>2005–2012</td>
<td>£1.1 bn</td>
<td>145,300</td>
<td>727</td>
<td>8,750</td>
</tr>
<tr>
<td>NHS South Glasgow Acute Hospital</td>
<td>Glasgow</td>
<td>2010–2015</td>
<td>£842 mil</td>
<td>170,000</td>
<td>1,109</td>
<td>–</td>
</tr>
</tbody>
</table>

Source: BDP Architects, HOK and HLM Architects.
Table 3
Environmental, technological, social and economic factors.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Feature</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Built environment</td>
<td>Accessibility</td>
<td>Cost of access</td>
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<tr>
<td></td>
<td></td>
<td>Equity of access</td>
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<tr>
<td></td>
<td></td>
<td>Transport and mobility</td>
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<tr>
<td></td>
<td>Constructability</td>
<td>Modularisation</td>
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<tr>
<td></td>
<td>Functionality</td>
<td>Prefabrication</td>
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<td></td>
<td></td>
<td>Acoustics</td>
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<td>Air quality</td>
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<td></td>
<td></td>
<td>Heating/cooling</td>
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<tr>
<td></td>
<td>Materials</td>
<td>Infection control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maintenance, disposal and reuse</td>
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<tr>
<td></td>
<td></td>
<td>Source</td>
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<tr>
<td>Technological environment</td>
<td>Energy</td>
<td>Control management</td>
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<td></td>
<td></td>
<td>Systems design</td>
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<td></td>
<td></td>
<td>Whole-life capacity</td>
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<tr>
<td></td>
<td>Information &amp;</td>
<td>Data management</td>
</tr>
<tr>
<td>Technology</td>
<td>Communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technology</td>
<td>ICT systems management</td>
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<tr>
<td></td>
<td></td>
<td>ICT systems maintenance</td>
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<td></td>
<td></td>
<td>Staff continuous professional development</td>
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<tr>
<td>Technological equipment</td>
<td>Equipment</td>
<td>Installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Management</td>
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<tr>
<td></td>
<td>Waste</td>
<td>Availability</td>
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<td></td>
<td></td>
<td>Waste management</td>
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<td>Recycling</td>
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<td>Social environment</td>
<td>Culture</td>
<td>Inequalities</td>
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<td></td>
<td>Demographics</td>
<td>Multicultural society</td>
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<td></td>
<td>Ageing population</td>
<td>Social attendance</td>
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<td></td>
<td>Age-related diseases</td>
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<td></td>
<td>Co-morbidities</td>
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<td>Models of care</td>
<td>Chronic illnesses</td>
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<td></td>
<td>Health care</td>
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<td></td>
<td>Service integration</td>
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<td>Patient-centred approach</td>
<td>Length of stay</td>
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<td></td>
<td>Privacy and dignity</td>
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<tr>
<td>Economic environment</td>
<td>Capital availability</td>
<td>Energy management</td>
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<td>Life-cycle management</td>
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<td>Investment capability</td>
<td>Turnover</td>
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<td></td>
<td>Market</td>
<td>Free competitions</td>
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<td></td>
<td>Research and</td>
<td>Health care challenges</td>
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<tr>
<td>development</td>
<td></td>
<td>New diseases</td>
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<tr>
<td></td>
<td></td>
<td>Technological integration</td>
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</tbody>
</table>

Kristensen et al. (2008) who confirmed over 400–600 beds have to face higher costs, while acute hospitals with 200–400 beds can represent the optimum size. Spang et al. (2009) recounted on previous studies which suggested that ‘economies of scale are exhausted at [...] usually around 200–250 beds’ (2009). Azevedo and Mateus (2014) in a study on Portuguese hospital mergers confirmed that economies of scale are exhausted close to a size of 230 beds, in line with previous research. In a review of hospital scale, scope and distribution, Mills et al. (2011) concluded that large hospitals (greater than say 500–600 beds) are less cost efficient and not necessarily better clinically than smaller ones. The above studies alone would prove to be against the European state-of-the-art and substantiate the theory that most of the standing infrastructure could be sustainable. Conversely, there may be justification for larger scale hospitals, as they are needed to support teaching, research and innovation, (Carr and Feldstein, 1967) which could make a higher cost per bed more acceptable.

