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Cancer-dedicated infrastructures (CDIs) and associated risks for its user — the link between architecture and cancer

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Introduction. In recent decades, significant advancements in oncological treatments, technology, survivorship rates, screening behaviors, and healthcare support services have occurred. Yet, there has been minimal research on the architectural design of spaces where these processes occur, their characteristics, evolution, and adaptation; this makes it difficult to understand how it impacts healthcare provision and reception. This systematic review aims to explore the impact of cancer-dedicated infrastructure (CDI) on user outcomes, identify key variables, and emphasize the importance of the care environment.

Material and methods. Our literature review on this association identified 13 relevant articles. However, increasing interest suggests opportunities for exploration.

Results. Findings indicate that architectural characteristics, spatial features, and physical elements influence patient health outcomes and users' performance.

Conclusions. However, generalizability is constrained by the early stage of spatial analysis and sparse evidence. This review underscores the untapped potential of studying CDI architecture and integrating it as a variable to enhance the overall healthcare experience.

Keywords: cancer, architecture, cancer-dedicated Infrastructures

Introduction

The precise origins of cancer-dedicated infrastructures can vary depending on the region and healthcare advancements, but the historical data of the establishment of the first CDI is associated with the foundation of The Royal Marsden as the first hospital in the world dedicated to the study and treatment of cancer. This institution was founded as the Free Cancer Hospital in 1851 [1]. However, CDIs gained significant momentum during the latter half of the 20th century and continue to evolve with advancements in cancer treatment and research.

The CDI construction program represents a pivotal, once-in-a-lifetime design project. In Europe, this undertaking is guided by several key entities: the European Society for Medical Oncology (ESMO), which sets standards for the quality of cancer care and treatment facilities; the European Organization for Research and Treatment of Cancer (EORTC), providing recommendations on research facilities; and European Union Directives and Regulations, including those concerning radiation protection (e.g., Council Directive 2013/59/Euratom), as well as the impact of constructing and operating radiotherapy facilities. Additionally, depending on the CDI's location, specific building codes and health regulations for healthcare facilities may vary across different countries within Europe.

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However, due to the continuous evolution and increasing demand for cancer care [2], as well as advancements in treatments, these infrastructures may have been initially constructed with standards that no longer fully reflect the current state of cancer care and might have several implications. In similar contexts, researchers have been studying what the implications are of hospital characteristics to either increasing or decreasing the risk of medical errors and the overall quality of healthcare, finding spatial layout and ergonomics as crucial contributors for cancer care [3–5]. These findings raise the question of whether a spatial layout designed for current processes is adaptable to future needs.

This discussion points to an interdisciplinary collaboration that pushes the research field to embrace evidence-based design principles in order to ensure that architectural layout choices, such as those in the construction or renovation of CDIs, are informed by rigorous research and aligned with evolving healthcare practices (Hamilton, D. K., 2003). By integrating empirical evidence into design decisions, healthcare facilities can not only better support efficient workflows, enhance patient safety, and improve overall healthcare delivery in the rapidly advancing field of cancer care [5], but also enable us to assess the under/over architectural performance of a space. This impacts not only the quality of care and patient experiences, but the conditions, comfort, and quality of work for medical staff that might be related with certain outcomes. Additionally, it could also impact the efficiency of the investment in CDI construction and renovation.

So far, CDIs' closest variables identified in scientific literature fit more on the spectrum of variables related to organizational performance of the institution such as levels of cancer care, hospital volume, population, racial composition, and availability of treatment [6] and patient physiotherapy [7]. However, spatial and architectural variables have still not yet been defined to be able to have a standard for the analysis of spaces and to understand the risks or benefits that it represents for diverse CDI users, such as patients or medical staff.

As early as the 1990s, research began exploring the link between architectural features, care quality, and patient wellbeing [8, 9] This research so far has focused on how improving design makes hospitals less risky and stressful and, while promoting more healing for patients, their families, and staff. However, judging how scientifically credible the evidence is that design affects clinical outcomes and staff effectiveness in delivering care is still not defined [10]. To our knowledge, this is the first review addressing the impact of CDI on its users.

Material and methods

We prepared systematically review the scientific literature to examine the relationship between architecture and spatial features of cancer-dedicated infrastructures (CDIs) and users' health/wellbeing-related outcomes. The study was performed in phases, with partial results reported in accordance with the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) checklist, updated in 2020 [11].

Search strategy

A systematic search of relevant papers was carried out in the following databases: PubMed, Science Direct, Scopus, and on the Health Environments Research & Design Journal from SAGE publications. The query was built to find original articles published between the years 2000 and 2023 and include the words "cancer facility" OR "cancer center" OR "oncology center" OR "hospital characteristics" AND "impact" OR "risk" OR "effect" in their title, abstract or keywords. The search strategy words organization varies in each database. For more detailed information refer to Table I.

Table I. Search strategies. Source: original. Elaboration: author

Source	Quantity	Query
PubMed	346	((((IMPACT[Title/Abstract]) OR (RISK[Title/Abstract])) OR (EFFECT[Title/Abstract]) AND ((ffrft[Filter]) AND (excludepreprints [Filter]) AND (fft[Filter]) AND (2000/1/1:2023/12/31[pdat]))) AND ((((HOSPITAL CHARACTERISTICS[Title/Abstract]) OR (CANCER CENTER[Title/Abstract])) OR (ONCOLOGY CENTER[Title/ /Abstract])) OR (CANCER FACILITY[Title/Abstract]) AND ((ffrft[Filter]) AND (excludepreprints[Filter]) AND (fft[Filter]) AND (2000/1/1:2023/12/31[pdat])))) AND (CANCER CARE[Title/Abstract] AND ((ffrft[Filter]) AND (excludepreprints[Filter]) AND (fft[Filter]) AND (2000/1/1:2023/12/31[pdat]))) Filters: Free full text, Full text, Exclude preprints, from 2000/1/1–2023/12/31
Elsevier	50	TITLE-ABS-KEY("cancer facility" OR "hospital characteristics" OR "cancer center" OR "oncology center") AND TITLE-ABS-KEY("impact" OR "risk" OR "effect")
Scopus	2074	TITLE-ABS-KEY("cancer+facility" OR "hospital+characteristics" OR "cancer+center" OR "oncology+center") AND TITLE-ABS-KEY("CANCER CARE") AND TITLE-ABS-KEY("impact" OR "risk" OR "effect") AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (EXCLUDE (DOCTYPE,"cb") OR EXCLUDE (DOCTYPE,"cr") OR EXCLUDE (DOCTYPE,"dp") OR EXCLUDE (DOCTYPE,"tb") OR EXCLUDE (DOCTYPE,"er") OR EXCLUDE (DOCTYPE,"sh") OR EXCLUDE (DOCTYPE,"ed") OR EXCLUDE (DOCTYPE,"le") OR EXCLUDE (DOCTYPE,"no"))
SAGE (HERD: Health Environments Research & Design Journal)	93	CANCER (2007–2023)
Total	2563	

Inclusion criteria

A decision was made to include only original articles that investigate the relationship between the selected topics, regardless of the type of cancer-dedicated infrastructures (CDIs) or their location. The target population of the selected studies were non-permanent users of CDIs (patients or visitors), and the outcomes of interest were those directly related to their health or well-being implications. To complement the definition and enhance the purpose of the research, we decided to include case-study articles that run qualitative architectural analyses of any area of the CDI. Article variables included architectural or spatial characteristics, and physical elements present in the space. Conversely, articles that focused on the CDIs' geographic distribution, capacity/volume, facility type, or oncology services' performance were not considered.

