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Development of a Cost Normalization Framework for Healthcare Facilities Cost Elements

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Abstract: Healthcare facilities (HCFs) are complex building structures that are becoming more challenging with ever-changing codes and regulations. Previously completed projects become a basis for future guidance regarding costs and scope. A robust normalization framework to assess previously completed projects with today's costs and location will benefit various stakeholders. The current study provides a complete picture for normalizing the overall project cost and phase cost by life cycle and HCF cost elements. This study aims to develop a cost normalization approach tailored to HCF-specific cost elements to extend the normalization framework for the overall project cost. Further, the researchers developed a distinct framework for normalizing the effect of shell space on the normalization of Total Installed Cost (TIC) to establish fixed cost adjustment rates for cold and warm shell spaces in HCFs, which can increase the accuracy of cost normalization of the overall project cost. This study identified an appropriate set of cost indices for normalizing HCF cost elements using publicly available indices. The cost elements identified for normalization included HCF-specific and Construction Specifications Institute Master Format (CSIMF) cost elements for assigning individual normalization procedures. This study provides individual and unique approaches for normalizing all identified cost elements, such as mechanical, concrete, etc. The initial framework was evaluated through a case study analysis that developed into the proposed approach built upon the collaborative efforts of academic researchers and industry experts. This study introduced shell space cost adjustment rates for warm and cold shell spaces to further develop a space normalization framework. This paper addresses the challenges of normalizing HCF project costs using the breakdown of HCF cost elements. Moreover, the paper provides the HCF's overall cost normalization approach, emphasizing cost elements that allow accurate comparisons between various HCFs for early scope and cost guidance.

Keywords: benchmarking; construction cost elements; healthcare; normalization

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1. Introduction

"The healthcare sector is characterized by high capital investment, increasing technological sophistication, and a competitive marketplace" [1]. The scale, function, technology, and materials for construction require further improvements in the post-pandemic era, and the industrialization degree of the assembly and automation systems adopted has become much higher [2]. Furthermore, the healthcare industry's Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) grew by 5% between 2017 and 2019; however, these earnings remained flat during 2020 and 2021. Further predictions expect a growth rate of 6% between the years 2021 and 2025, adding USD 31 billion in HCF profits [3]. These trends predict the healthcare and pharma sectors to be some of the fastest-growing sectors in the United States, suggesting a high demand for the construction of new healthcare facilities and renovation of existing facilities. According to [4], COVID-19 was a major driving force that brought change in healthcare facilities' design, operations, and sustainability efforts.

Healthcare projects are complex to design, build, and operate in the industry [5], requiring extensive planning for successful delivery. Furthermore, the efficient delivery of healthcare projects requires managing a diverse set of data variables that influence the scope of the project and its estimated cost [6]. The timing of key decisions in the project life cycle can significantly affect costs; therefore, early identification of factors that influence overall project costs is extremely important to healthcare facility owners [1,6]. The complexities in design and facility planning often raise the need for flexible, adaptable, and multifunctional solutions to meet the rapidly changing demands of the industry [7]. Healthcare projects require extreme precision during the design and construction phases and, therefore, need a robust benchmarking program and a cost normalization framework. These analytics assist HCF owners and the construction management team in validating the normalized costs based on similar projects from peers [1].

As a part of the benchmarking program, [8,9] developed frameworks for normalizing the overall project cost and project cost by life-cycle phases, respectively; however, the challenges of extensive planning in healthcare necessitate a cost normalization framework for individual HCFs, specific cost elements to allow the comparison of different healthcare systems across the nations [1,10].

Benchmarking is "the process of establishing a standard of excellence and comparing a business function or activity, a product, or an enterprise as a whole with that standard" [11]. Benchmarking is a performance tool that compares similar projects that extrapolate data into useful comparative metrics. A normalization framework is at the heart of a benchmarking program, and its success depends on its customization to the program, facility type, and detailed cost elements of the facility. Internal benchmarking describes comparisons within an organization, while external benchmarking involves comparing the subject company or property to external organizations. External benchmarking is defined as "the process of identifying, understanding, and adapting outstanding practices from organizations anywhere in the world to help an organization improve its performance" [8,12]. External benchmarking builds a consortium of peers or like-minded organizations to support comparisons of similar facilities through various performance parameters. Therefore, facilities with different systems, locations, and costs need to be normalized to today's costs at a common location for meaningful comparisons. The external benchmarking application allows one company to evaluate another company's ideas, practices, or methods and, if possible, apply them to its own business [13,14].