Florence Nightingale in 1850s codified the hospital as a place where care was provided to patients in consideration of their needs as human beings (1859). These needs change over time and they can be satisfied through appropriate integration of different aspects that are not only related to the built environment, but also to the social, technological and economic elements (Pantzartzis, 2008; Barrera, 2011). ‘Dynamic efficiency, that is the choice of a feasible consumption path such that the economy is on the Pareto frontier’, is a necessary condition towards sustainability, as only choosing feasible consumption paths may lead to avoid unnecessary degradation of resources (Stavins et al., 2003) and only a ‘dynamic model’ can contribute to the assessment of how sustainable the reduction of acute care hospital beds might be (Olgiati et al., 2013). Change is inevitable over the life of most healthcare facilities, and it is necessary to first define the driving factors and the extent to which their effects can be foreseen and challenged (McKee et al., 2002). The rising pressure from growth in need and demand and the emerging awareness of the limited availability of resources (Muir Gray, 2007) would require additional caution to ‘the use the minimum resources to produce the maximum feasible output for a fixed level of inputs’ (O’Neill et al., 2008).

6. Bed capacity: economies of scale versus local needs

Previous studies have demonstrated that a variety of factors other than bed capacity may be directly and indirectly relevant to achieve and sustain economies of scale in healthcare facilities (Carr and Feldstein, 1967; Preyra and Pink, 2006; Fidler et al., 2007; Tiemann and Schreyögg, 2009; Castro et al., 2012).

In consideration of energy efficiency purposes, the ‘environmental sustainability’ of buildings (e.g. housing stock) has been related to ‘support local services and public transport within walking distance’, towards ‘renovation, repair and upgrading’ (Power, 2008). The needs of existing communities encompass the variety of aspects (Weinstein and Stason, 1977) described so far in precisely defined space and time settings. An ideal sustainable healthcare facility is adapted to the local situation (Sartorio, 2011). To define
and develop sustainable hospitals a wider and more comprehensive consideration than a ‘cost per health service’ approach beyond the Diagnosis-Related-Group (DRG) system is required. A recent study described a new framework to measure sustainability in German facility management, which looks at ‘socio-cultural quality’ of the buildings (Graubner et al., 2016). Nevertheless, the above mentioned work appears to have two limitations for the purpose of this paper: the reference only to ‘commercial healthcare buildings – new construction’ among other building typologies, and the catalogue of assessment criteria for ‘socio-cultural quality’ still dependent on the built environment quality and conformity. A balanced integration of different aspects can effectively respond to the demands and efficiently satisfy the needs of the community, in line with the concept of change described by Weeks in the seventies, still valid today and in the future, with changed needs. ‘Medicine is developing at a fast pace and medical infrastructure requires constant modifications’ (Codina, 2010). In 2015, the aim is still to plan and design facilities that possess the least constraints as possible, in order to allow future change, as ‘wherever it is situated a hospital is never likely to be complete’ (Cox and Groves, 1981).

In a study on human resources management, a multi-specialty 600 beds hospital with 1750 staff employees and an orthopaedics 460 beds hospital with 900 staff employees did not present significant differences (De Pietro, 2006). This might suggest that different hospitals, of different sizes with different staff employed can be sustainable against different local needs. Preyra and Pink demonstrated how hospital beds do not adjust optimally in the measure of short run economies of scale, where an expansion in size (e.g. due to a merge) does not mutually correspond to an economic gain (2006).

Posnett recognised that ‘optimum hospital scale is a function of […] patient access, economies of scale and volume as a determinant of patient outcome’, thus it is variable (2002). Kokangul (2008) identified variations in arrivals rate and Length of Stay (LoS) as adding complexity to the optimum size of the requested bed capacity of a hospital unit, whereas Bachouch et al. (2012) considered the increase in service demand and the reduction in hospital resources as relevant factors to develop a model for hospital bed planning. It is highly important to understand how change impacts procurement, planning, design and management of sustainable healthcare facilities. Hospital size is affected by local factors which include ‘input use’ and ‘output generation’, where scale might play a role (Ozcan and Luke, 1993). Economies of scale have direct impact on efficiency, as variable returns to scale exist in the healthcare sector, depending upon the discrepancy in evaluation between the short run and the long run (Adang and Wensing, 2008). Economies of scope require attention when computing the optimal number of beds and outputs, and the type of services delivered should be among those, with recognition that the market is driven by the demand of people.