Additionally, all non-original studies (such as abstracts, brief notes, commentaries, conference proceedings, reviews, and correspondence) were excluded from the analysis. No geographic restrictions were applied. A detailed description of the inclusion criteria is provided in Table II.

Study selection

As the first step, all the identified records were integrated and deduplicated using EndNote Web. After deduplication, we performed a two-phase screening procedure, the first for titles and abstracts and the second for full texts, as is usually done in this kind of work.

The screening of titles and abstracts was conducted using the machine-learning-powered tool ASReview (v1.0rc0) [12]. ASReview is a "free open-source machine learning tool for screening and systematically labeling a large collection of textual data" [13]. It utilizes natural language processing and active learning to identify the features of articles that meet the inclusion criteria of a review. Based on the inclusions and exclusions made by the reviewers, it iteratively suggests the next article. This approach ensures that the most relevant papers are identified early in the screening process, significantly saving time. The full-text screening involved evaluating all articles deemed potentially relevant based on their titles and abstracts to make the final decision regarding their inclusion in the review.

In both phases, authors of this article collaborated to label each record as relevant or irrelevant based on the inclusion criteria. Any disagreements were resolved through a secondary analysis discussion, which included a third-party researcher from the institution.

Table II. Inclusion criteria. Source: original. Elaboration: author

Inclusion criteria	
Publication year	2000–2023
Country of publication	Any
Population type	Oncology infrastructure users (patients, visitors/families, or medical staff)
Population size	Any
Population age	18 years old or more
Type of cancer	Any
Type of article	Original articles only
Infrastructure definition	Cancer center private or public oncology ward

Data extraction

A pre-defined, customized, and original spreadsheet was utilized to extract and collect useful data from the selected papers [14]. The data encompassed both qualitative and quantitative aspects. Qualitative data recorded included: source, name of the first author, journal's name, title, year of publication, country, study design, cancer facility type, population type of cancer, study aim, space focus, space variables, type of architectural analysis, main variable analyzed, outcome measure, and results. Quantitative data extracted included sample size, scope, and other significant results quantifying the studied association.

Moreover, the articles were grouped based on the type of space under analysis: indoor spaces, outdoor spaces, and analysis not focused on a single space. In addition, the architectural variables were divided into three categories: architectural characteristics, spatial features, and physical elements present in the area under analysis.

Risk of bias assessment

The risk of bias due to sample selection, robustness of comparability, and ascertainment of exposure for all included articles was assessed jointly by authors of this article using the Cochrane Risk of Bias assessment tool and represented using the Risk of Bias Assessment tool (RobVis).

Results

Included studies

The search of the repositories yielded 2563 articles. After removing duplicates (n = 282), 2281 articles were loaded into ASReview for screening. Out of these, 2149 articles were categorized as irrelevant based on a review of their titles. The remaining 87 articles underwent abstract screening, during which 74 articles were considered potentially eligible for review. However, 63 of these were excluded after the full-text screening. Ultimately, 11 articles met all the inclusion criteria. Additionally, 2 more articles were identified through snowballing and reference list, bringing the total to 13 articles, all of which were included in the review. The PRISMA flowchart in Figure 1 summarizes the selection process.