Many factors impact cost benchmarking. For instance, a shell space in HCF affects cost comparisons, specifically the dollars per Building Gross Square Feet (USD /BGSF) metric. Shell space can be defined as the space constructed within the exterior building shell that is left unfinished to meet the future requirements of the facility [15]. Shell space is categorized into cold and warm shell space—wherein the cold shell is defined as an HCF's non-habitable space with no finishes or walls, no flooring, no lighting, and no air conditioning. On the other hand, a warm shell is completed with fittings and air conditioning ducts, electrical distribution, and fire suppression [6]. The program of a facility planned with shell space is less than a wholly developed facility since the square footage of unfinished floors (because the cost of the shell space is less than the fully built space) is not added to the BGSF. Therefore, the current paper addresses the challenge of comparing a facility with shell space and another entirely built-out facility. Hence, without separate consideration for the shell space cost, the normalized Total Installed Cost (TIC) for the complete facility becomes inconsistent. A separate framework for normalizing shell space costs can lead to a more accurate cost normalization of the overall project cost. Therefore, this study addresses space normalization as a separate entity and develops different cost adjustment factors for warm and cold shell spaces.

This study has identifies HCF-specific and CSIMF cost elements and develops individual normalization methods adhering to the specificity of each cost element. Furthermore, this study develops a space normalization methodology validated through various case study examples. The objectives of this study are to:

1. Identify and recommend a set of indices that best suit the time and location adjustments.
2. Evaluate the applicability of the normalization framework for TIC towards phase costs and HCF-specific cost elements.
3. Develop/complete the overall normalization approach to healthcare facilities costs: the overall cost, cost elements, and an adjustment for shell space.
    a. Specific normalization framework for CSIMF cost elements.
    b. Identify adjustment rates to develop a prototype space normalization procedure.

Further, this study outlines the challenges and considerations associated with the cost indices applicable to cost normalization and discusses the limitations and the availability of future improvements for the framework.

2. Literature Review—Selection of Indices

In order to collect and record data for benchmarking across the healthcare sector, project costs from different times and locations need to be normalized to a comparable scale using different benchmarking frameworks developed through previous research. Previous studies on benchmarking have developed a unique framework for normalizing the overall project cost [8] and the project cost through different life-cycle phases [9]. Each framework developed a normalization approach for the program's overall cost. This study, by extension, has studied construction cost elements specific to HCFs and developed a framework to normalize individual cost elements, including CSIMF cost elements.

According to [8], TIC is defined as "the total actual project cost (excluding the cost of land) from programming/front-end planning through commissioning, including capitalized amounts expended for in-house salaries, overhead, travel, etc." The authors of [8] developed a normalization framework for TIC based on this definition. Furthermore, according to [16,17], construction costs for HCFs largely depend upon local conditions such as material/equipment costs, labor, and suppliers/contractors. The authors of [9] define construction costs as "all cost elements associated and included within the project phases." Based on these findings, a benchmarking framework for healthcare projects measuring performance at the phase level has been developed by collecting data across all five construction phases—programming, engineering/design, procurement, construction, and commissioning of a project [18]. In extension, a framework to normalize HCF cost elements such as material, equipment, labor, contractor overhead, local taxes, project management costs, and other CSIMF cost elements is developed in this study.

The normalization framework will ultimately provide quantitative information to support decision making on the specific project scope and improvement of work processes used to execute healthcare projects. Benchmarking is impacted by cost normalization; therefore, selecting appropriate indices for normalization is necessary. As all the programs primarily use publicly available indices and each index is built differently, a brief understanding of the indices is essential for a normalization framework.

2.1. Cost Indices

Cost indices measure the fluctuation in prices of certain construction elements over time and/or location using a standard series of values [19]. Cost indices are primarily divided into input, output, and selling price indices. Various publicly available indices provide a variety of alternatives for adjusting time and location. According to [20], inaccurate selection and application of location adjustment indices (input or output) results in significant cost adjustment fluctuations. Therefore, a basic understanding is developed before selecting specific indices to normalize HCF cost elements.

2.1.1. Input Price Indices

Input price indices focus on inputs to the construction processes, such as materials, equipment, and labor. The main objective of input indices is to track and reflect changing market conditions with respect to the costs of these components individually. Input indices help organizations track and understand the differences between material, equipment, and labor costs at different locations for construction cost comparisons [20]. This entails the compilation of weighted indices of wages and materials costs. Table 1 illustrates that the RSMeans [21], ENR (Engineering News-Record), and Marshal & Swift Building Cost Index (BCI) are input indices developed using the standard factor method. Based on the number of comparison cities, RSMeans is typically used for location adjustment in the normalization process for a case where the midpoint of the construction phase and locations are defined [8]. BCI derives an index specific to location without reference to time.