7. The four dimensions of sustainability for healthcare facilities

The World Commission on Environment and Development, known as the Bruntland Commission, in its report ‘Our Common Future’ (WCED, 1987) defined the concept ‘sustainable development’ as ‘the development that meets the needs of the present without compromising the ability of future generations to meet their own needs’. In the first UN Conference on Environment and Development, held in Rio de Janeiro in 1992, Principle 1 affirmed: ‘Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature’.

A definition of sustainability commonly found in the literature was initially proposed by Elkington (1994), who advocated a combination of strategies that ‘simultaneously benefit the company, its customers and the environment’. Thus, economic, social and environmental dimensions were openly recognised as jointly contributing to the sustainable development of a business (Elkington, 1999). The Triple Bottom Line (TBL) aimed at gaining attention on social and environmental aspects, besides the economic ones. The underlying concept was the interdependency existing among the elements, which is key when dealing with healthcare facilities.

The social perspective (and well-being) was largely investigated with the understanding that the environmental and economic choices would have had impact on the lives of communities (Mileti, 1999). ‘Intergenerational equity’ over time was introduced to provide a balanced definition of sustainability (Stavins et al., 2003). Borgonovi and Compagni (2013) defined social sustainability as ‘enabling participation from the society/users’. A recent systematic review of the concept from a social perspective retained the original definition of ‘sustaining’ activities over a long period of time through the use of resources, leading to the definition of ‘collaborative sustainability’ (Hearld et al., 2016). Further research on social sustainability in healthcare has led to the identification of three main criteria: humanisation, comfort, and distribution (Capolongo et al., 2016), demonstrating how social aspects play a great role in determining key aspects in the definition of sustainability of healthcare facilities. More than six decades ago Whitaker (1952) defined a hospital as a ‘public service institution’, ‘a physical property’, ‘all the people who populate the healthcare facility’.

The debate on economic, social and environmental dimensions has yet to be exhausted by scholars. A study completed by Ratiu and Anderson (2014) demonstrated how multiple sustainability dimensions are not all captured by the general public, thus offering opportunities to capture further dimensions in relation to different stakeholder groups. These dimensions include: ecological balance, economic performance, institutional capacity, and viable governance, in a quest for ‘a higher plain of technological, environmental and ecological integration’ (Scott, 2003).
The book ‘Dimensions of sustainability’ edited by Andrew Scott (2003) did not run out of the possible dimensions that the concept of sustainability may embrace, but it provided a snap-shot of which dimensions were included in the debate on non-domestic buildings, and brought more attention on technology.

Barbier (1987) introduced the technological dimension as a ‘qualitative dimension of sustainable economic development associated with change or innovation broadly defined’. More recently Arrow et al. (2004) reflected on change and specifically how the technological changes impact on sustainability, thus reinforcing the need to address this additional dimension within the definition of the sustainability concepts. Sustainability is not a steady state: it is ‘a continuous, cyclical process of organisational reflection, decision making and change’ (Heard et al., 2016). Change is a key element for healthcare facilities: ‘planning based on the idea that operational regimes are permanent must fail since all health buildings change constantly’ (Weeks, 1973). Healthcare sites have always been spaces ‘in a nearly continual state of flux’ (Verderber and Fine, 2000).

Mickaityte et al. (2008) identified six ‘sustainable dimensions’ in relation to efficient refurbishment process in non-domestic buildings: social, ecological, economic, cultural, architectural and technical. These dimensions, were validated through a university case study, however they could be equally applied to other public buildings (e.g. hospitals) and to new design schemes, where there are less constraints than refurbishment schemes. Each proposed dimension encompasses multiple factors. The ecological dimension looks at the quality of the environment, while the architectural dimension looks at the quality of the building: they comprehensively look at the quality of the built environment. The cultural dimension can be considered a sub-dimension of the social dimension, if the latter refers to people’s ‘attitudes and behaviours’ within an organisation (e.g. hospital trust) (Bernardo et al., 2013; Greene et al., 2014).

In an attempt to challenge the current views and put forward a comprehensive set of factors, which can embrace environmental, technological, social and economic dimensions, this work developed and adopted the following working definition: a sustainable healthcare facility is a physical and organisational structure that should meet the health care needs of a community in the present, without compromising the ability of the same, or of new communities, to meet their future health care needs.