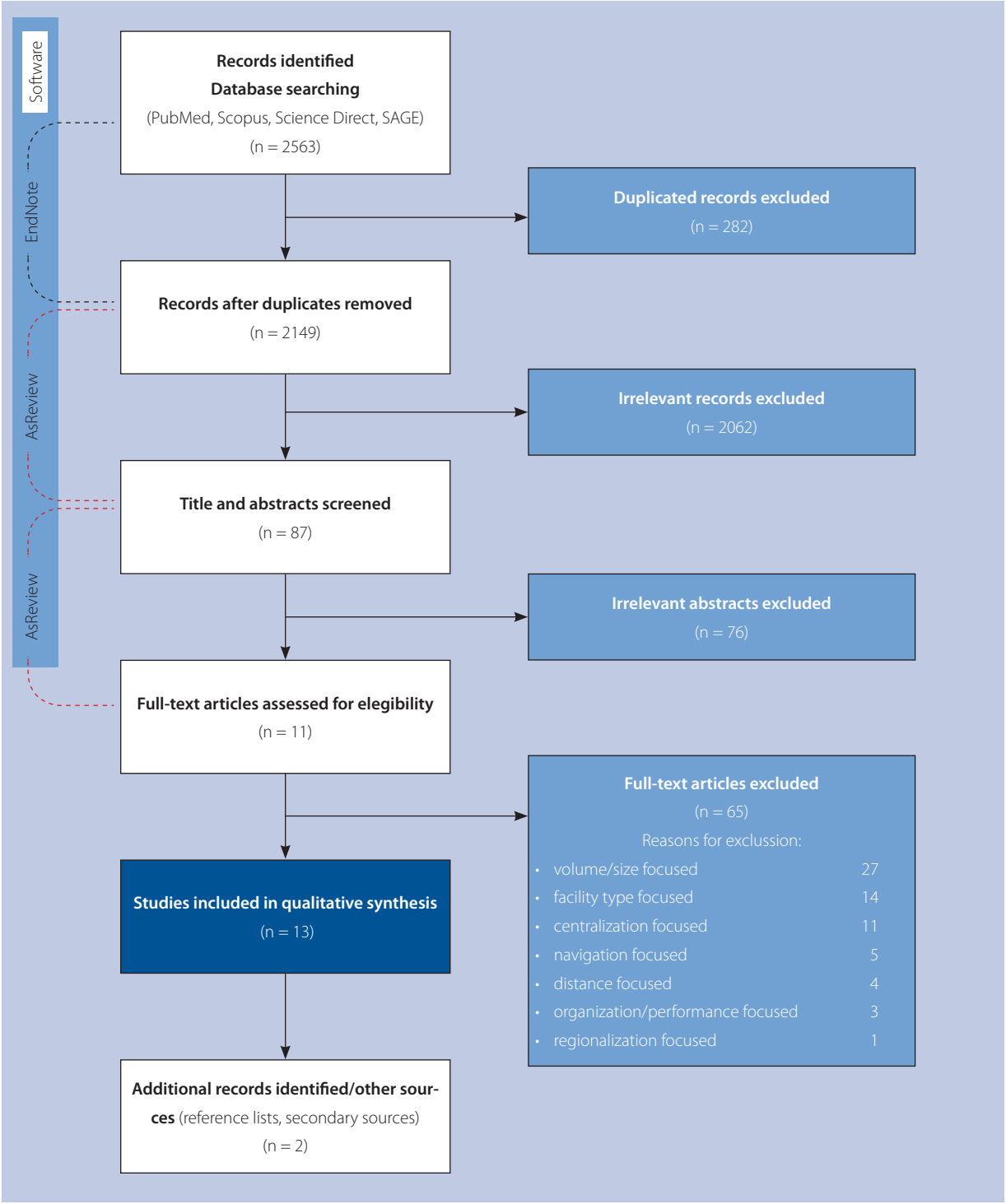

Figure 1. Systematic review process. Author: Rafael J. Salas Carretero. Source: own study

Characteristics of included studies

The relevance of the topic is highlighted by the fact that most of the articles (11/13, 85%), were published in the last 9 years (2014–2023). The geographic distribution of the articles shows a North American predominance, with 5 articles written in the USA and 1 in Canada (6/13, 46%). Four studies were written in Europe: one each Belgium, Italy, Poland, and The United Kingdom (4/13, 31%). South America is represented in two articles written in Brazil (2/13, 15%). Lastly, one article was written in Australia (1/13, 8%), representing Oceania.

Regarding the facility type, 5 studies were conducted in oncological academic hospitals (5/13, 38%), 3 were conducted in oncological centers but did not have precise details (3/13, 23%), 2 were conducted in non-academic oncological centers

(2/13, 15%). Additionally, 1 study was conducted in a breast center, 1 in a cancer-related non-medical facility, and 1 did not focus on any specific institution. Regarding the specific spaces inside the infrastructures, 6 studies analyzed indoor spaces, 1 study analyzed an outdoor space, and the remaining 6 did not focus on any single space.

Ten articles (10/13%, 77%) focused on analyzing the three types of variables identified by the authors simultaneously: architectural characteristics, spatial features, and physical elements. Of the remaining studies, two focused on spatial features and one on the physical elements present in the space.

As for the study population, 4 studies focused solely on cancer patients (4/13, 31%), and 3 studies focused on both patients and staff members (3/13, 23%). Furthermore, 1 study collected data from staff and family members, another collected data from patients, staff, and family members; and 1 study collected data only from staff members. Three studies did not have a specific study population due to their study design, as they are case-study designs (3/13, 23%).

Finally, the remaining studies' study designs were as follows: 4 were qualitative (4/13, 31%), 3 used a multi-design approach (3/13, 23%), and the last three were cross-sectional, retrospective, and comparative observational studies, respectively. For more detailed information, refer to Table III.

Observed results of included studies

For better identification, the authors categorized the observed results into three distinct categories based on the spatial focus analyzed in the articles: indoor spaces, outdoor spaces, and articles not specifically focused on a particular space.

Indoor spaces

Infusion room

The article by Wang and co-authors examines how different spatial arrangements — private rooms, semi-open areas, or open areas in chemotherapy care units — affect the experiences of cancer patients, their families, and nursing staff. Private rooms offer maximum privacy and are quiet but limit social interaction and are more costly. Semi-open areas provide a balance of privacy and social interaction, allowing for some patient interaction while maintaining personal space. Open areas facilitate easy monitoring by staff and social interaction among patients but offer the least privacy [15]. Another study, focusing on the same space with an emphasis on identifying the impact of the architectural layout of infusion rooms on nurse activities, nurse and patient satisfaction, patient privacy, and clinical collaboration, also highlighted the importance of balancing privacy and social interaction needs for both patients and staff [16]. Both studies stated the need for further research to determine the best design solutions to optimize these spaces, highlighting the need for spatial optimization and balanced environments.

ICU units

The article written by Matos and co-authors explores whether the design of ICU rooms, specifically single bed versus multibed layouts, has an impact on the stress levels and burnout rates of ICU staff and on the satisfaction levels of patients' families. The findings reveal that while room design significantly affects ICU staff stress and family satisfaction, it does not have a discernible influence on the burnout rates among ICU staff. However, it provides valuable insights into the considerations for ICU room design to optimize staff well-being and family experience [17]. On the other hand, the article of Caruso and co-authors compares the prevalence of delirium in patients admitted to single-bed rooms versus those in multibed rooms. The findings suggest that the architectural design of ICU rooms plays a significant role in influencing delirium rates, with notable differences observed between the two room types. This research highlights the importance of ICU design considerations in patient outcomes, particularly regarding the mental health and cognitive function of critically ill patients [18].

Palliative care ward

The article by Rowlands J. and co-author [19] focuses on studying how the environment of the palliative ward and its design impacts the quality of life of advanced cancer patients. As a result of this study, four themes emerged as impactful: staff behavior, the immediate environment, single *vs.* multi-bedded rooms, and contact with the outside environment. Findings show that the attitude, competence, and helpfulness of the staff create the atmosphere of the ward — regardless of layout, furnishings, equipment and décor; however, most of the patients in this study expressed a strong preference for a multi-bedded room when they were well enough to interact and a single cubicle when they were very ill or dying, which is contrary to the current advice for building new hospitals with all single rooms [19].

Waiting room

The article from Blaschke and co-authors [20] explores the impact of incorporating artificial greenery into the waiting room of an oncology clinic. The study investigates how the presence of artificial plants and green decor affects patient well-being, anxiety levels, and overall satisfaction with the clinical environment. Despite the use of non-natural elements, the findings indicate that the introduction of artificial greenery can significantly enhance the perceived quality of the space, providing psychological benefits to patients during their waiting periods. This research underscores the potential value of environmental enhancements in healthcare settings, even when natural elements are not feasible [20].