Table 1. Input Price Indices.

S. No.	Publisher	Index	Purpose	Application	Start Year	Periodicity	Places Available
1	RSMeans	City Cost Index	Location Adjustment	Building	Created in 1942	Quarterly	296 cities
2	RSMeans	Historical Cost index	Time Adjustment	Building	Created in 1942	Quarterly	30 cities
3	ENR	Building Cost Index	Time Adjustment (Labor component: 68.38 skilled labor hours)	Building	1978	Annually	20 cities
4	ENR	Construction Cost Index	Time Adjustment (Labor component: 200 common labor hours)	Building—Structures	1978	Annually	20 cities
5	Marshal & Swift	Equipment Cost Index	Time adjustment	Construction	1913	Annually	Not available
6	Marshal & Swift	Building cost index	Time adjustment	Building	1901	Annually	100 cities

ENR's Construction Cost Index (CCI) and the RSMeans Historical Cost Index (RSMHCI) represent the general trend of construction costs in reference to time. CCI provides an average of 20 cities, while RSMHCI reflects an average of 30 cities [22]. While the ENR BCI and ENR CCI apply to general construction costs, the main difference between BCI and CCI is consideration of the labor component. While CCI uses 200 h of common labor multiplied by the 20-city average rate for wages and fringe benefits, BCI uses 68.38 h of skilled labor multiplied by the 20-city wage-fringe-average for three trades—bricklayers, carpenters, and structural ironworkers. The BCI and CCI material components utilize 25 cwt (hundredweight; cwt = centum weight) of fabricated standard structural steel at the 20-city average price, 1.128 tons of bulk Portland cement priced locally, and 1088 board ft of 2×4 lumber priced locally [23]. Primarily, the ENR indices measure the costs to purchase this hypothetical package of goods compared to what it was in the base year.

2.1.2. Output Price Indices

Output price indices measure changes in the price of the output of specific activities in the construction processes [19]. These generally include materials, labor, equipment hires, land preparation costs, bathroom/kitchen fittings, overhead, profits, and trade margins [24]. Output price indices compare the change in construction costs of a proposed structure by time or location. They require a more wide-ranging data collection but are preferred since they capture the effects of productivity, profit margins, and labor tradeoffs on the overall project cost [20,25].

Three types of indices can help develop output-based price indices: the model price index, hedonic price index, and bid/unit price index [26]. These output indices include the cost of labor, materials, the use of fuel and equipment, job overhead, profit, taxes, etc. Under the model price index, the output-based indices compare the construction cost of a hypothetical structure by location and/or time [8]. The quality of the final product is used as a measure in constructing the hedonic price index [26]. Hedonic price indices are component pricing types using cross-section regression to estimate component prices. Based on the indices' properties, the model price index under output-based price indices synchronizes effectively with the construction sector. A bid/unit price index estimates specific types of engineered construction costs based on their unit bid prices. Hence, this index has limited application to HCF construction.

As illustrated in Table 2, the Producer Price Index (PPI) measures the changes in prices paid for production sold outside the industry [27]. The PPI calculates the average change in selling prices for domestic producers' output over time. The prices included in the PPI are from the first commercial transaction for many products and services. The PPI for new healthcare building construction (NAICS code 236224) from the Bureau of Labor Statistics (BLS) is based on the North American Industry Classification System (NAICS) [27]. By simulating multiple vernacular building types, the model price index allows for construction heterogeneity and is more sensitive to market shift situations. The Mortenson Construction Cost Index is calculated quarterly by pricing a representative non-residential construction project in geographies throughout the country. Similarly, the Turner Building Cost Index [28] measures costs in the non-residential construction market in the country. The Rider Levett Bucknall (RLB) Cost Relativity Index [29] calculates the construction cost differential between two selected cities worldwide.

Table 2. Output Price Indices.

S. No.	Publisher	Index	Purpose	Application	Start Year	Periodicity	Places Available
1	Bureau of Labor Statistics	Producer Price Index—Non-Residential—New Warehouse Building Construction	Time Adjustment	Building—Warehouse	2005	Monthly	OECD Total countries and OECD Europe countries and G7 countries (Canada, the United States, Japan, France, Germany, Italy, and the United Kingdom)
2	Bureau of Labor Statistics	Producer Price Index—Non-Residential—New Healthcare Building Construction	Time Adjustment	Building—Healthcare	2013	Monthly	
3	Bureau of Labor Statistics	Producer Price Index—Non-Residential—New School Building Construction	Time Adjustment	Building—School	2006	Monthly	
4	Bureau of Labor Statistics	Producer Price Index—Non-Residential—New Industrial Building Construction	Time Adjustment	Heavy Industrial (Some), Light Industrial, and Infrastructure—Water/Waste	2008	Monthly	
5	Bureau of Labor Statistics	Producer Price Index—Non-Residential—New Office Building Construction	Time Adjustment	Building–Office	2007	Monthly	