8. Identifying environmental, technological, social and economic factors

In order to identify the viability of small hospital, this study considered four sustainability dimensions, namely environmental, technological, social, and economic. The taxonomy of sustainable-related factors relevant to the four dimensions identified through the literature review is presented in Table 3 and subsequently discussed. Each dimension builds on four main features, which are classified into 13 factors, derived from literature. Alike hierarchical structures have been widely used by scholars to classify sets of elements that can satisfy sustainability needs (Marshall and Toffel, 2005) and that can contribute to achieving sustainability (Capolongo et al., 2015).

8.1. The built environment

The built environment dimension is determined by the interplay of four features: accessibility; constructability; functionality; and materials. Rapid urban development and an increasing lack of space are two key issues that hospital built environment has to take into account. The need for new technological installations and for future expansion is moving hospitals into suburban areas, where a brand new project development is more likely to succeed. Cost and equity of access are directly related to geographical settings (Posnett, 2002) and transport systems (Enoch, 2016).

The use of prefabricated systems was introduced in the sixties in healthcare construction with the ‘Oxford Method’, to assure quality in health buildings and to reduce building costs, by adopting a modular prefabricated building and engineering system solutions to design problems, which would eventually be standardised after positive feedback and review (Oxford Regional Health Authority, 1975). Nowadays, pre-assembly and fast-installation methods are used for modular compartments (i.e. theatre suites and en-suite facilities) to reduce construction time and to deliver the best possible solutions within budget and time constraints as the ProCure22 National Framework has been demonstrating (i.e. acute single bedroom, multi-bed bay, consult room and mental health room).

Space flexibility is the key assumption to future development (i.e. expansion and contraction) in an era in which technology and research move fast forward (Nightingale, 1859; Pantzartzis et al., 2012). A recent paper by Babu (2016) attempted to bring together the ‘dynamics of flexibility in hospital design’ and the ‘perspectives of the end users’ in a classification of operational, strategic, short-term and long-term flexibility, linked into various degrees of change. The building layout should take into account that the structure contains and supports the physical capacity to house new functions and services. The use of energy-efficient glazing can be a way to increase thermal insulation, but it has to cope with increasing energy consumption and climate change effects (Short et al., 2012). The choice of heating and lighting solutions affects functionality and flexibility. The development of new non-toxic and bio-based materials to make the buildings able to be effective over a longer period of time and then to be re-used, re-cycled or composted is increasing (Rossi and Lent, 2006). The use of environment-friendly materials that can more effectively respond to infection-control is widely diffused. Local sourcing of construction products and employment of local workforce have increased. Dis-
posal and reuse of materials can reduce construction costs and despite this only accounts for 30 per cent of EU construction industry (Prism Environment, 2012); and the Waste Directive 2008/98/EC is expected to implement it over the future.

8.2. The technological environment

Since the beginning of the 1990s, hospital organisation has been mainly driven by technological innovations and rapid development of communications, imaging and Information and Communication Technology (ICT). The technological environment dimension is the result of four main features: energy; ICT; technological equipment; and waste.

In a time when the EU Commission is targeting the efficient use of energy, to achieve the 20 per cent energy savings objective by 2020 (European Commission, 2006; European Parliament, 2009), monitoring the consumption, evaluating alternative solutions, defining feasible action plans, systems planning and design are acquiring a strategic value in the hospital energy whole-life capacity (Castella, 2010). Right-sizing of building systems and equipment is a sustainable design goal, as it has been recognised that running systems at a reduced capacity is less energy efficient than running the same systems at, or near, capacity (Rostenberg et al., 2009). The extent and the typology of healthcare provision are both directly related to the development of ICT.

The ICT development and the free market have led to an abundance of equipment available for immediate worldwide installation, which nevertheless requires operation and maintenance. The growth of knowledge management applications helps reducing clinical error, increasing privacy and security, improving disease surveillance. Nonetheless, it calls upon data capacity management and hospital staff continuous professional development (CPD) (e.g. nurse who uses a computer to update patients’ daily records).

New technologies mean new tools and new policies. Modern technologies and related equipment (e.g. X-ray) require fundamental organisational changes (Howell and Harden, 1996), thus a whole apparatus to make the change possible. Furthermore, technological equipment installation, management and maintenance on people’s competences (e.g. developers and users) to implement innovative changes (Lettl et al., 2006).

