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IMPACT OF DEVELOPMENTS IN CANCER TREATMENT ON THE DESIGN OF CONTEMPORARY CANCER CENTRES IN EUROPE

Rafał STROJNY [a*], Nicoletta SETOLA [b]

[a] PhD; Faculty of Civil Engineering and Architecture, Lublin University of Technology, Nadbystrzycka 40, 20-618 Lublin, Poland
ORCID: 0000-0002-2451-9152
*E-mail address: *r.strojny@pollub.pl*

[b] Associate Prof.; Department of Architecture – TESIS Centre, University of Florence, Piazza S. Marco, 4 – 50121 Firenze, Italy
ORCID: 0000-0002-0632-5354

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Abstract
As a relatively young field of medicine, oncology is an important element in society, as cancer is one of the major diseases of civilisation in recent decades. As recently as the 20th century, the types of oncology centres were mainly limited to university clinics and bed wards, and the most common method of cancer treatment was invasive surgery. The development of cancer treatment methods that occurred at the turn of the 20th century influenced the architectural and functional design of cancer centres. Innovative treatment methods required new spaces, and thus cancer centres evolved into new types. An analysis was carried out in terms of what types cancer centres in Europe currently take. For further research, 12 facilities considered as reference were selected to represent different types of cancer facilities established in the 21sh century. The aim of the research was to classify contemporary types of cancer centres in the context of the development of treatment methods and to characterise them generally in an architectural context. As a result of the research, five main forms in which cancer centres occur were identified. The general characteristics of these facilities and the differences between them depending on the profile of services provided were presented. The zones present in the centres in question that define their functional layout and shape were also specified.

Keywords: **Architecture of healthcare facilities; Cancer centre; Cancer hospital; Contemporary forms of cancer centres.**

1. INTRODUCTION

Cancer is responsible for one in six deaths worldwide [1]. According to 2020 statistics, 1.3 million people will die from it and 2.7 million people will be diagnosed with cancer in the European Union. According to experts, the number of cases could increase by 24% by 2035. Cancer is predicted to become the leading cause of death in the EU [2]. The projections are pessimistic and access to state-of-the-art cancer treatment is uneven across countries, especially in less developed countries. Although cancer is likely to be more prevalent among the population, they are in a much better position than in the 20th century. The development of medicine after the Second World War, which accelerated at the turn of the 20th century with the rapid advances in technology, has contributed greatly to the development of modern cancer treatments and the improvement of older methods. This has had a significant impact on the evolution of oncology-related hospitals themselves, the way they function and their architectural and functional design. This article aims to illustrate these changes in the form of a characterisation of new types of oncology centres closely linked to cancer treatment methods.

In the contemporary architecture of healthcare facilities, an increasing humanisation of the space is perceptible [3], which is characterised, among other things, by a more friendly, homelike and less institutional atmosphere enhanced by an appropriate interior scale, natural finishing materials, greenery and appropriately selected art elements [4–5]. In addition to taking clinical or technological requirements into account, optimising patient wellbeing is an important consideration. One element that helps to achieve this is involving patients and staff in consultation during the development of the hospital design [6]. Equally important is the humanisation of care, which is an individualised approach to the patient, increasing the quality, efficiency and safety of care [7]. These trends, together with significant developments in medicine and technology, are influencing both the way contemporary healthcare facilities are designed and the evolution of their forms. A clear example demonstrating these relationships is the contemporary forms and architecture of cancer centres.

2. MATERIAL AND METHODS

The first stage of the research was to analyse the available literature related to the history of oncology in order to characterise the main cancer treatments over the centuries and to outline the history of cancer hospitals. The databases used were Google Scholar, Publons, Research Gate, Science Direct and Scopus. The following keywords were used: "history of oncology", "history of cancer hospitals", "cancer treatment methods", "architecture of cancer hospitals", "cancer hospital", "cancer care facilities", "oncology ward", "cancer treatment centre", "cancer care/support centre".

A review of websites (264) was also carried out to work out which types of cancer centres exist today in different European countries and with what frequency. The Google browser and the keywords "cancer hospital", "cancer unit", "cancer care centre", "contemporary cancer care centre", "cancer support centre", "contemporary cancer hospitals", "contemporary cancer centres" were used. The names of individual European countries were also added to the selected keywords. On this basis and based on the available scientific articles in the field of oncology and, in particular, on the surveyed facilities, the contemporary types of cancer centres were identified in the context of cancer treatment methods.

The next stage of the research was to compile a list of various types of facilities related to oncology in Europe and then to select reference facilities meeting the following selected criteria: year of construction of the facility (possibly the most recent facilities), availability of research materials (photographs, projections and other drawings of the facility, etc.), provision of medical services including the most modern methods of cancer treatment, and original and high-quality architectural and functional solutions. The basis for the selection of criteria was the selection of state-of-the-art facilities, characterised by the highest quality functional, material and technological solutions, whose distinctive architecture reflects contemporary design trends.

Having met the established criteria, twelve different oncology-related healthcare facilities were selected for further study. These were built over the last decade. An in-situ study was also carried out for five facilities in the UK. Preliminary research and a survey of the selected 12 facilities allowed an attempt to create a typology of contemporary oncology facilities in Europe. Based on the survey of these facilities, the main zones within them, their characteristic spaces, their functional arrangements and their characteristic architectural solutions (in the context of the treatment methods used in the facility) were detailed.

3. THE DEVELOPMENT OF ONCOLOGY FROM 20TH TO THE 21ST CENTURY – METHODS OF TREATING CANCER

3.1. Invasive surgery

Surgery was initially the main treatment for cancer. Other therapies were used for inoperable tumours [8]. The early years of the 20th century saw the beginning of the development of surgical oncology techniques. Surgery and radiotherapy were the mainstay of tumour treatment until the 1960s [9].