Table 2. *Cont.*

S. No.	Publisher	Index	Purpose	Application	Start Year	Periodicity	Places Available
6	Mortenson	Construction Cost Index	Time Adjustment	Building—Non-Residential	2009	Quarterly	-
7	Rider Levett Bucknall	Global Construction Cost Relativity Index	Location Adjustment	Building	2008	Quarterly	12 cities
8	Turner	Building Cost Index	Time Adjustment	Building—Non-Residential	2005	Quarterly	44 cities

2.1.3. Selling Price Index (SPI)

The Selling Price Index (SPI) evaluates the average variation in the building's selling price over time. As a result, this index assesses the changes in construction output costs paid by the owner. The SPI measures the total cost of completed construction, including materials, labor, equipment, contractor's margins, overhead expenses, land, direct and indirect selling expenses, and the seller's profit margins. The SPI can be used to adjust construction project costs over time. One example of an SPI is the DoD (Department of Defense) Selling Price Index (DoD-SPI), which represents an average of three widely accepted construction price indices, namely, the RLB Construction Cost Index (output), Turner Construction Cost Index (output), and Saylor Subcontracting Index [30,31].

Saylor discontinued issuing their index in October 2009; therefore, the current third index utilized in the DoD calculation is the BLS PPI for NAICS 236223. The DoD created the SPI to precisely reflect actual (historical) market escalation as experienced by the DoD as the project owner for the construction type in the portfolio [31]. Previously, the DoD (Table 3) used the Engineering News-Record Building Cost Index (ENR BCI). The ENR BCI tracks the costs of three basic materials and one skilled labor type but does not account for other pricing influences (such as risk and competition) impacting the project owner's total delivered price.

Table 3. Selling Price Indices.

S. No.	Publisher	Index	Purpose	Application	Start Year	Periodicity	Places Available
1	Department of Defense (DoD)	Area Cost Factors	Location Adjustment	Buildings-Healthcare/Residential	1997	Annually	52 countries and the United States

As discussed in the background study, selecting appropriate indices is vital to reflect cost normalization accurately. Due to the abundance of publicly available cost indices, it is a challenge to determine the most suitable indices for adjusting the detailed cost breakdown. Therefore, this study further evaluated the publicly available input and output indices to determine the most suitable indices for normalizing HCF-specific and CSIMF cost elements for location and time.

2.2. Cost Normalization

Cost normalization refers to adjusting total project costs from different times and locations to comparable standards by adjusting all cost data to a common time and location [32]. Absolute metrics require normalization since the measures are external and of different values; however, cost normalization is unnecessary for relative metrics due to internal measures of the same values using planned versus actual data [17]. Currency, time, and location adjustments are the three required steps of cost normalization to evaluate accurate project costs [16]. In order to analyze cost performance using absolute metrics, cost data must be normalized from the project location and time to the reference location and time [1,17]. According to [1], the HCF benchmarking program and the Hanscomb Means International Construction Cost Index use Chicago, IL, as a reference location. Furthermore, the normalization approach established for TIC also uses Chicago as a reference city for the currency, location, and time adjustment [8]. The detailed normalization procedure for TIC is illustrated in Table 4 for a hypothetical healthcare project in Indianapolis, with 2012 as the midpoint of construction.

Table 4. Standard Normalization procedure.

Project Details: Location: Indianapolis, IN, U.S. Midpoint of Construction: 2012 (Note: Step 1—Currency Conversion Is Not Required Since the Project is Based in the U.S.)	**Step 2: Location Adjustment (LA)**	**Step 3: Time Adjustment (TA)**	**Normalization of Total A/E and CM Cost**
	(Indianapolis to Chicago in 2012)	**(2012 to 2022 in Chicago)**	**(2012 to 2022 in Chicago)**
Total Installed Cost = USD 50,000,000	Intentionally left Blank	Intentionally left Blank	Intentionally left Blank
Total A/E + CM + Capital medical equipment cost = USD 15,000,000			
Net cost to be normalized for location (USD 50,000,000–USD 15,000,000) = ***USD 35,000,000***			
RSMeans Indianapolis 2012 = 180.6	(Refer to Equation (1) in Section 2.2.2 for location adjustment)		
RSMeans Chicago 2012 = 225.2			
Cost after location adjustment/Project TIC in Chicago 2012	***USD 43,643,411***		
BLS−PPI 2012 = 99.7	Intentionally left Blank	*(Refer to Equation (3) in Section 2.2.3 for time adjustment)*	
BLS−PPI 2022 = 147.0			$\boldsymbol{B = \left[\frac{BLS-PPI\ 2022}{BLS-PPI\ 2012}\right] \times USD\ 15{,}000{,}000}$
Cost after location adjustment/Project TIC in Chicago 2022 (A)		***USD 64,348,861***	***B = USD 22,116,349***
Total normalized A/E + CM + Capital medical equipment cost using BLS−PPI 2012 and 2022 **(B)**			***USD 22,116,349***
Final Normalized Cost (A+B) = USD 86,465,210			