The EU 7th Environment Action Programme (EAP), based on the earlier 6th EAP (European Commission, 2014b) identified waste prevention and management among the nine priority objectives, with a special focus on turning waste into a resource. The EU approach is based on: waste prevention, recycling and reuse, improving final disposal and monitoring. Hospitals produce infectious waste, sharp waste, pathological waste, pharmaceutical waste, radioactive waste and general waste, as classified by the WHO (2011). Recycling policies have to face infectious and toxic risks that can be passed on raw materials.

8.3. The social environment

The social environment dimension is determined by the interaction of four features: culture; demographics; models of care; and patient-centred approach.

Society and the way of living have changed in the last three decades. The spaces and the techniques through which the medical care is provided have now new and different constraints. Cultural differences have always existed; nowadays they co-exist in a multi-cultural society. Patient comfort, privacy, dignity and safety have been a concern since the advent of Nightingale’s nursing theories (1860) and access to services, LoS, discharge and lifelong health checks are all emotional experiences. Recognising a space, having freedom of action, feeling protected, keeping personal dignity, being safe in a non-institutional setting improves quality of care and patient’s satisfaction.

Ageing populations and chronic diseases are responsible for increasing demand in the healthcare provision. In the past 20 years the number of people in the EU aged over 65 years and above increased by 3.6 per cent and this is expected to rise up to 29.5 per cent by 2060 (Giannakouris, 2010). Living conditions have brought people to live longer lives, but chronic disability co-morbidities have an exponential relationship to increasing age. This demographic shift affects patients, staff and carers.

In addition, there are new definitions of care not necessarily exclusively related to health. The boundary between health and social care becomes everyday less rigid (Prior et al., 2010; Oven et al., 2012). The healthcare provision is today more concerned for physical and psychological prevention than it was in the past, leading to new models of care. The concept of intermediate care, introduced in the NHS framework for older people in 2001, often creates a separation of provision between primary and acute tertiary care. Even though it has been described as services more elaborate than primary needs of patients first seeking health care, but less acute, intense and urgent than those in which the centres of excellence specialise, it still contains a degree of variability (Melis et al., 2004).

The interdependency of health, well-being and built environment is not an innovative concept: Nightingale (1860) recognised the value of natural ventilation, fresh air, proper lighting, warmth, clean water and quietness for a more rapid recover; and Ulrich (1984) found that patients with a view of nature improved sooner, with fewer complications, using less pain medications than those with a brick-wall view. Despite the patient flow input-throughput-output model can improve healthcare delivery performance, a patient-centred approach is more likely to offer effective and efficient clinical outcomes, when care services are adequately planned and distributed and extra-journeys are avoided.

8.4. The economic environment

The cost of healthcare continues to rise (Deloitte, 2016; PWC, 2016) and the cost of hospital planning, design,
maintenance, refurbishment and disposal represents one element of this cost. The economic environment dimension is determined by four features: capital availability; investment capability; market; and research and design (R&D).

Capital availability impacts on life-cycle operation and long-term maintenance of the facilities and of the services provided over time. Cost-effectiveness of a facility precludes first building (i.e. planning, design, and construction) and whole-life (i.e. maintenance, refurbishment, and disposal) costs (Cole, 2007), where the complexity of the mechanical maintenance acquires more relevance as contemporary healthcare buildings are undergoing small and large refurbishments (Nedin, 2007).

The rapid and continuous growth and evolution of diseases directly affects the investment capability, as drivers of change, impact on the built environment and on the healthcare market, and people individual and collective responses need to be foreseen. The application of economic theory to the healthcare sector leads to cost-benefit analysis of products and cost-effectiveness of treatments. The nature of health services has changed since most of existing and operating healthcare facilities had been built. While restructuring and refurbishing is not always the most cost-effective solution to enhance flexibility, planning and construction of brand-new hospitals have to cope with urban development and technological evolution (Baker et al., 2004).

The global economic dynamics have extended the boundaries of the countries, enabling a wider and more diffuse trade, leading to an increase in investments and competition of resources (Kekomaki et al., 2006). Open international trade enables any producer to offer their services and any client to purchase these services all over the world. The impact on health service systems results in free competitions in the design, planning and operation of healthcare facilities.

Research is proven to be among the major drivers of change in the European context, as directly correlated to the evolution of society, diseases and technology. Despite the fact that research investments and research incomes not always break even, it is experimental medicine that faces new challenges in new healthcare settings, thus it remains a recognised contradiction of healthcare economy, both at small and large scale.