3.2. Radiotherapy

The discovery of X-rays in 1895 by the German physicist Roentgen is considered the beginnings of radiotherapy, as EH Grubb first used X-rays to treat cancer as early as 1896 [10]. In turn, the discovery of radium in 1898 by Marie Skłodowska-Curie and Pierre Curie led to the development of brachytherapy [11]. Radiotherapy is a cancer treatment method that uses high-energy rays or radioactive substances to damage tumour cells and stop them from growing and dividing [12]. There is also a subspeciality called palliative radiotherapy, which is a cost-effective and efficient palliative intervention [13].

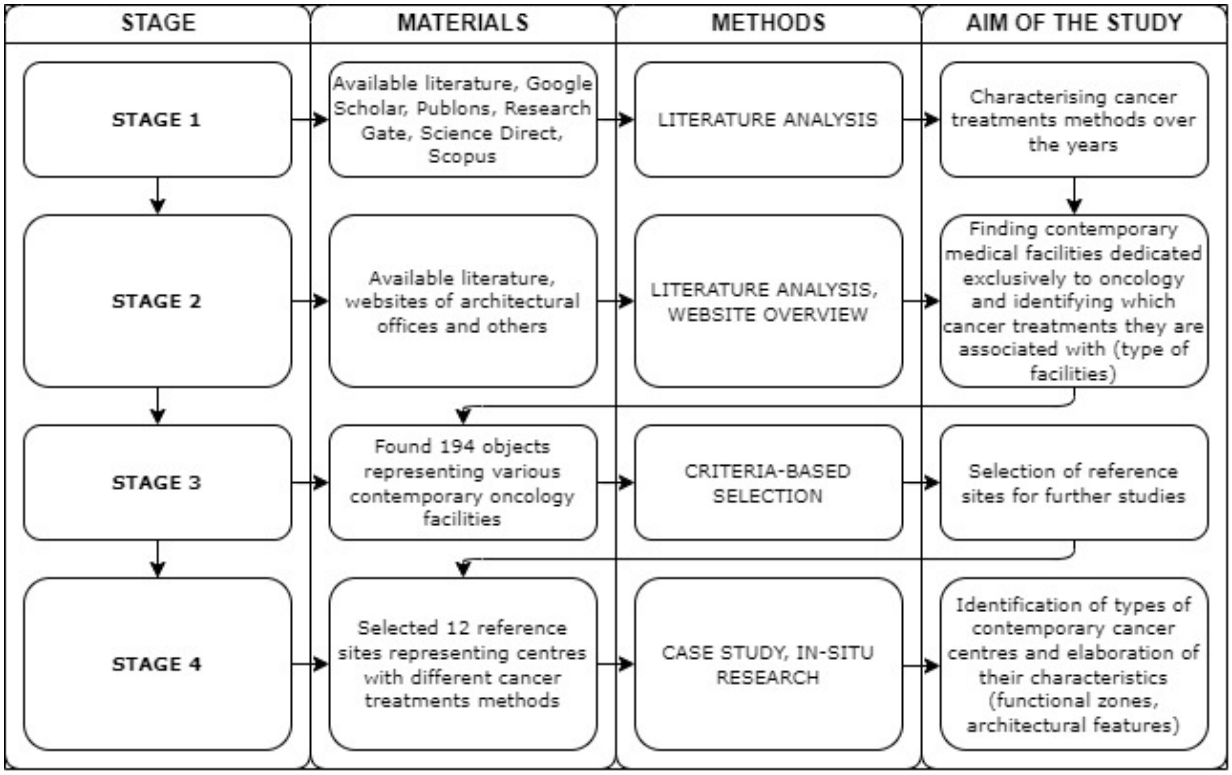


Figure 1.
Stages of research outlining the research material adopted, the research methods and their purpose. Elaborated by the authors

In 1953, the first linear accelerator treated the first cancer patient in London [14]. Computed tomography (CT) began to be used in radiotherapy from around 1972 [10]. Modern radiotherapy technologies are helical tomotherapy (HT), intensity-modulated radiotherapy (IMRT) and proton radiotherapy [15]. Since 2018, a new radiotherapy technology called FLASH-RT has started to be developed, taking significantly less time compared to conventional radiotherapy [15]. One contemporary form of cancer treatment is image-guided radiotherapy (IGRT), which allows precise targeting of the tumour while sparing the organs at risk. The development of this method is linked to magnetic resonance imaging (MRI). Further technological developments have led to the integration of MRI with the linear accelerator (MRL) [16].

Radiotherapy has developed significantly over the past 100 years. Its progress is expected to lead in the future to the transformation of cancer from acute to chronic disease using genetics, resulting in effective radiation treatment [17].

3.3. Chemotherapy

The roots of chemotherapy can be traced back to antiquity, despite the fact that the practices for treating cancer at that time were largely unfounded in the context of modern medicine. However, some of the compounds developed in the 1950s and 1960s that are used in chemotherapy today are identical to compounds derived from natural sources used in antiquity [18]. Chemotherapy was pioneered by the German chemist Paul Ehrlich in the early 20th century. However, these were the beginnings of this type of therapy, as invasive surgery and radiotherapy were the main cancer treatments. In the following decades, cancer cure rates using radical treatments reached quite low levels [19]. The development of chemotherapy occurred after the Second World War, and was initiated by the surprising discovery of the effect of a mixture of chemical weapons and oil from a sinking tanker on the destruction of white blood cells in sailors in contact with the substance [20]. Chemotherapy began to be used more frequently for certain cancers only in the late 1960s. Nowadays, chemotherapy has changed significantly, thanks to research that is leading to the development of new drugs and targeted therapies [19]. In addition to

prevention and early diagnosis, advances in cancer treatment, including the use of chemotherapy in treatment programmes, have contributed to a decrease in the number of deaths since the 1990s [19]. Currently, surgery, radiotherapy and chemotherapy are the conventional treatments for cancer [1].

3.4. Proton therapy

Proton therapy was first applied in 1957 in Uppsala, Sweden, using a cyclotron. Since the 1990s, 21 particle therapy centres have been established in Europe (until 2018) [21]. In 2022, there were 25 proton therapy centres in Europe [22], and five are currently under construction. Particle therapy using protons or heavier ions is currently one of the most advanced forms of radiotherapy [23].