2.2.1. Currency Conversion

Due to extensive globalization, many construction companies have entered international markets and delivered healthcare projects while paid in local currencies [16]. Therefore, currency conversion is the first crucial step in normalization when the costs of international projects are paid in the local currency. This step-in cost normalization is designed to accommodate the future expansion of healthcare benchmarking to include international healthcare owners and contractors. Currency conversion allows seamless expansion of the healthcare benchmarking program to include foreign projects. In this globalizing economy, multiple equilibrium structures and frameworks of currency exchange exist using trade links between countries [33]. Therefore, any cost data could be converted to a single currency unit of the United States (U.S.) dollar. Currency conversion can be applied to all cost elements of healthcare facilities.

2.2.2. Location Adjustment

Comparing two projects built at different locations requires adjusting cost elements that vary from one geographical location to another [16]. This allows the healthcare benchmarking program to expand to include healthcare projects located in different places with different aspects of local environments. According to [1], the design, Architectural/Engineering (A/E), Construction Manager (CM), and capital medical equipment costs remain the same across the nationwide markets or regional conditions and, therefore, do not need to be adjusted for location. Therefore, post currency conversion, the design, A/E, CM, and capital medical equipment costs are deducted from the total project cost, and the net cost is normalized for the location—Chicago, IL. For projects in the U.S., the TIC can be normalized for the location using Equation (1).

Equation (1): Location Adjustment Using the City Cost Indexes (RSMeans data, 2023):

$$\frac{Index\ for\ City\ A}{Index\ for\ City\ B} \times Cost\ in\ City\ B = Cost\ in\ City\ A \tag{1}$$

For projects outside of the U.S., TIC can be normalized for location using Equation (2).
Equation (2): Adjustment from the National Average (RSMeans data, 2023):

$$\frac{Index\ for\ City\ A}{100} \times National\ Average\ Cost = Cost\ in\ City\ A \tag{2}$$

2.2.3. Escalation/Time Adjustment

Because the cost of an item has a time value, it is essential to know the year in which funds were spent. For example, a cost element of USD 100 in 1990 is more expensive than the same cost element in 2005 based on inflation growth over 15 years, which means that the cost element in 1990 will cost more when converted to a 2005 equivalent cost [34]. Time adjustment is the third and final step of cost normalization, where the net cost after location adjustment is converted from the midpoint of construction in Chicago to the present cost of the project in Chicago [16]. At this stage, the design, A/E, CM, and capital medical equipment costs eliminated from the location adjustment are normalized separately for time to reach the final comparable normalized cost of a cost element or the total project cost. According to [16], the midpoint of the construction phase in the project life cycle is when the majority of project expenditures occur. The construction phase costs are also significantly affected by the local conditions, such as construction labor, equipment, suppliers, and material costs [16,17]. Therefore, location and time adjustments both use the midpoint of the construction phase for normalization. A more accurate result could be achieved by adjusting every project transaction, but extensive efforts are required.

Equation (3): Time Adjustment for the National Average Using the Historical Cost Index (RSMeans data, 2023):

$$\frac{Index\ for\ Year\ A}{Index\ for\ Year\ B} \times Cost\ in\ Year\ B = Cost\ in\ Year\ A \tag{3}$$