Outdoor spaces

Healing gardens

The article by Valente and Cooper Marcus [21] explores the concept of healing gardens and their role in promoting health and well-being for cancer patients. It delves into the design

Table III. Characteristics of included studies. Main elements of the included studies for the systematic review on cancer-dedicated infrastructures (CDI) and user's outcomes (n = 13)

A.	Study information							Study design	
ID	Author	Title	Year	Source/Journal	Country	Cancer facility type	Cancer type	Population	Study Design
1	De Matos et al.	Single-Bed or Multi-bed Room Designs Influence ICU Staff Stress and Family Satisfaction, But Do Not Influence ICU Staff Burnout	2020	Review/Health Environments Research and Design Journal	Brazil	480-bed teaching oncology hospitals with 45 ICU beds	Not specified	156 ICU staff, 176 family members	Comparative observational study. Cross-sectional data collection
2.	Caruso et al.	ICU architectural design affects the delirium prevalence: A comparison between single-bed and multi-bed rooms	2014	Critical Care Medicine	Brazil	290-bed teaching oncology hospital with 31 ICU beds	Not specified	1253 patients	Retrospective observational study
3.	Blaschke et al.	Artificial but better than nothing: The greening of an oncology clinic waiting room	2017	Review/Health Environments Research and Design Journal	Australia	Metropolitan comprehensive cancer center	Not specified	72 patients, 13 staff, 52 careers, 5 "other"	Cross-sectional survey study
4.	Tinner	Perceived Importance of Wellness Features at a Cancer Center: Patient and Staff Perspectives	2018	Review/Health Environments Research and Design Journal	USA	Cancer center, details nor provided (90000 square foot)	Not specified	52 patients, 59 staff	Qualitative. Post-occupancy evaluation study
5.	Gronostajska & Czajka	Architecture therapy: principles of designing and shaping space in centers for cancer patients, based on the architecture of Maggie's Centers	2021	Review/Builder Science	Poland	Maggie's center: independent building with recreational and facilities without accommodation	Not applicable	Not applicable	Case-study. Analysis of literature on elementary design principles; architectural analysis of plans; and a critical analysis
6.	Bloom et al.	Ten trends transforming cancer care and their effects on space planning for academic medical centers	2015	Review/Health Environments Research and Design Journal	USA	Academic Medical Center (AMC) cancer center	Not applicable	Not applicable	Case-study. Review of the implication of the cancer care trends
7.	Wang & Pukszta	Private Rooms, Semi-Open Areas, or Open Areas for Chemotherapy Care: Perspectives of Cancer Patients, Families, and Nursing Staff	2018	Review/Health Environments Research and Design Journal	USA	Academic Medical Center	Not specified	171 patients, 145 family member, and 16 staff	Mixed method designquantitative and qualitative with open-ended questions

Table III cont. Characteristics of included studies. Main elements of the included studies for the systematic review on cancer-dedicated infrastructures (CDI) and user's outcomes (n = 13)

Study information						Study design			
ID	Author	Title	Year	Source/Journal	Country	Cancer facility type	Cancer type	Population	Study Design
8.	Guevara	Specialty Space: Breast Care Centers	2021	Review/Health Environments Research and Design Journal	USA	Breast Cancer center	Breast cancer	19 staff, 1 Center coordinator	Multi-design. Comprehensive review of literature; photographic analysis, and a field evaluation
9.	Jalalianhosseini et al.	The Impact of Infusion Center Layout on Workflow and Satisfactions in Two Cancer Infusion Centers: A Case Study on Staff and Patients	2019	Review/Health Environments Research and Design Journal	USA	2 Medical Campus Cancer centers	Not specified	19 staff, 22 patients	Mixed method design. Nurse shadowing and survey
10.	English et al.	Health, healing and recovery: Therapeutic landscapes and the everyday lives of breast cancer survivors	2008	Review/Social science and Medicine	Canada	Not focus on a single institution	Breast cancer	14 patients	Qualitative-in-depth interviews
11.	Jellema et al.	Foregrounding the built environment in the experience of cancer care: A qualitative study of autobiographical cancer narratives	2019	Review/European Journal of cancer care	Belgium	Several Cancer Hospital, not details provided	Not specified	7 patients	Qualitative — analysis of the narratives
12.	Valente & Marcus	Giardini che guariscono: processi progettuali e realizzazioni di ambienti benefici	2015	Literature quote/ /Research and experimentation	Italy	Rocky Mountain Cancer Center Hospital (270 000 square foot)	Not applicable	Not applicable	Case-study
13.	Rowlands & Noble	How does the environment impact on the quality of life of advanced cancer patients? A qualitative study with implications for ward design	2008	Literature quote/ /Palliative medicine	United Kingdom	Cancer Hospital, not details provided	Type not specified	12 patients	Qualitative — phenomenological

Table III cont. Characteristics of included studies. Main elements of the included studies for the systematic review on cancer-dedicated infrastructures (CDI) and user's outcomes (n = 13)

B.	Study info				Architectural analysis		Outcome	
ID	Author	Study aim	Type of space	Space focus	Type of variable	Specific Variables	Outcome Measure	Results
1.	De Matos et al.	Compare the impact of single-bed *vs.* multi-bed room intensive care units (ICU) architectural designs on the stress and burnout of ICU staff and, on the stress and satisfaction of family visitors	Indoor space	ICU Unit	Architectural characteristics, spatial features and physical elements	Multi-bed room: Larger size, Window, view, shared toilet, furniture (chair), temperature, bed, space curtain, reading light Single room: bed, furniture (chair), tv, temperature, natural light, window, windows cover, view, artificial light controllable, reading light, dedicated toilet, sliding door	Maslach Burnout Inventory for Human Services Survey (MBI-HSS; Maslach, Schaufeli, & Leiter, 2001) for burnout and psychological stress.ISSL for Adults (Lipp & Guevara, 1994), and a modified version of Molter's Critical Care Family Needs Inventory (Johnson et al., 1998), respectively for psychological stress and satisfaction	Single-bed ICU design was associated with greater satisfaction of family visitors yet with higher levels of stress for ICU staff. Meanwhile, similar burnout levels were observed for ICU staff who worked in single-bed or multi-bed rooms
2.	Caruso et al.	Compare the ICU delirium prevalence and characteristics (coma/ /delirium-free days, first day in delirium, and delirium motor subtypes) of critically ill patients admitted in single or multi-bed rooms	Indoor space	ICU Unit	Architectural characteristics, spatial features and physical elements.	Multi-bed rooms: Bed, Furniture (chair), temperature, natural light, curtains, reading light Single rooms: Bed, Natural light, toilet, furniture (2 chairs), temperature, windows cover, sliding door, room light controllable	Level of consciousness using the Richmond Agitation Sedation Scale or Glasgow Coma Scale, as appropriate. Delirium using the Confusion Assessment Method for ICU (CAM-ICU) and its motoric subtype is classified as hypoactive, hyperactive, or mixed	Prevalence was significantly lower for patients in single-bed rooms, and the admitted due to a medical or postoperative reason. However, once the delirium occurred, the coma/ /delirium-free days, the first day in delirium, and the delirium motoric subtypes were not different from patients in single or multi-bed rooms.
3.	Blaschke et al.	Investigate patient, staff, and carer responses to an environmental intervention in an oncology clinic waiting room and evaluate the acceptability of artificial plants	Indoor space	Oncology outpatient clinic waiting room	Physical elements	Artificial plants divided in: two movable green walls covered in plants, six hanging plant displays, one movable rock garden and 12 tabletop plant arrangements. Mostly green foliage and few colored flowers	Questionnaire. Topic: times of visit to the place, notice-ability, type of plant preference (natural or artificial), and nature preferences and effects (effect on the aesthetics of the place and sensation self-effect, how does it make them feel)	The environmental intervention positively impacted patients', staff, and carers' perceptions of the oncology waiting room environment. Patients, staff, and carers mostly accepted artificial plants as an alternative design solution to real plants