3.5. Other therapies

In the 1990s, photodynamic therapy was developed as a tool for cancer treatment. This was linked to the discovery of the properties of haematoporphyrin for tumour localisation and its phototoxic effect on cancer cells [24]. In the last two decades, diagnostic and therapeutic agents using nanomaterials have also been developed. Their aim is to deliver therapeutic molecules to tumour cells in a controlled manner. Other cancer treatments include targeted therapy (using pro-drugs that activate when they reach cancer cells), hyperthermia (using microwaves, ultrasound and radio waves) and gene therapy (introducing DNA, RNA etc. into specific cells or tissues) [9]. Targeted therapy has the effect of inhibiting the growth and spread of cancer cells, resulting in less damage to healthy cells. Ablative therapy, on the other hand, burns or freezes tumours without the need for open surgery, making it a minimally invasive procedure [1].

In addition to traditional cancer treatments, i.e. surgery, radiotherapy and chemotherapy, modern treatments include hormone therapy, anti-angiogenic therapy, stem cell therapy and immunotherapy [1]. One popular therapy used in the 21st century is immunotherapy. It uses components of the immune system to treat cancer, among other things [9].

3.6. Multidisciplinary patient support as an adjunct to cancer treatment methods

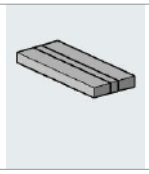
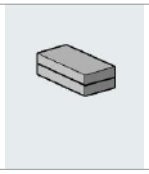
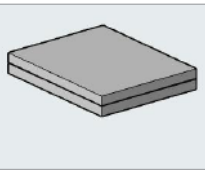
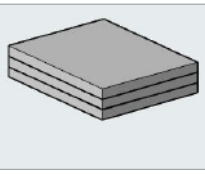
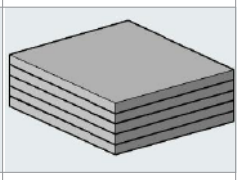
In the 21st century, there is widespread awareness of the impact of the built environment on humans, as evidenced by a number of studies on this topic in recent decades, especially in the context of Evidence-Based Design. Environmental quality and comfort are particularly important for cancer patients positively influencing their wellbeing [25–26]. This is reflected in the idea of support centres created by Maggie and Charles Jencks. These centres provide additional space for patients and their relatives by offering multidisciplinary practical and social, lifestyle and emotional support. This is recognised as an integral component to complement the cancer treatments used. Patient awareness and support for, among other things, dietary and lifestyle changes and adaptation to a new life situation is important in the treatment process [27].

4. TYPES OF CANCER HOSPITALS UNTIL THE END OF THE 20TH CENTURY

The first hospital with 12 beds for the care only (not including treatment) of cancer patients opened in 1740 in Reims, France. At the time, cancer was thought to be contagious, so patients were isolated. In 1779, patients were transferred to the new Hôpital Saint Louis. The first hospital dedicated to treating cancer patients was the Free Cancer Hospital opened in 1851 in London (now The Royal Marsden Hospital). It treated cancer mainly by surgery and radiotherapy [28]. It was the world's first centre for the study and treatment of cancer. It was founded by William Marsden, whose wife had died of cancer. Its aim was to classify tumours, investigate the causes of their formation and find new treatments [29].

Until the 20th century, the main treatment for cancer was surgical removal, regardless of whether the cancer was located in one site or many. However, this was not a perfect method, as the disease returned after some time and further operations were needed [30]. The treatment of cancer mainly by radical surgery in the 20th century required patients to stay longer in hospital. As virtually most modern cancer treatments were in the research and development stage in the second half of the 20th century, the standard forms of cancer hospital were oncology clinics and oncology departments in university hospitals. Due to the limitations in the types of therapies, as well as in the diagnosis of cancer, it is worth noting the fact that this had an impact on the late detection of cancer and thus, in many cases, its inoperability. For this reason, palliative care was also needed, also requiring space in hospital for a longer stay. Thus, the

Table 1.
Classification of contemporary types of oncology-related healthcare facilities with schematic representation of differences in scale and height of facilities. Developed by the authors

CONTEMPORARY TYPES OF CANCER CENTRES					
Name	Oncology bed ward	Day cancer care centre	Single-therapy day treatment centre	Daytime multi-therapeutic treatment centre	Multi-therapeutic day and long-stay treatment centre
Scheme					
Treatment methods	Many types of therapy offered at the facility that require a long-term stay	Multidisciplinary patient support (as an adjunct in the treatment process - holistic approach)	One type of therapy provided at the facility	Many types of therapy offered at the facility that do not require a long-term stay	The many types of therapy offered at the facility, both not requiring a long-term stay and requiring one
	Invasive surgery with complementary therapies (e.g. chemotherapy etc.)	Multidisciplinary practical and social, lifestyle and emotional care (background to treatment methods)	Proton therapy or radiotherapy (mostly)	Day surgery, radiotherapy, chemotherapy, other therapies, multidisciplinary patients support	Invasive surgery, radiotherapy, chemotherapy, proton therapy, other therapies, multidisciplinary patients support
Spatial characteristics	Part of a larger hospital with patient bed rooms. Treatment spaces include, for example, chemotherapy areas. Surgical procedures take place in the general operating theatre of the hospital.	A small facility located near a cancer hospital that provides spaces for patients and their relatives to learn about the diagnosis, receive multifaceted support. Providing a non-institutional environment in the treatment and recovery process.	Small or medium-sized facilities (depending on the number of treatment devices and additional areas), a large part of which is occupied by a technical area related to the treatment method offered - proton therapy or radiotherapy.	Small or medium-sized facilities (depending on the types of treatment offered and their specificities). Larger facilities have bunkers with radiotherapy, operating theatres and post-operative areas (same-day surgery) etc.	Much larger than other cancer centres because they have long-term care units. In addition, the size and form of the facility is influenced by the type of therapies offered, e.g. in the case of proton therapy, a special bunker and an extensive technical area, etc.

primary oncology spaces were bed wards for longer stays, operating theatres and radiotherapy areas.