2.3. Space Normalization

Space normalization works through dimensional metrics for a shell space. Two types of shell space are prevalent in healthcare institutions. The first is the cold shell space, which is unfit for occupancy and does not include finishes or walls. Fire separation requirements are based on the intended use and local regulations by the authority having jurisdiction. A cold-shell constructed space typically does not have plumbing, electrical, heating, ventilation, or air conditioning (HVAC) systems. Sometimes, the main mechanical unit(s) may be absent. The second is a warm shall space and is constructed with basic electrical, plumbing, and HVAC systems but does not include walls, flooring, or other finishes. However, the basic infrastructure provided makes it operational for occupancy and cost effective for tenants. In dimensional metrics, warm- and cold-shelled spaces are measured in terms of BGSF and Departmental Gross Square Footage (DGSF). Specific exterior envelope materials are also assessed in terms of their ratios to the exterior surface area. These spaces can be found in various facility types. They can significantly impact the cost per BGSF since they add square footage despite being unfinished, accounting for a substantial cost in constructing a new facility. The presence of a shell space—warm or cold—adds to the total square footage of the building despite the space being underdeveloped. Therefore, when calculating the BGSF, differences between the cost of a shell space and the built-out structure develop inconsistencies in the normalized BGSF for the total square footage of the building. This challenge can be mitigated by developing separate adjustment factors for warm and cold shell spaces, which copes with the inaccuracy in the total normalized BGSF. Since space adjustment for the final metric computations is distinctive to healthcare benchmarking methods, it is essential to study space-based adjustments for healthcare facilities.

Based on the background study, this paper is an extension to an approach to the normalization of the TIC and phase-based project cost; however, there is a gap in the research regarding normalizing cost elements of HCFs. Due to the complexity of HCFs, this paper proposes another possible approach for normalizing healthcare facility costs, i.e., by normalizing individual HCF cost elements. In addition, it is necessary to know how to normalize CSIMF cost elements (i.e., HVAC, foundations, etc.), which is the study's focus. CSI UniFormat is a categorization system for various building components, systems, and assemblies, offering a structured approach for design and operational considerations throughout a building's existence. This paper does not include procedures for normalizing cost elements based on CSI UniFormat. The previous benchmarking and normalization methods lack guidance on space adjustments for two identical building structures, while this study paves the ground for space normalization of healthcare facilities.

3. Methodology

3.1. Selection of Cost Indices

Multiple healthcare industry leaders, subject matter experts, and researchers (steering committee) within the National Healthcare Facilities Benchmarking Program (NHCFBP) developed standardized definitions for metrics relevant to HCFs and identified HCF-specific and CSIMF cost elements most relevant to HCFs. The Healthcare Facilities Benchmarking Program developed the metrics framework for the category costs, schedule, safety, rework, and changes unique to HCFs. Cost metrics included relative and absolute metrics, where absolute metrics like the dollar per square foot needed normalization for time and location for meaningful comparisons [1]. A comparative analysis of all the publicly available cost indices within the framework was conducted. This study presents a cost normalization framework for construction cost elements, adhering to the previously established guidelines of a normalization framework for TIC and phase-based approaches. The cost indices reviewed in the background study were first compared based on their use in the healthcare sector, designated purpose, public availability, representation of market conditions, and consideration of construction cost elements. Appropriate indices for normalization by HCF-specific and CSIMF cost elements with respect to location and time adjustment were established through this study.

During the steering committee discussions, certain criteria were established before reviewing the available cost indices for an appropriate selection. First, the indices were reviewed for their particular use in the healthcare sector, as many cost indices have been created to suit a particular industry or establish cost adjustment in a certain way [35]. Selection of the most suitable cost index is critical to developing preliminary cost estimates with an accuracy of $+/-20\%$ [36]. Second, they were reviewed for their designated purpose, i.e., for location and/or time adjustment. Third, the indices were reviewed to gauge their representation of the wide pool of identified cost elements, such as material, labor, equipment, contractor expenses, profit margins, local taxes, etc. Table 5 illustrates a detailed study of the available indices and their applicability to the cost elements. Lastly, the index values were reviewed based on their reflection of the economic trends and local market conditions to establish their reliable use for time adjustment (Figure 1). Due to the wide availability of input and output indices, all the available cost indices were compared over time to examine the impact of the 2008 economic downturn (Figure 1).