9. A 130 beds case study: the IRCCS Giovanni Paolo II

The IRCCS Giovanni Paolo II is an oncologic health centre located in Bari, Italy. The original facility was built in 1935 for the treatment of pulmonary diseases, with open balconies facing south-east for heliotherapy, and surrounded by a green park in a 46,250 m² site, which protects it from city noise, pollution and traffic. Since it was first opened to the public in 1939, it has undergone various refurbishments, until 1998, when healthcare services were moved to a fit-for-purpose facility, before being re-opened to the public in 2010 as IRCCS after a complex, three year refurbishment, including the construction of new blocks to allocate laboratories, offices, and heating, water and power stations.

As in the rest of Europe, in the Apulia Region, where Bari is located, health services net restructuring actions have been undertaken. Among those, to achieve a proportional reduction in the cost per single health service provided, facilities with less than 100 inpatient beds have been closed with (number of) beds transferred to larger hospitals, and brand new infrastructures have been designed to accommodate bed capacity resulting from two or more hospital merges.

The findings of how the case study responded to environmental (i.e. 11 out of 13 factors), technological (i.e. 10 out of 13 factors), social (i.e. 10 out of 13 factors), and economic (i.e. 11 out of 13 factors) needs of the local community are reported below and summarised in Table 4, in which positive is reported as ‘yes’ (Y) and negative as ‘no’ (N).

9.1. Environmental needs of the IRCCS in Bari

The IRCCS is located in Bari city centre, in an area easily accessible by public and private transport. The complex refurbishment strategy has been based on the preservation of the 30 s reinforced concrete structure, of the exterior walls for higher thermal insulation and of the high ceilings for more spacious rooms. Self-adjustable brise-soleil and blind systems on the south-east façade reduce the sun radiance, particularly high in spring and summer time. Neat separation of inpatient, outpatient, office and research areas in the functional building layout leads to a more efficient provision of services to the patients, a better organised working environment for the technical staff and a more secluded research area for the researchers. The design of a 100 seats conference hall for hospital meetings and conferences, available for community and cultural use, brings the neighbourhood into the IRCCS and it brings social and cultural activities to the patients themselves. A modern e-library accessible by students, researchers and patients gives them all the chance to spend time in readings, researches and educational activities. The extensive 40,000 m² green park, with benches and picnic areas, the chapel and the bar are all fully accessible by patients, staff, visitors, students, researchers and the entire neighbourhood.

9.2. Environmental technological needs of the IRCCS in Bari

The building hosts the first angio-Computed Tomography (CT) scan that has been installed in Bari: the combined
system of angiography and CT imaging allows up-to-date complex oncologic treatments, as the Radio-Frequency Ablation (RFA), an innovative reality for primitive tumours and unique chance for inoperable tumours. The Linear Accelerator (LINAC) with Multi Leaf Collimator (MLC) offers the chance of safer and more effective treatments, preserving the patient from unnecessary radiations. In addition, the mobile linear accelerator for Intra-Operative Radio-Therapy (IORT) gives the clinician the opportunity to treat the inpatient only once, in specific cases, avoiding more numerous radiotherapy cycles and unnecessary coming back to the facility. The handling antiblastic drugs and preparing chemotherapy unit with Laminar Airflow Work-Benches (LAWB), as well as the cell

### Table 4
Sustainability appraisal in the IRCCS: summary of findings.

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therapies laboratories, offer safer and technologically advanced working environment to clinical staff, in compliance with national and regional regulations. The onco-haematology department provides two one-bed clean-bedrooms, with buffer rooms for immune-compromised patients to be accessed through areas of progressive levels of sterility. Alarmed doors, in critical hospital areas, and Closed-Circuit television (CCTV) system, inside hospital and office buildings, in the parking area and in the green park, guarantee patients, staff and visitors freedom and security. Modern technological heating, water, power, telephone, air-conditioning, medical gas, fire, safety and security systems rely on a control room to daily monitor the systems and to prevent accidents and manage emergencies. Remote patient and staff control of light and air helps to reduce energy consumption and increases patient and staff comfort.