Table III cont. Characteristics of included studies. Main elements of the included studies for the systematic review on cancer-dedicated infrastructures (CDI) and user's outcomes (n = 13)

B.	Study info				Architectural analysis			Outcome
ID	Author	Study aim	Type of space	Space focus	Type of variable	Specific Variables	Outcome Measure	Results
4.	Tinner	Determine the hierarchical importance of wellness building features for both patients and staff at a healthcare facility using targeted post-occupancy evaluations and, second, to determine whether patients who are ill and caregivers who are well have different needs concerning the design, layout, and implementation of wellness features	Not focus on a single space	Not focus on a single space	Architectural characteristics, spatial features and physical elements	Views of nature; access to the roof garden; plants inside the building; pictures and artwork representing nature; daylight; the lack of visible medical equipment; ease of movement through the center; access to privacy; and access to spaces that promote social interaction, thermal comfort, and acoustic tranquility	2 different questionnaires, one addressed to the patients (building feature rating outcomes, patient confidence in care and building features, and patient preferred treatment areas) and one addressed to the staff workers (building feature rating outcomes and staff break area preferences)	Access to private and quiet spaces is the top need for caregivers. For patients, the top are ease of movement, thermal comfort, and natural light. Features with high common values between patients and staff include thermal comfort, views of nature, and natural light. In contrast, there are significant differences regarding art and murals and indoor plants
5.	Gronostajska & Czajka	The goal of the study is to aid in humanizing the built environment and medical and healthcare settings by presenting a case study of good practice in design solution focused on architecture that supports CDI users	Not focus on a single space	Not focus on a single space	Architectural characteristics, spatial features and physical elements	Public (entrance zone, kitchen, dining room, large rest zone, group space, administrative spaces, and garden) semi-private (group space, and small rest zone) and private (therapy room, and toilets)	Architectural analysis based on the concise Maggie's architecture and landscape brief	Applying a hierarchy analysis of functional zones so as to gradually ease guest emotions; ensure a triple center functioning scheme
6.	Bloom et al.	Understand the spatial implication of the ten trends transforming cancer care and their effects on space planning for academic medical centers	Not focus on a single space	Not focus on a single space	Spatial features	Flexibility of the space, collaboration, treatment requirement space, technology requirement space and correspondence with the processes done in the space	Analysis of the new models expanding and emerging in health reform specifically in AMC cancer care	There is a direct relation between alignment of processes, technology and treatment updates, and space requirements. Planning of new spaces in CDI should aim to multipurpose function, conversion between uses, and planning for future steps. Working spaces, strategies should emphasize opportunities for sharing and collaboration

Table III cont. Characteristics of included studies. Main elements of the included studies for the systematic review on cancer-dedicated infrastructures (CDI) and user's outcomes (n = 13)

B.	Study info				Architectural analysis			Outcome
ID	Author	Study aim	Type of space	Space focus	Type of variable	Specific Variables	Outcome Measure	Results
7.	Wang & Pukszta	Analyze what type of treatment environments (private, semiopen, or open) do most chemotherapy patients, patient's families, and nursing staff preferand the environmental needs during chemotherapy treatment	Indoor space	Chemotherapy/ /infusion room	Architectural characteristics, spatial features	Preferred environments (private, semi-open, and open), Privacy/ /openness of the space, socialization opportunity within/ /beyond family, patient-nurse access, window views/daylight, sound/ /noise, bathroom availability	Three different questionnaires with same research focus for patients, families, and staff participants about preferred environment and appropriate number of patients with a section of qualitative analyzed through key word and content analysis on patients'statements	Semi-open areas were preferred by the staff, whereas the three types of treatment environments were equally popular among both patients and families. Female patients and patients receiving longer periods of treatment per occurrence were more likely to prefer private rooms. Three common reasons were needs for privacy, social interaction, and patient– –nurse access. Additional reasons included needs for sleep, openness, and access to nature. A shared environment of chemotherapy care was suggested to be appropriate for four to seven patients to occupy
8.	Guevara	The objective of this study was to support future evidence based design and universal design guidelines use in the development of patient areas by presenting case studies of good practice in design solutions.	Not focus on a single space	Not focused on a single space	Architectural characteristics, spatial features and physical elements.	Design factors (support to variety of users, seating choices, and wheelchair maneuverability chance), lighting and views (artificial light, indirect light, natural light, and views of nature), privacy (auditory and visual, and web-based patient intake tool), and aesthetics (spa-like atmosphere, monochromatic choice of colors, and wood and plants presence)	Multi-design. First a comprehensive review of literature; then an photographic analysis of best practices on worldwide cancer centers and finally, a field evaluation including an interview with the coordinator, a survey to collect data from nine staff members and architectural surveillance and analysis of the interior space characteristics	Recommended guidelines in breast care center should target the following features: robes (*vs.* hospital gowns), spa-like atmosphere, mono-chromatic color scheme, use of wood and stone, private checkin areas, way-finding, room temperature comfort, seating comfort, seating style choice, personal items storage, access to natural light, indirect artificial lighting, living plants, views of nature, flooring comfort, and wheelchair accessibility

Table III cont. Characteristics of included studies. Main elements of the included studies for the systematic review on cancer-dedicated infrastructures (CDI) and user's outcomes (n = 13)