As a result, RSMeans CCI, ENR—CCI, ENR—BCI, Turner Cost Index, RLB, and BLS-PPI NAICS 236224 (BLS, 2016) were observed to have a specific use in the healthcare sector. Further, RSMeans CCI and RLB were observed to have been designed for location adjustment; therefore, their public availability was considered. RSMeans CCI collects data in over 970 cities in the U.S. In contrast, RLB collects data in over 12 cities in the U.S., as illustrated in Table 5. Both RSMeans and RLB track cost data for specific cost elements, indicating that both indices reflect changing market conditions. However, when compared based on their stability post-2008 economic downturn, the RSMeans CCI was observed to have shown more stability in terms of economic growth than RLB. After carefully analyzing the above-mentioned decision criteria, the RSMeans CCI was chosen for location adjustment of the HCF-specific and CSIMF cost elements. The Hanscomb Means International Cost Index was chosen for international projects, as the previous cost normalization frameworks used the same index for location adjustment [1,8,9]. For validation, the RSMeans CCI and RLB were compared using a hypothetical example to calculate the difference between the initial and normalized value using both indices (Table 6). As the normalized cost using RSMeans was closer to the initial value than the normalized value using RLB, the RSMeans CCI was chosen for location adjustment within the United States. For time adjustment, the RSMeans HCI, ENR-BCI, ENR-CCI, Turner Cost Index, RLB, and BLS-PPI were considered for further comparison. Indices, namely Turner, RLB, and BLS-PPI, were observed to track cost data beyond the material, labor, and equipment costs as opposed to the RSMeans HCI, ENR-CCI, and ENR-BCI. Furthermore, RLB and BLS-PPI represented cost elements beyond material and labor productivity as opposed to the Turner cost index. However, compared to their reflection of the changing market conditions and stability post-2008 economic downturn, the Turner cost index demonstrated the highest fluctuation, whereas the RSMeans HCI and BLS-PPI showed great stability (Figure 1). In Figure 1, the sources for the comparison of cost indices were, RSMeans data, 2023; Turner Construction Company, 2023; ENR, 2022; DoD, 2023; RLB, 2022; BLS, 2016. Also, all the available index values were normalized to the reference year 2008 with an index value of 100 to understand the stability of the index values.

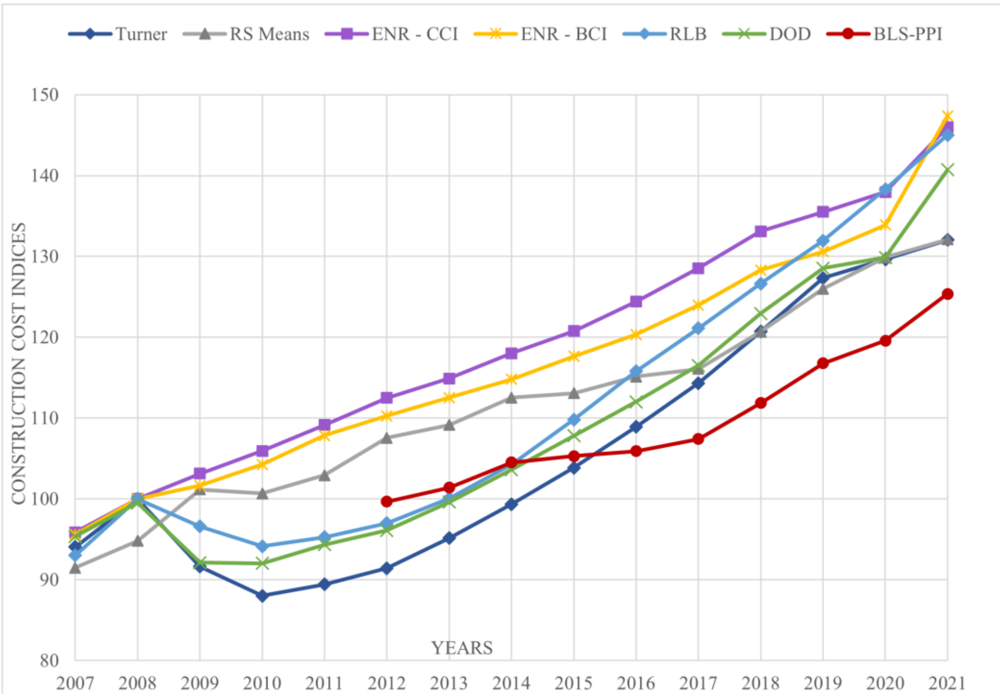

Figure 1. Comparison of Cost indices (Normalized to 2008 = 100).

Since BLS-PPI was a relatively new cost index—developed in 2012, it was not affected by the 2008 economic downturn. Since RLB represented a Global Construction Cost Relativity Index, as opposed to BLS-PPI, which was focused on the market conditions in the U.S., this study chose a similar approach as the normalization framework for TIC [8] by ultimately choosing a hybrid index of RLB and BLS-PPI [26] for time adjustment for projects before 2012. For normalizing cost elements of projects after 2012, BLS-PPI's new healthcare building construction with the base year of 2012 was chosen for normalization. This analysis was validated using a hypothetical example to calculate the difference between the initial and normalized values using both indices, as shown in Table 6.

Table 5. Applicability of indices to construction cost elements.