In the 20th century, the diagnosis of cancer most often consisted of taking tissue sections for examination by surgery. Since the 1970s, new imaging methods such as ultrasonography (USG), computed tomography (CT) and magnetic resonance imaging (MRI) have developed [31]. The new diagnostic devices required dedicated space and special architectural and building requirements, as in the case of CT and MRI. This has led to an increase in diagnostic spaces in hospitals.

5. CONTEMPORARY TYPES OF CANCER CENTRES AND THEIR CHARACTERISTICS

5.1. General characteristics of cancer centres

Significant developments in cancer diagnosis and treatment methods at the turn of the 20th and 21st centuries, have significantly impacted oncology. Many of the new cancer treatments required new forms of space in cancer centres or even entirely new facilities. Originally, in the 20th century, oncology clinics mainly operated in university hospitals, as oncology was a relatively young field of medicine and was in its developmental stage. In addition to the clinics, there were bed-based oncology wards in university or multi-speciality hospitals. Nowadays, university clinics still exist, adapting to modern cancer treatments and also acting as research centres. Their most modernised form is the multi-therapeutic treatment centres for day and/or longer stays, which are most often part of a university hospital campus or directly linked to a specific university. Bed-based oncology wards involve longer hospital stays for patients who have to undergo invasive surgery, for example. This mainly applies to cases where less invasive methods are insufficient for treatment. In addition to the development of cancer treatment methods, it is still not always possible to cure a cancer, and

Table 2.
List of oncology facilities included in the study and their general characteristics. Elaborated by the authors. Source: [33-44]

No.	Name	Location	Designer	Treatment methods	Type of facility	Total area [m^2]	Number of floors	Opening year
1	Chemotherapy Outside	Hilversum, The Netherlands	VANDERSALM-aim	Chemotherapy	Oncology ward	196	1	2015
2	Maggie's Centre at the Royal Marsden	London, UK	Ab Rogers Design	Multidisciplinary patients support	Day cancer care centre	468	2	2019
3	Kálida Sant Pau Centre	Barcelona, Spain	Benedetta Tagliabue - EMBT			400	2	2019
4	Maggie's Leeds Centre	Harehills, UK	Heatherwick Studio			462	2	2020
5	Ipo Porto – Radiotherapy Centre	Porto, Portugal	ACTIU	Radiotherapy	Single-therapy day treatment centre	6000	1	2012
6	Quironsalud Prothon Therapy Centre	Madrid, Spain	IDOM	Proton therapy		2380	3	2014
7	Skandion Clinic	Uppsala, Sweden	LINK Arkitektur			14300	7	2019
8	UCH Macmillan Centre	London, UK	Hopkins Architects	Day surgery, radiotherapy, chemotherapy, other therapies, multidisciplinary patients support	Daytime multi-therapeutic treatment centre	14000	9	2012
9	Cancer Centre at Guy's Hospital	London, UK	Roger Stirk Harbour + Partners			20000	15	2016
10	NGS Macmillan Unit	Chesterfield, UK	The Manser Practice	Chemotherapy, other therapies, multidisciplinary patients support		2140	2	2017
11	Princess Máxima Center	Utrecht, The Netherlands	LIAG Architects	Invasive surgery, radiotherapy, chemotherapy, other therapies, multidisciplinary patients support	Multi-therapeutic day and long-stay treatment centre	45000	6	2018
12	Grafton Way Clinic	London, UK	Scott Tallon Walker Architects	Invasive surgery, radiotherapy, chemotherapy, proton therapy, other therapies, multidisciplinary patients support		34500	11	2022

modern treatment methods are tailored to specific types of cancer. For this reason, there are also, among others, palliative care units that are primarily intended to provide the highest level of care and a dignified quality of life at the end of life for terminally ill patients.

Based on the research carried out on what type of oncology facilities occur in Europe, a collection of 28 day cancer care centres, 26 single-therapy day treatment centres and 140 multi-therapeutic treatment centres for longer and day stays was obtained (total of 194 objects, of which 12 were selected for further study). The number of objects found does not represent the total number of oncology sites in Europe, but is a representative group for this type of site. The authors attempted to analyse as many of these facilities as possible for the study, but it is difficult to obtain complete information due to the differences that exist in the different countries in terms of administrative division and the health care system. Some of the building types studied are innovative in that more than half of them are the first of their kind in selected European countries. Many countries do not have such facilities or they are at the planning stage. This demonstrates the ongoing development of this type of facility.

Through their research, the authors has made an attempt to define contemporary forms of cancer centres (Table 1). These forms represent completely new facilities, characteristic of the 21st century, which are day cancer care centres and single-therapy day treatment centres. Multi-therapeutic day and/or longer-stay treatment centres, as mentioned earlier, can be considered as forms of cancer facilities that have evolved from the first cancer clinics established in the 20th century. The classification created also includes bed-based oncology wards, which are found in multi-speciality hospitals and are not typical of the 21st century. However, the way they are designed is changing somewhat, which is linked to modern research on the

impact of the built environment on humans. Therefore, there are few examples of completely new approaches to cancer treatment.

The IAEA (International Atomic Energy Agency) publication identifies the specifics of today's cancer centres, from which a similar division into their types can be deduced as in the research conducted by the authors. When discussing the topic of oncology facilities, it is also important to mention that most often cancer diagnosis and prevention is carried out in primary care facilities rather than in hospitals. However, this does not exclude the existence of diagnostic areas in cancer centres. Part of the IAEA publication also addresses the topic of palliative care and support [32].