B.	Study info				Architectural analysis			Outcome
ID	Author	Study aim	Type of space	Space focus	Type of variable	Specific Variables	Outcome Measure	Results
9.	Jalalianhosseini et al.	Compare nurses' operational workflow and nurses' and patients' satisfactions of two different infusion center design. Identify the impact of the layout of infusion rooms on nurse activities, nurse and patient satisfaction, patient privacy, and clinical collaboration	Indoor space	Infusion room	Architectural characteristics, spatial features and physical elements	"Open bay design: infusion chair, curtains, guest chair. semi-private design: infusion chair, television, guest chair, and hand sanitizer. inclusion of embedded pharmacy."	"Mixed-method approach. Shadowing nurses to capture time spent in different areas of the cancer treatment center, travel patterns, activities performed, frequency and duration of nurse–patient/ /family member interactions, medication delivery, and workflow processes. Online survey for a staff and paper-based questionnaire using a 5-point Likert-type scale."	Comparison of shadowing data indicated that although the infusion centers have different layouts, there are no significant differences in the activities or time spent by nurses in different areas among the centers. However, staff have different satisfaction levels with visual and speech privacy, ability to concentrate, collaboration, and the process of medication delivery. Patients also had slightly different satisfaction levels with their ability to communicate with staff and design of bays
10.	English et al.	Examine the importance of the place for shaping health and healing among breast cancer survivor. Understand how different landscapes are conductive to healing and recovery process for woman who have experienced breast cancer	Not focus on a single space	Not a single space	Spatial features	Exposure to dangerous materials, individual space, emotional, social, and informational needs spaces	Qualitative semi-structured interviews	Extraordinary therapeutic landscapes and the broader community and nature are important for healing. Landscapes with which women interact on an everyday basis are most important for physical and psychological healing. In addition, the research suggests a strong interplay between emotions and place, which appear to be embedded within places of healing, and play an important role in shaping and maintaining therapeutic landscapes
11.	Jellema et al.	The role of built environment in the experience of cancer care.	Not focus on a single space	Not a single space	Architectural characteristics, spatial features and physical elements	Facility's physical features, Furniture, Accessibility and Psycho-spiritual perception	Autobiographies about the experience of people undergoing cancer treatment	Architecture impacts the experiences of cancer patients as the exposure to buildings where formal cancer care takes place is intense and meaningful. Additionally, the buildings around them offer metaphors that help patients rethink their experiences of illness and care and can be used on identification of variables for future research.

Table III cont. Characteristics of included studies. Main elements of the included studies for the systematic review on cancer-dedicated infrastructures (CDI) and user's outcomes (n = 13)

B.	Study info				Architectural analysis			Outcome
ID	Author	Study aim	Type of space	Space focus	Type of variable	Specific Variables	Outcome Measure	Results
12.	Valente & Marcus	Identify the main characteristics of therapeutic gardens, analyze them and understand what is the opportunity that they provide for cancer infrastructure's patients, staff and relatives	Outdoor space	Garden	Architectural characteristics, spatial features and physical elements	Garden 1: location, visibility, seating (orientation, availability, design), tables, cushions, plants, light stanchions, greening/paving ratio, furniture material Garden 2: location, visibility, feature availability (playground), seating availability/ /orientation, plants (color, type) Garden 3: size, shape, feature availability (fountain), seating, plants (color, odor)	Qualitative analysis of the functioning of the spaces	Positive results frequently encountered in patients' health and in the cost benefits for medical facilities encourage further studies of healing gardens as therapeutic tools for various diseases
13.	Rowlands & Noble	Analyze the environment from the patient's perspective and understand the effect it may have on them	Indoor space	Palliative care ward	Architectural characteristics, spatial features and physical elements	Cleanliness, light and a view outside, possibility of interaction, layout of room, privacy, natural light, pictures, & colors	Semi-structured qualitative interviews	Four main themes emerged: staff behaviors, the immediate environment, single *vs.* multi-bedded rooms and contact with the outside environment. The attitude, competence and helpfulness of the staff creates the atmosphere of the ward regardless of layout, furnishings, equipment and decor. The majority of the patients in this study expressed a strong preference for a multi-bedded room when they were well enough to interact and a single cubicle when they were very ill or dying, which opposes the current advice for building new hospitals with all single rooms

ICU — intensive care unit; CDI — cancer dedicated infratructure; AMC — academic medical center

processes and practical implementations of these therapeutic spaces, outlining the design principles and processes involved in creating healing gardens, including user-centered design, natural elements, and accessibility. The article states that healing gardens are effective in promoting well-being and recovery, suggesting that incorporating therapeutic gardens into healthcare can significantly enhance the quality of life for users and offer cost benefits for medical facilities. Further research and interdisciplinary collaboration are recommended to continue the development of these beneficial environments [21].

Not linked to specific spaces

Space characteristics

In the article by Tinner and co-authors [22], which aims to determine the importance of wellness-building features and their design, layout, and implementation on the satisfaction of patients and caregivers' needs, it is shown that caregivers' top need is access to private and quiet spaces. This contrasts with patients' needs, who prioritize ease of movement, thermal comfort, and natural light. Additionally, spatial features with high common values between patients and staff include thermal comfort, views of nature, and natural light. In contrast, there are significant differences regarding the importance of art, murals, and indoor plants [22].

Regarding the article by Gronostajska and Czajka [23], which analyzed architectural characteristics, the spatial features and physical elements of a non-medical oncological infrastructure that supports cancer patients and their relatives during the journey in the CDI showed that the application of a hierarchy of functional zones allowing for a mix of spaces accessible to all patients and accompanies at the same time, spaces accessible to few patients at the same time and spaces accessible only to a single patient (or plus 1) that ensure too little natural light, spatial openness, ease of movement, mobility adaptation, application of colors, and contrasts, produce positive emotions and reduce the treatment burden [23].

The article from Guevara ran an analysis [24] of the architectural design of a breast center's interior based on the evidence-based design (EBD) process and the Universal Design (UD) guidelines standards available. The study of layout-design factors, lighting and views, privacy, and the aesthetics of the space along with the mixed-method approach of the research of the study produced recommended design guidelines, enhancing CDIs design to target the following features: robes (*vs.* hospital gowns), spa-like atmosphere, monochromatic color scheme, use of wood and stone, private check-in areas, wayfinding, room temperature comfort, seating comfort, seating style choices including bariatric, personal item storage, access to natural light, indirect artificial lighting, living plants, views of nature, flooring comfort, and wheelchair accessibility [24].

Finally, the article by Jellema and co-authors [25] analyzed the narratives of cancer patients to understand the role of the built environment (such as place of residence, ease of commuting) in their experience of cancer care. The article found out that the facility's architectural characteristics, spatial features, and physical elements impact the experience of cancer patients as the exposure to buildings becomes intense and meaningful. Results show that furnishings, distance to the center, technology availability, physical limitations, odour control, temperature, and noise all impact the experience in the cancer center [25].