9.3. Social needs of the IRCCS in Bari

The IRCCS provides up-to-date complex oncologic treatments in the centre of the Apulia Region, where patients can easily and not expensively travel for the whole treatment period and for the subsequent whole-life checks. The non-institutional environment positively influences the patients’ perception of the oncologic reality and enhances patient strength in tolerating the therapies. The centre is an excellent example of lean and self-conscious patient flow, through which patients routes are shorter and more effective, from the point of access to the point of care provision to the point of exit. Freedom of movement in a protected and healing environment, together with daily psychological and social attendance is guaranteed at any time to patients and relatives. Staff empathy with the patients humanises cancer care and increases patient comfort, improving clinical results. Views of nature and direct natural light reduce patient stress and enhance a more self-confident patient approach. Facilities like the game room and the nursery for the employees’ children and for all the children accessing the facility with patients and visitors, providing a free social service.

9.4. Economic needs of the IRCCS in Bari

The total refurbishment cost, including construction, equipment and external works, of approximately 2,000 €/m² has resulted extraordinarily inexpensive for the complexity of the project and for the services that are being provided in the building. The project had to cope with: installation of contemporary technologies; existing regulations; heritage site and building; future increase of oncologic activities. The refurbishment strategy, in which conservation and upgrading have led the works, rather than pulling down was essentially led by the six floor building, one of which is partly below the ground level, being the second construction built in Bari in reinforced concrete, with a higher percentage of concrete rather than rebar.

It needs to be stated that the management costs faced in the first year of operation have been higher than the predictions, as the centre was not working at regime, though buildings high energetic demands and equipment installation costs had not yet been paid back by the health services provided. The IRCCS provides free access to oncologic health services, except for the ticket, as provided without additional costs for the patients at the point of access, as paid out of taxes. The high amount of outpatient and of specialised inpatient oncologic health services provided (i.e. over 10,000 in the year 2011) allows a sustainable turnover for the 130 bed capacity infrastructure, despite the high standard cost per each single health service, The facility has a high case mix level, which reveals IRCCS excellent performance on more complex DRGs (e.g. digestive surgery, interventional radiology and haematology) if compared to less complex DRGs. Research costs impact on the total centre incomes, as it is a research centre by definition. However, the IRCCS accesses national public funds for research activities and project developments, provided by the Italian Ministry of Health, on the basis of the Impact Factor Value. In 2015 the IRCCS was accredited ‘Clinical Cancer Centre’ for the years 2015–2018 by the Organisation of European Cancer Institutes (OECI), following a European benchmarking Programme against the patient-centred infrastructure and organisational model, and it is now a Certified Member and Representative of the OECI Quality Programme and Network.

10. Discussion

A sustainable healthcare facility encompasses various combinations of responses to environmental, technological, social and economic needs. Identifying, measuring and monitoring them can lead to improve sustainability in hospitals of dissimilar sizes. It is the accurate balance between: accessibility, constructability, functionality, materials, energy, ICT, technological equipment, waste, culture, demographics, models of care, patient-centred approach, capital availability, investment capability, market, and R&D.

Bed capacity is linked to efficiency of facilities in a linear way only if each hospital element is operated at an optimum scale, thus there is a point after which this may stop to be valid. Different external factors come into play and affect healthcare facilities planning, which are variable over time, thus turning the concept of efficiency into dynamic efficiency. Healthcare facilities are subject to change, due to their nature. Planning can help control possible changes, but cannot prevent changes to happen. In this view, available resources (i.e. natural and manufactured) become essential to achieve efficiency; nevertheless additional factors need to sustain the change. The literature generated a set of factors that go beyond the concept of efficiency and are relevant to four dimensions: the built, the technological, the social, and the economic environment.

The environmental needs of the IRCCS are significantly satisfied if the following elements of the built environment
are taken into account: use of an existing infrastructure of the 30’s, with architectural and historical value; accessible location from the suburban areas and from the whole Region, with free 400 spaces car parking access for staff, patients and visitors; compliance to seismic national regulations and with heritage local guidelines. The technological needs are fulfilled beyond the standard requirements with respect to the level of technology that it is contained in a refurbished construction and the level of care that is locally provided, in compliance with national safety regulations and emergency protocols. The IRCCS is a recognised point of reference for clinical provision, research outcomes and social attendance for more than only the Apulia Region, in a central historical location and within local development and reorganisation policies, which completely satisfies the social needs of the community. The refurbished and highly specialised (in the provision of up-to-date oncologic diagnostic and treatment services, and in the development of high level clinical research) facility opened to the public in 2010 and not yet working at regime at the time of the data collection, remarkably compensated the economic needs. The case study validated the assumption that responding to the needs of the community is key to deliver environmental, technological, social and economic sustainability.