Due to contemporary trends in the approach to healthcare, especially in oncology, in addition to typical cancer centres offering specific treatments, the classification of contemporary cancer centres includes day cancer care centres, which are closely related to oncology. Although these centres are not for treatment, providing wide-ranging emotional, practical or social support, they are an integral part of the treatment process. This is evidenced in the UK, where the target is to establish such centres at every cancer hospital in the country. The key role of this type of support is also demonstrated by the fact that, for example, day and long-stay treatment centres tend to have areas offering the same support as day cancer care centres.

A final type of oncology-related facility is palliative care centre (hospice), which is not related to cancer treatment, but to the provision of care in the event of a patient's terminal condition. The majority of patients in this type of facility are usually cancer patients, but there are also people with other diseases (including neurological diseases, AIDS, cardiomopathy, etc.). Due to the nature of the research, which focuses strictly with cancer centres dedicated exclusively to oncology, palliative care facilities were not included in further studies. However, this does not exclude the fact that they are partly linked to "indirect" cancer treatment.

In terms of scale, some differences are noticeable in certain types of cancer centres. The smallest are the bed wards, which are one floor in a building and have an area of a few hundred square metres - nowadays, in order to keep the space from being too institutional and to provide a welcoming atmosphere, the aim is to keep the wards in hospitals small (short corridors, a few dozen bed rooms).

Day cancer care centres (e.g. Maggie's Centres in the UK) are similar in size but different in form. These are usually 2-storey buildings (rarely 1 or 3 storeys). Their spatial forms vary, depending on the designer's concept and the local context. Their surface area is usually around 500 m^2, in a few cases more (but not exceeding several hundred square metres).

The scale of single-therapy day treatment centres varies due to the type of zones within them. Smaller centres usually have 1-3 storeys and an area of several thousand m^2. They usually contain mainly treatment and administrative zones. In larger facilities, which can reach more than five storeys, there are additional patient zones (e.g. diagnostic-consultation, social, research or training zones) and therefore their surface area can reach several thousand m^2.

Daytime multi-therapeutic treatment centres are also divided into small and large in terms of scale. When a facility offers selected therapies such as chemotherapy, its floor space covers several thousand m^2 and has 1-3 floors. On the other hand, facilities that offer most of the available therapies and additionally have diagnostic and consultation spaces, their surface area may be a dozen to a few tens of m^2 (usually in the range of 10000-20000 m^2). Similarly, their height is greater, and can range from four to a dozen storeys.

The largest in terms of scale are multi-therapeutic treatment centres for day and longer stays. They range in height from five storeys or more and the surface area usually reaches more than 30000 m^2. The large scale is due to the fact that these facilities sometimes include bed wards in addition to large areas of treatment or technical spaces.

5.2. Oncology bed wards

A typical form associated with oncology is bedded wards, which can occur, for example, in multi-speciality hospitals as a surgical oncology ward or an oncology ward that includes various therapies but requires the patient to stay longer in hospital. This is a typical form of space associated mainly with the surgical treatment of cancer, which requires a longer stay in the facility. The architecture of an oncology ward must include elements that will improve the psychological comfort of patients. Therefore, it is important here to shape the space in such a way that the sense of security, care and appropriately chosen colours and art elements have a positive effect on patients, their families and staff alike. The importance of art and colours in shaping a cancer ward was confirmed by a study in one ward in Graz, Austria, which was designed by the renowned artist Hundertwasser [45].

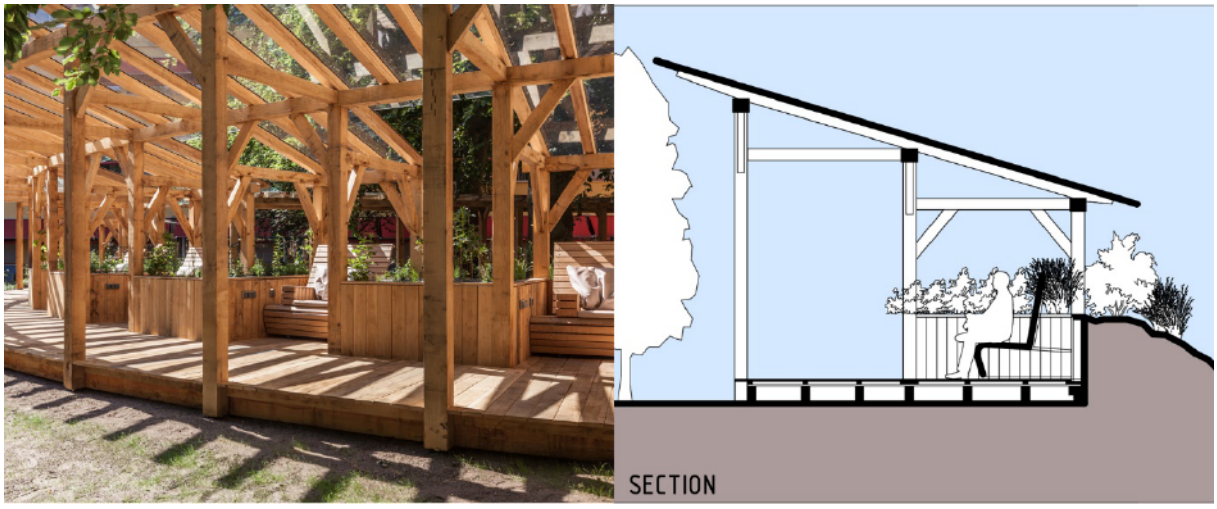


Figure 2.
View and cross-section of the chemotherapy space in Hilversum. Photo by Milad Pallesh. Drawings elaborated by the authors from online material available at vandersalm-aim.nl. Source: https://vandersalm-aim.nl/project/chemotuin-hilversum

The evolution of the environment in healthcare facilities towards a focus on the patient and the provision of a welcoming and therapeutic environment is also very evident in some oncology wards. Chemotherapy areas, for example, were originally located in a typically "hospital" space, with chemotherapy "boxes" with no views to the outside. As an alternative, an unusual form of chemotherapy space was developed in 2015 in Hilversum, the Netherlands (Fig. 2.). It is a form of timber-framed gazebo located outdoors. A key role in it is played by the natural environment as a backdrop for chemotherapy. Surrounded by parkland, the gazebo was designed to provide unusual views of the greenery. This has been achieved by projecting the gazebo in a circular plan, on which the covered patient seats are arranged. These are separated from each other by pots of low greenery. The gazebo also contains nesting boxes and wintering areas for birds and bats [46]. This is a blunt example of the humanisation of the oncology treatment space, and perhaps such an evolution of the typical oncology ward will become a new trend in the future. This would be desirable from the point of view of the patient's psychological comfort, which is particularly important in the case of an extremely severe disease such as cancer.