Space needs

The article by Bloom and co-authors [26], which studied the trends transforming cancer care and effects on space planning for academic medical centers, showed that as treatment advances, there is a current spatial need for new and improved health services as the translational research, clinical trials, and supportive & complementary care. This article emphasized the direct relation between the alignment of processes, technology, and treatment updates with the space requirements, enhancing the multipurpose design of new spaces in order to be able to implement future changes in oncological treatment and care [26].

The article by English and co-authors [27] focused on studying the importance of the place in shaping health and healing among breast cancer survivors. For them, understanding how different landscapes contribute to healing and aid the recovery process of women who have experienced breast cancer is key to identifying therapeutic spaces for better health outcomes. Results from this study show that it is important to consider individual space availability, as well as emotional, social, and informational spaces that fulfill the needs of the patient [27].

Discussion

The findings of this systematic review underscore the importance and significance of the architectural design of CDIs in the experience of cancer care. It has been identified that architectural design can impact patient outcomes, family and visitors' experiences, and medical staff's performance in delivering care, while also minimizing their work-related risks such as burnout. The study and evaluation of CDIs offering a good balance between spaces that provide well-being to the patients and families while also allowing medical staff perform efficiently has not been deeply explored in the literature despite the potential impact of its benefits.

From this, it is evident that more qualitative research is needed to promote the building of evidence-based design spaces that might impact health and well-being-related outcomes for all users of CDIs. This kind of research is essential to identify the main variables of these spaces. Results from our review have identified beneficial architectural characteristics such as indoor greenery, access to green areas, contrast-color walls, and natural light; spatial features such as adaptability, ease of movement, and privacy/social interaction opportunities;

and physical elements such as privacy screens, support tools, and diverse seating options which might play a positive role during the cancer care journey for patients and visitors/ /families. Meanwhile, room visibility, working space size, layout distribution, and green area accessibility play a significant role in the performance and well-being of medical staff.

These findings align with previous research on different populations [28, 29], in which new health infrastructure has been built or renovated. The design of this health infrastructure has been guided by qualitative research using a user-centered approach to understand the behavior and needs of the patients.

However, with the continuous evolution of treatments, technological developments, the increasing number of survivors, screening behaviors, and healthcare support services, the needs of CDI users are in constant evolution. Despite the need for more space being consistently supported by the sustainable growth of infrastructures worldwide [30–33], this alone does not seem to be the solution. Infrastructure's role remains primarily as a support for medical services, with the possibility of it becoming a significant factor in treatment outcomes still not enough explored.

Other facts identified in this review, such as the different denominations given to CDIs according to their capacity, volume, teaching activity, or location; along with the non-definition of a standard categorization of architectural variables; and the lack of data about the architectural layout of CDIs in medical databases, challenge the progression of research in analyzing how they are linked to patients' health outcomes. At the same time, it complicates the possibility of evaluating the performance of spaces in adapting to new current improvements in oncology care delivery and treatments.

Finally, from the analysis, it has been noted that due to the intrinsic characteristics of CDI architecture, such as form, structure, and materiality, along with the high levels of hygiene and infection guidelines for health infrastructure, a high level of maintenance is needed. At the same time, there is no evidence in research about the maintenance of CDIs on their spatial adaptation to the actual processes, and the populations treated inside them.

Conclusions

The results of this systematic review show a scarcity of research on the impact of oncology CDI related variables on patients, family, and medical staff outcomes. However, the increasing appearance of the topic in recent years suggests growing interest in this interdisciplinary relationship. The results of the reviewed literature support the hypothesis that CDI variables such as architectural characteristics, spatial features, and physical elements are associated with specific patient health outcomes, visitor/family well-being, and staff performance levels. More specifically, the results demonstrate that CDI variables can significantly contribute to improving certain aspects of the lives of cancer patients, their families, and medical staff. In fact, the results show that places designed with a user-centered approach, especially those based on evidence-based design research, are currently contributing positively to cancer patient's treatment journey.

So far, the investigation is still in its early stages, and the results are quite inconsistent, so the possibility of a comparison between them still represents a high risk of bias as they have not taken into consideration the same variables. Consequently, it seems that the need to identify these variables and promote an international standard of categorization for them, becomes more relevant for their inclusion in epidemiological studies. Finally, as physical spaces are undeniably necessary for the delivery of healthcare, especially in oncological care where procedures involve a diverse range of professionals and processes, future directions for the inclusion of architectural layout are needed as it implies potential improvements for all users.

Future directions

This systematic review explored the current knowledge about the relationship between the architectural layout and its variables and the diverse health-related, well-being, and performance outcomes of CDIs' range of users. Including this type of interdisciplinary research underscores the importance of considering architectural design as a significant factor in healthcare delivery, and some considerations must be made.

1. The cancer journey is a long process encompassing prevention, diagnosis, treatment, and survivorship stages. Users are exposed to infrastructure at different levels in each stage.
2. Cancer-dedicated infrastructure combines multiple users. User-centered design research is encouraged, but it must encompass the diversity of oncology infrastructure users.
3. Space division in oncological infrastructure must be developed, with a categorization based on collaboration between both disciplines.

Article information and declarations

Authors contributions

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Mariola W. Borowska — data curation, project administration, writing — original draft preparation, writing — review and editing.

Conflict of interest

None declared.