Moreover, the provision of health and social care services is responding in multiple ways to the changed needs of the community (e.g. ageing population, chronic conditions, and tele-care). Therefore, a shift from care provided exclusively in health care settings (i.e. hospitals) to care provision in multiple settings (e.g. day centres, homes) has been taking place over the last decade, resulting in re-scaling healthcare facilities, whose capacity may not any longer related exclusively to (number of) beds available. With this in mind, and with the evidence that built environment impacts on health outcomes and well-being of people, new opportunities should be identified to deliver sustainability, which may include refurbishment and/or reconfiguration of small-scale facilities.

Bed capacity is a powerful and meaningful indicator that should be taken into account in combination with other factors. Larger bed capacity facilities may result in more efficient and cost-effective service provision, due to their larger scale. They improve research and teaching development and they are highly cost-effective for non-specialist treatments, in combination to the high-specialised services. They can be more easily adapted to deliver different services and they can rely on a greater variety of competences within staff, with the chance to increase more flexible treatment provision. They allow more cost-effective recycling policies over the long term and a better costs control policy management overall. Smaller bed capacity facilities are more sustainable in terms of energy demands and patients and staff access to the facility. They increase the provision of very complex services locally and they drive innovation and performance. They offer better chance of accurate control of the procurement process and of the service provision management, due to their more manageable size. They enhance emotional patient experience and better allow them to be in control during their access and stay in the facility. The variability captured in hospital bed capacity in Europe and in the UK, together with the sustainability of the typical small case study in Italy offered initial evidence of how efficiency and economies of scale can be also achieved in small size hospitals.

11. Conclusions and recommendations

This information paper suggested that a small facility can be equally viable and that a more comprehensive point of view of balanced economies of scale is required to support future healthcare design policies, where large hospitals may no longer be environmentally, technologically, socially and economically sustainable.

Sustainability is made by different factors that need to be individually considered in the specific context (i.e. space and time), before being combined to deliver efficiency. In some circumstances, a smaller healthcare facility may perform better than a bigger one on specific aspects (i.e. factors), which enhance a defined value.

The IRCCS Giovanni Paolo II is sustainable despite its small number of beds, as it is correctly located, highly specialised, well organised, patient-centred and cost-effective. The IRCCS bed capacity exactly and effectively satisfies the needs of the community that accesses it today (i.e. patients, clinical staff, researchers and visitors) and it avoids compromising the ability of the same, or of new communities, to meet their needs tomorrow. This typical case study was used to validate the factors determined through the literature review, thus demonstrating how a small bed capacity does not preclude the opportunity of being a sustainable healthcare facility. The consideration of multiple factors can lead to the justification of the relevance that the evaluation and satisfaction of local needs is the key to the development of a sustainable hospital, prior to the building planning, design and operation.

Only within a wider and more comprehensive consideration than that related to the cost per health service is possible to define sustainable development of future healthcare facilities. The sustainability of a facility is to be found in the effective answer to the needs of the community that goes there. In the third millennium, it is necessary to search for sustainability not in the mere belief that reducing energy consumptions, or increasing bed capacity, or offering choice of treatments, or planning brand-new infrastructures at the edge of futuristic visions, may separately be actions sufficient to achieve that objective, if not taking into account the local community, and how its needs will change over time.

12. Limitations and future research

This research has led to the definition of an exploitable and adaptable set of sustainable-related factors of healthcare facilities. It does not aim to be exhaustive, but it
intends to raise self-consciousness on a number of factors that are not always taken into account and integrated when defining sustainability policies and when managing healthcare facilities against service-efficiency and cost-effectiveness. Further studies can be pursued to identify indicators relevant to the proposed factors, thus comparing the four dimensions, determining weighting systems, and finally developing a tool that could be applied in healthcare facilities management.

A newly refurbished small-scale facility in Italy provided original insights; however it sets limitations to this piece of work and suggests that further research needs to be developed to better understand the correlations among the built, technological, social and economic environment, so that ways of measuring and implementing all the factors described can be put forward.

Acknowledgments

The authors want to acknowledge the IRCCS ‘Giovanni Paolo II’ in Bari, its staff and his Technical Area Manager Giancarlo Salomone for the information and support provided during the interviews and focus groups. They also credit BDP Architects, HOK, HLM Architects, EGM Architeceten, White Architects, and AIDHOS Arquitecte for the data provided on the UK and European hospital projects cited in this paper.

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