5.3. Day cancer care centres

One of the best examples of healthcare facilities specific to oncology in the 21st century are day cancer care centres. More widely known as Maggie's Centres, the idea for which originated in the 1990s in

Figure 3.
Maggie's Centre at the Royal Marsden, London – view of one of the elevations and a schematic cross-section through the building. Photo by Rafał Strojny. Drawings elaborated by the authors from online material available at the AB Rogers Design office. Source: https://www.abrogers.com/portfolio/maggies-at-the-royal-marsden/

Scotland. Charles Jencks authored the concept with his wife Maggie, who died of cancer [27]. There are now just under 30 such facilities in Europe, most in the UK, but also in Spain, Denmark and other developed countries. Ultimately, 60 such centres are planned in the UK alone (at every hospital treating cancer patients). There are also plans to build centres in Norway and the Netherlands, among other countries [27]. Centres of this type are built adjacent to cancer hospitals. They provide a therapeutic space for cancer patients and their families at the stage of learning about the diagnosis, getting used to the disease and the treatment process itself. These facilities offer more than twenty modalities of assistance, including practical and social support, lifestyle support (crucial in the cancer treatment process) and emotional support [47].

From an architectural point of view, these centres are characterised by architectural, functional and material solutions of the highest quality. Each is characterised by a unique impressive form given by the most renowned architects and architectural studios. Functionally, they are divided into an open and inviting entrance area, communal spaces such as rooms with sofas and armchairs, a library, a garden, a kitchen designed to integrate patients, volunteers, but also to serve various types of workshops and meetings. Other areas have a more intimate character providing quiet spaces where the patient can learn about the diagnosis, treatment strategy and also receive the necessary emotional support. All the spaces in the cancer care centres have been thought out down to the smallest detail, and the specially selected natural materials are adapted to the extremely sensitive oncology patients. They thus provide them with an excellent space that is a safe and welcoming environment during this difficult time for them. A characteristic feature of these facilities is the "inviting" design of the building with an open plan aimed at stimulating human interaction. Among other things, greenery (inside and outside), appropriately selected art elements (paintings, graphics, sculptures, etc.) and natural materials play an important role in them. The colour scheme is also important. Depending on the nature of the room, it can be calm colours (e.g. dark, soothing colours) in spaces where the patient learns about the diagnosis, receives psychological support. On the other hand, bright, lively and even stimulating colours (e.g. yellow, red, etc.) can be seen in communal areas, which are also intended for various group activities (workshops, talks, etc.).

The cancer care centres are a direct reflection of research related to the built environment and its impact on patients and their wellbeing. Maggie's Centres are linked to the concept of "Healing Environment" providing psychosocial support to cancer patients and their relatives [48]. They are centres providing non-institutional support [49], although they are not centres where patients are treated, they should be included in the group of contemporary forms of cancer hospitals. The argument for this is a completely new approach to the patient, and the support offered in these centres is recognised as an indispensable part of the whole treatment process for cancer patients. The element of multidimensional support is crucial in complementing cancer treatment, going beyond the treatment aspect of the body to include non-physical aspects.

5.4. Single-therapy day treatment centres

Single-therapy day treatment centres represent the second group of cancer facilities that have started to be established on a larger scale since the last 20 years. These are mainly centres for proton therapy, which is now one of the most modern and effective treatments for certain types of cancer. There are now almost 30 such centres in Europe. Radiotherapy centres can also be included in this group.

Examples of single-therapy centres are the Skandion Clinic in Uppsala (Fig. 4.) and the Quironsalud Proton Therapy Centre in Madrid. These are the first facilities of their kind with proton therapy in Sweden and Spain. The functional layout of the Skandion Clinic can be distinguished between main zones such as the entrance area, the treatment area (with preparation rooms, recovery rooms, etc.), the technical area (with a cyclotron, technical rooms next to the treatment area) and the administrative area (with offices, meeting rooms and conference rooms). The Quironsalud centre in Madrid additionally uses a diagnostic/consultation and training zone.

These centres, due to the specific nature of the therapy, are characterised by a much smaller treatment area compared to the very large technical space required by the proton therapy equipment. This space takes up about 30% of the total facility area. In addition, this type of therapy requires special building solutions in the form of walls up to 3.5 metres thick which form a bunker that acts as a radiation barrier to the environment. Depending on local conditions, the bunker is placed below or above ground level.

Figure 4.
Skandion Clinic, Uppsala (Sweden) – view of the building and schematic cross-section through the building. Photo by Hundven Clements Photography. Drawings elaborated by the authors from online material available at the LINK Arkitektur office and archdaily. Source: https://www.archdaily.com/804089/skandion-clinic-link-arkitektur

The Ipo Porto Radiotherapy Centre is an example of a day treatment centre focused on the radiological treatment of cancer. The facility consists of an entrance area, an administrative area, a treatment area and also a training area. With 16 treatment rooms and seven linear accelerators, the centre provides 80000 radiotherapy sessions a year [36].

Architecturally, the day treatment centres are characterised by the high-quality materials used on the outside, but also on the inside (outside the treatment areas). Natural materials (e.g. stone, wood) and neutral light colours (whites, greys, beiges) are used in the common areas. Colours are used as accents - for example as furnishings or finishes (furniture, selected wall/floor surfaces). These are medium-sized facilities because they are dedicated to a specific cancer treatment therapy that does not require bed wards. The general spaces in these facilities, together with the entrance area (usually single-storey), occupy an insignificant area compared to the technical area.