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References

1. Goldberg K. Which cancer center was first? The answer depends on what you mean by "cancer center." The cancer letter [Internet]. 2021 Jul 9; 47(27). https://cancerletter.com/in-the-archives/20210709_6/ (07.05.2024).
2. IARC. Trends in Cancer Data Visualization [Internet]. Cancer over time; 2024. https://gco.iarc.fr/overtime/en/dataviz/trends?populations=12400_11200_20800_20300_19100_57800_61600_47000_44000_42800&sexes=1&cohort=period&cancers=0&multiple_populations=1.
3. Evans J, Reyers E. Patient room considerations in the intensive care unit: caregiver, patient, family. Crit Care Nurs Q. 2014; 37(1): 83–92, doi: 10.1097/CNQ.0000000000000007, indexed in Pubmed: 24309462.
4. Rashid M. Two decades (1993-2012) of adult intensive care unit design: a comparative study of the physical design features of the best practice examples. Crit Care Nurs Q. 2014; 37(1): 3–32, doi: 10.1097/CNQ.0000000000000002, indexed in Pubmed: 24309457.
5. Stichler JF. Is your hospital hospitable? How physical environment influences patient safety. Nurs Womens Health. 2007; 11(5): 506–511, doi: 10.1111/j.1751-486X.2007.00226.x, indexed in Pubmed: 17897432.
6. Onishi H, Ishida M, Kawada S. [The importance of psycho-oncology]. Gan To Kagaku Ryoho. 2012; 39(3): 331–336, indexed in Pubmed: 22421756.
7. Wood H, Connors S, Dogan S, et al. Individual experiences and impacts of a physiotherapist-led, non-pharmacological breathlessness programme for patients with intrathoracic malignancy: a qualitative study. Palliat Med. 2013; 27(6): 499–507, doi: 10.1177/0269216312464093, indexed in Pubmed: 23128902.
8. Ulrich RS. Effects of interior design on wellness: theory and recent scientific research. J Health Care Inter Des. 1991; 3: 97–109, indexed in Pubmed: 10123973.
9. Ulrich R, Simons R, Losito B, et al. Stress recovery during exposure to natural and urban environments. Journal of Environmental Psychology. 1991; 11(3): 201–230, doi: 10.1016/s0272-4944(05)80184-7.
10. Ulrich RS, Zimring C, Zhu X, et al. A review of the research literature on evidence-based healthcare design. HERD. 2008; 1(3): 61–125, doi: 10.1177/193758670800100306, indexed in Pubmed: 21161908.
11. Page M, McKenzie J, Bossuyt P, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021, doi: 10.31222/osf.io/v7gm2.
12. ASReview LAB developers. ASReview LAB Software Documentation. 2023 Nov 2. https://zenodo.org/doi/10.5281/zenodo.4287119 (08.07.2024).
13. Schoot Rv, Bruin Jde, Schram R, et al. An open source machine learning framework for efficient and transparent systematic reviews. Nature Machine Intelligence. 2021; 3(2): 125–133, doi: 10.1038/s42256-020-00287-7.
14. Microsoft Corporation. Microsoft Excel [Internet]. Redmon, WA; 2018. https://office.microsoft.com/excel.
15. Wang Z, Pukszta M. Private Rooms, Semi-Open Areas, or Open Areas for Chemotherapy Care: Perspectives of Cancer Patients, Families, and Nursing Staff. HERD. 2018; 11(3): 94–108, doi: 10.1177/1937586718758445, indexed in Pubmed: 29480029.
16. Jalalianhosseini M, Freihoefer K, Doyle N, et al. The Impact of Infusion Center Layout on Workflow and Satisfactions in Two Cancer Infusion Centers: A Case Study on Staff and Patients. HERD. 2020; 13(3): 70–83, doi: 10.1177/1937586719888221, indexed in Pubmed: 31779490.
17. de Matos LB, Fumis RR, Nassar Junior AP, et al. Single-Bed or Multibed Room Designs Influence ICU Staff Stress and Family Satisfaction, But Do Not Influence ICU Staff Burnout. HERD. 2020; 13(2): 234–242, doi: 10.1177/1937586719878445, indexed in Pubmed: 31597490.
18. Caruso P, Guardian L, Tiengo T, et al. ICU architectural design affects the delirium prevalence: a comparison between single-bed and multibed rooms*. Crit Care Med. 2014; 42(10): 2204–2210, doi: 10.1097/CCM.0000000000000502, indexed in Pubmed: 25226117.
19. Rowlands J, Noble S. How does the environment impact on the quality of life of advanced cancer patients? A qualitative study with implications for ward design. Palliat Med. 2008; 22(6): 768–774, doi: 10.1177/0269216308093839, indexed in Pubmed: 18715977.
20. Blaschke S, O'Callaghan CC, Schofield P. „Artificial But Better Than Nothing". HERD. 2017; 10(3): 51–60, doi: 10.1177/1937586716677737, indexed in Pubmed: 27956590.
21. Cooper MC, Valente R. Healing gardens: design processes and realizations of beneficial environments. TECHNE - Journal of Technology for Architecture and Environment. 2015: 180–190.
22. Tinner M, Crovella P, Rosenbaum PF. Perceived Importance of Wellness Features at a Cancer Center: Patient and Staff Perspectives. HERD. 2018; 11(3): 80–93, doi: 10.1177/1937586718758446, indexed in Pubmed: 29488391.
23. Gronostajska J, Czajka R. Architecture therapy: principles of designing and shaping space in centres for cancer patients, based on the architecture of Maggie's Centres. BUILDER. 2021; 284(3): 64–68, doi: 10.5604/01.3001.0014.7434.
24. Guevara D. Specialty Space: Breast Care Centers. HERD. 2021; 14(3): 358–373, doi: 10.1177/1937586721990563, indexed in Pubmed: 33653164.
25. Jellema P, Annemans M, Heylighen A. Foregrounding the built environment in the experience of cancer care: A qualitative study of autobiographical cancer narratives. Eur J Cancer Care (Engl). 2019; 28(6): e13156, doi: 10.1111/ecc.13156, indexed in Pubmed: 31436912.
26. Bloom M, Markovitz S, Silverman S, et al. Ten trends transforming cancer care and their effects on space planning for academic medical centers. HERD. 2015; 8(2): 85–94, doi: 10.1177/1937586714565598, indexed in Pubmed: 25816384.
27. English J, Wilson K, Keller-Olaman S. Health, healing and recovery: therapeutic landscapes and the everyday lives of breast cancer survivors. Soc Sci Med. 2008; 67(1): 68–78, doi: 10.1016/j.socscimed.2008.03.043, indexed in Pubmed: 18440112.
28. Norouzi N, Martinez A, Rico Z. Architectural Design Qualities of an Adolescent Psychiatric Hospital to Benefit Patients and Staff. HERD. 2023; 16(4): 103–117, doi: 10.1177/19375867231180907, indexed in Pubmed: 37365801.
29. Przesmycka N, Strojny R. Architectural solutions of contemporary pediatric hospitals – a study of selected projects. BUILDER. 2021; 284(3): 88–91, doi: 10.5604/01.3001.0014.7444.
30. Al-Shamsi HO. The State of Cancer Care in the United Arab Emirates in 2022. Clin Pract. 2022; 12(6): 955–985, doi: 10.3390/clinpract12060101, indexed in Pubmed: 36547109.
31. Berns A, Ringborg U, Celis JE, et al. Towards a cancer mission in Horizon Europe: recommendations. Mol Oncol. 2020; 14(8): 1589–1615, doi: 10.1002/1878-0261.12763, indexed in Pubmed: 32749074.
32. Liu M, Yu Q, Liu Y. Developing quality indicators for cancer hospitals in China: a national modified Delphi process. BMJ Open. 2024; 14(4): e082930, doi: 10.1136/bmjopen-2023-082930, indexed in Pubmed: 38594187.
33. National Cancer Institute. Global Oncology Survey of NCI-Designated Cancer Centers. US Department of Health and Human Services, National Institutes of Health. Retrieved from 2021.