Figure 5.
Cancer Centre at the Guy's Hospital, London – view of the building and schematic cross-section through the building. Photo by Rafał Strojny. Drawings elaborated by the authors from online material available at the RSHP office. Source: https://rshp.com/projects/health-and-science/cancer-centre-at-guys-hospital/

5.5. Daytime multi-therapeutic treatment centres

Daytime multi-therapeutic cancer treatment centres are another form of modern cancer facilities. It stems from the need to adapt to new cancer treatment therapies, as well as old ones, which, thanks to medical developments, are much more advanced and accessible than in the previous century. Centres of this type offer several types of cancer treatment therapies in a single facility.

The UCH Macmillan Centre and the Cancer Centre at Guy's Hospital in London are examples of multi-therapy day treatment centres. The former offers, among other things, an entry area, a diagnostic and consultation area that also includes counselling, screening or complementary therapies and support. This centre also provides facilities for clinical trials and research [39]. The Centre at Guy's Hospital (Fig. 5.) was shaped in a slightly different form. The building, on a triangular plan, has been divided into a social zone on each floor on the south side and treatment and other zones on the north side. The social zone in this building functions similarly to the support centres (Maggie's Centres). Vertically, the centre is divided into an entrance area with a staff area and recreation spaces on the first three floors. The next three floors comprise the radiotherapy areas, above which is the day surgery area and the outpatient clinic. Above this is the chemotherapy area and above this is the staff area. The building unusually located the radiotherapy zone on the third floor, which is usually located in non-daylighted parts of the building [40]. In this facility, it was crucial to ensure a balance between treatment areas and social areas that offer a welcoming and relaxing space for patients. This is crucial to minimise stress levels in cancer patients and also their relatives.

The NGS Macmillan Unit opened in 2017 at the Royal Chesterfield Hospital in the UK and is an example of a smaller-scale day treatment centre. It is a self-contained building connected by a link to the existing hospital and a main entrance with a waiting area for patients from outside. It has no bed rooms. Amongst other services, the facility provides haematology, chemotherapy, acute oncology care and palliative care. The building offers a relaxing space especially for chemotherapy, with views of the greenery. It

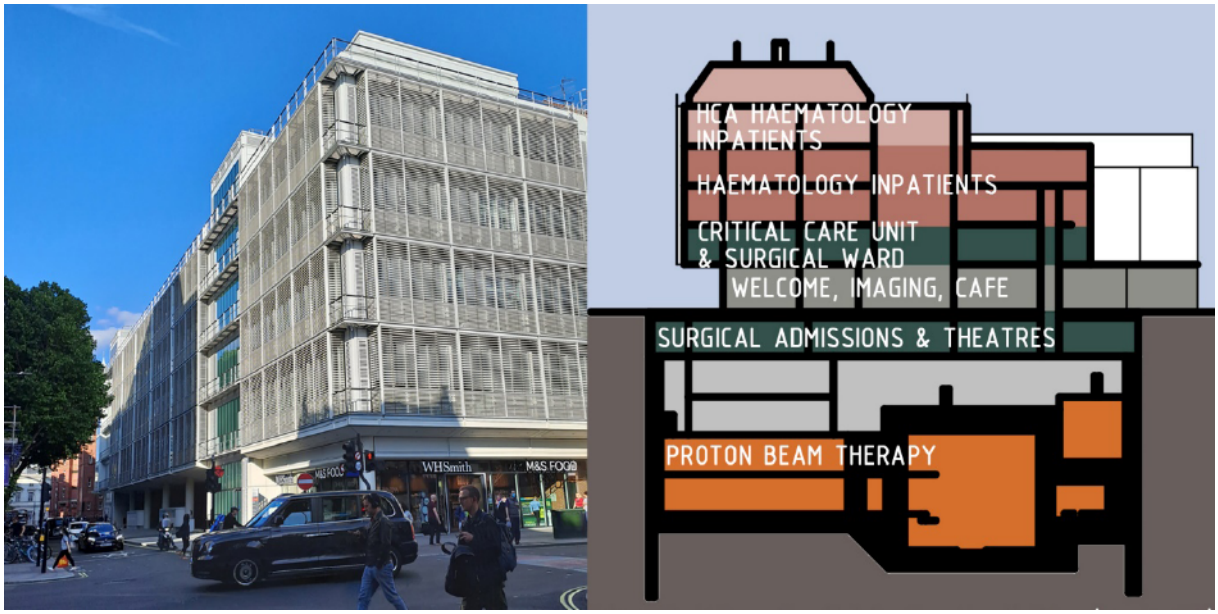


Figure 6.
University College Hospital Grafton Way Building, London – view of the building and schematic cross-section through the building. Photo by Rafał Strojny. Drawings elaborated by the authors from online material available at the Edward Williams Architects office. Source: https://www.edwardwilliamsarchitects.com/projects/view/uclh-phase-4-and-proton-beam-therapy-unit-london-uk

also provides space for relatives to accompany patients undergoing chemotherapy or other cancer treatments [41].

5.6. Multi-therapeutic day and long-stay treatment centres

The University College Hospital Grafton Way Building (Fig. 6.) opened in 2022 and is an example of a multi-therapeutic treatment centre with day and longer stays. It is a cancer hospital with an intensive care unit, surgical ward and operating theatres. It is also one of Europe's largest centres for the treatment of blood diseases. In addition, the centre houses a proton therapy centre in the lowest underground floors. Due to the limitation in the height of the building and the provision of sufficient floor space, this facility has an underground section with a volume similar to that of the above-ground section of the building. This is a very unusual solution due to local conditions.

Multi-therapeutic treatment centres can also exist in other forms. In Poland, for example, these are oncology centres linked to a specific province. They can also be specialised oncology facilities for children. An example of such a facility is the Princess Máxima Centre for Child Oncology in Utrecht, which is the largest paediatric oncology centre in Europe [42]. The building features spacious general areas, children's play and recreation areas, large single rooms combined with a separate family room and a balcony. The building is also characterised by high-quality architectural and material solutions creating a friendly, safe and calm atmosphere. Architecturally, the form of the buildings is noteworthy, with a spacious atrium in the entrance area ranging from two to even several storeys in height. The individual zones are clearly arranged vertically. The general zones are dominated by high-quality materials and elements of art and greenery. The facades are also distinguished by unique solutions using very high-quality materials. In many cases, the sun shading elements dominate, giving an original character to the whole building. In the Cancer Centre at Guy's Hospital, the façade is characterised by a colour scheme that corresponds to the functional layout of the building (including the wayfinding system), designating the different zones for specific cancer treatments.

6. SUMMARY

Depending on the type of cancer centre, characteristic zones shaping its functional layout can be distinguished in each centre (Table 3.). For some hospitals these are similar, while in others they are absent. This is related to the cancer treatment methods used in a particular facility. For example, in single-therapy day treatment centres there is a treatment area that is much smaller than the technical zone required by the

Table 3.
Matrix showing the zones occurring in each type of cancer centre (blue). The green colour indicates zones that may or may not occur. The x symbol indicates the absence of a given zone in the facility. Developed by the authors

	A	B	C	D	E
Entrance area					
Administrative area					
Social area					
Diagnostic and consultation area		x			
Treatment area		x			
Technical area		x			
Staff area		x			
Research area		x			
Training area		x			

LEGEND

A – oncology bed ward
B – day cancer care centre
C – single-therapy day treatment centre
D – daytime multi-therapeutic treatment centre
E – multi-therapeutic day and long-stay treatment centre

equipment used for proton beam therapy or radiotherapy. A treatment zone is also present in multi-speciality centres. However, in centres with longer stays, its form is the operating theatre with all the facilities.

Regardless of the type of facility and the treatment methods used, there is always an entrance area that corresponds in scale and form to the form of the facility. The same is true of the administrative area, which takes up a considerable amount of space, especially in day treatment centres. Most often there is also a social area, necessary to provide a friendly environment for patients and their accompanying relatives. As most of the cancer hospitals described are specialised centres, they most often do not have diagnostic and consultation areas. This is because patients who have already been diagnosed and have a specific therapy selected are referred to such facilities. Treatment areas are the main defining zone of modern cancer hospitals. More often than not, they require a significant amount of technical space for the operation and maintenance of treatment equipment. In addition to these zones, the staff area is also fundamental, providing space for staff in both the treatment and research zones. A research and training zone also occurred in some of the facilities analysed. This is due to the frequent association of the cancer centres studied with universities, which conduct research into cancer treatments and their improvement. Table 4 lists the spaces characteristic of specific zones in the cancer hospitals.

Cancer care facilities play an important role in confronting cancer. Sensory qualities, atmosphere as well as good spatial organisation are important aspects in cancer facilities creating a sense of stability [50]. The design of healthcare facilities needs to take into account the changing psychosocial needs of young adults as well as adolescents with cancer, as the stress of the disease as well as the treatment environment itself can negatively affect different types of age-related developmental changes in these individuals [51].

Depending on the specific facility, the facilities studied appear to be adapted to the needs of patients and their age, focusing particular attention on providing a flexible and welcoming environment as a background for oncology treatment. The facilities selected for the study also reflect a change in the approach to shaping space in a way that focuses not on the treatment itself, but also on the patient. This is linked to the

Table 4.
Selected spaces occurring in a given zone in contemporary cancer centres. Developed by the authors.

ZONE NAME	SPACES IN THE ZONE
Entrance area	Lobby, reception, waiting area, hygiene and sanitary facilities, services (e.g. restaurant, shop) etc.
Administrative area	Office rooms, meeting rooms, conference rooms, archives, staff room, hygiene and sanitary facilities, etc.
Social area	Common spaces, recreation spaces, garden, support spaces, catering, services etc.
Diagnostic and consultation area	Consultation rooms (including counselling, advice), doctors' surgeries, diagnostic rooms (surgeries, X-ray, MRI etc.).
Treatment area	Treatment rooms (in various forms – depending on the therapy), operating theatres with facilities (clean and dirty communication, washrooms, staff changing rooms, hygiene and sanitation rooms, clean and dirty rooms, staff rooms, patient sluices, etc.), preparation rooms, changing rooms, control rooms, recovery/observation rooms, bed unit etc.
Technical area	Technical rooms of various forms depending on the therapy – e.g. in proton therapy the cyclotron, maintenance rooms, storage rooms, server room etc.
Other zones	Staff area, research area, training area

concept of humanising the hospital environment [52]. State-of-the-art contemporary oncology facilities are based on evidence that demonstrates the direct impact of physical space, social systems and all patient-facing services on the quality of care. Contemporary designs must take into account the needs of patients, their loved ones as well as staff, in order to improve the work of staff and the well-being of the patient [53].

7. CONCLUSIONS

Contemporary types of cancer centres are a direct reflection of the evolution that has taken place in oncology and cancer treatment methods in recent decades. What is significant here is the clear form following function. On the basis of the research carried out, five forms of cancer centres were classified. Four of them represent facilities characteristic of the 21st century. Some facilities, such as day cancer care centres or proton therapy centres, are not yet found in all European countries. These are facilities that represent a completely new approach to oncology treatment. Contemporary trends indicate that more facilities of this type are being established in many European countries.

A fundamental element, crucial in shaping the oncology treatment and support space, is to provide the highest quality space for patients. This is not only about the use of state-of-the-art treatments, but above all about providing a therapeutic environment that creates a calm, safe and supportive backdrop for the entire treatment process. This approach should take into account all the needs of oncology patients on a par with advanced treatments [54]. The facilities selected for the study appear to meet these needs by which, in combination with their innovative treatment methods, they can be considered exemplary facilities.

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