Index Type	Index Name		Purpose	Availability	Construction Cost Elements (HCF and CSIMF)
INPUT	RSMeans	City Cost Index	Location adjustment	970+ cities	Yes Material, labor, and equipment
		Historical Adjustment	Time adjustment	30 cities	Yes Material, labor, and equipment
INPUT	ENR	Building Cost Index	Time adjustment	20 cities	Yes Material and labor only
		Construction Cost Index	Time adjustment	20 cities	Yes Material and labor only
INPUT	Marshal & Swift	Equipment Cost Index	Time adjustment	-	Yes Major equipment only
		Building Cost Index	Time adjustment	100 cities	Yes Materials, equipment, and labor
OUTPUT	Bureau of Labor Statistics	Producer Price Index—Non-Residential—New Warehouse Building Construction	Time adjustment	-	Yes Material and installation. Preconstruction site preparation work, postconstruction landscaping or reclamation work, architectural fees, and building design fees are not in scope.
		Producer Price Index—Non-Residential—New Healthcare Building Construction	Time adjustment	-	
		Producer Price Index—Non-Residential—New School Building Construction	Time adjustment	-	
		Producer Price Index—Non-Residential—New Industrial Building Construction	Time adjustment	-	
		Producer Price Index—Non-Residential—New Office Building Construction	Time adjustment	-	
OUTPUT	Mortenson	Construction Cost Index	Time adjustment	7 cities	Yes Labor, material, equipment, and labor feedback
OUTPUT	Turner	Building Cost Index	Time adjustment	44 cities	Yes Material, labor rates, and productivity, and market conditions only.
OUTPUT	Rider Levett Bucknall	Global Construction Cost Relativity Index	Location adjustment	12 cities	Yes Labor, materials, general contractor and sub-contractor overhead costs, fees, profit margins, applicable sales/use taxes.

Table 5. *Cont.*

Index Type	Index Name		Purpose	Availability	Construction Cost Elements (HCF and CSIMF)
OUTPUT	Rider Levett Bucknall	Global Construction Cost Relativity Index	Time adjustment	12 cities	Yes Labor, materials, general contractor and sub-contractor overhead costs, fees, profit margins, applicable sales/use taxes.
SELLING	Department of Defense	Area Cost Factors	Location adjustment	-	-

Table 6. Comparison of Cost indices (Normalized to 2008 = 100).

Initial Value = USD 10,000,000	Index @ 2012	Index @ 2021	Normalized Value	Difference (Δ)
RS Means CCI	226.2	286.4	USD 12,661,362	**USD 2,661,362**
RSMeans HCI	194.0	238.3	USD 12,283,505	USD 2,283,505
ENR-CCI	112.5	146.0	USD 12,977,778	USD 2,977,778
ENR-BCI	110.3	147.3	USD 13,354,488	USD 3,354,488
Turner	91.4	132.0	USD 14,442,013	USD 4,442,013
RLB	97.0	145.0	USD 14,948,454	USD 4,948,454
BLS-PPI	99.7	125.4	USD 12,577,733	**USD 2,577,733**

3.2. Normalization Framework for CSIMF Cost Elements

The normalization framework developed in this study adheres explicitly to CSIMF cost elements. This framework follows a similar approach to the normalization procedures for each identified cost element, as proposed by [8], for the overall project cost (Appendix A); however, it is altered to cater to MasterFormat cost elements (Figure 2). The three key elements critically influencing cost normalization for project benchmarking are (1) project currency, (2) project location, and (3) the point in time considered for cost normalization, which were the basis of designing this framework (Figure 2).

Currency conversion is proposed as a first step for projects outside of the U.S., with respect to the appropriate market exchange rate to U.S. dollars at the midpoint of construction. As [8] established, the next two steps in normalization consider the project location and the time at the midpoint of the construction phase. However, in the absence of the midpoint of the construction phase, the entire normalization process is advised to be aborted altogether. As a first step, an appropriate set of cost indices was identified through a complete evaluation of publicly available cost indices. Since RSMeans represented the most stability, including changing market conditions, and a set of indices tailored to the CSI MasterFormat (MF) cost elements, it was chosen as the most suitable cost index for normalization. Therefore, the framework proposed by the RSMeans MasterFormat (MF) index for location adjustment at the midpoint of the construction phase. An inconsistency was observed while developing this framework concerning the CSIMF divisions. Differences in the division I.D.s and descriptions of cost elements were observed in the CSIMF before and after 2005. Due to the lack of a previous study based on the normalization of CSIMF cost elements, this challenge has yet to be addressed. Therefore, Appendix C outlines a detailed mapping of each cost element conducted to cope with these differences. Each question I.D., MF division, and the question name referring to each CSI division were considered during this process to gauge the appropriate steps to be followed for normalization.

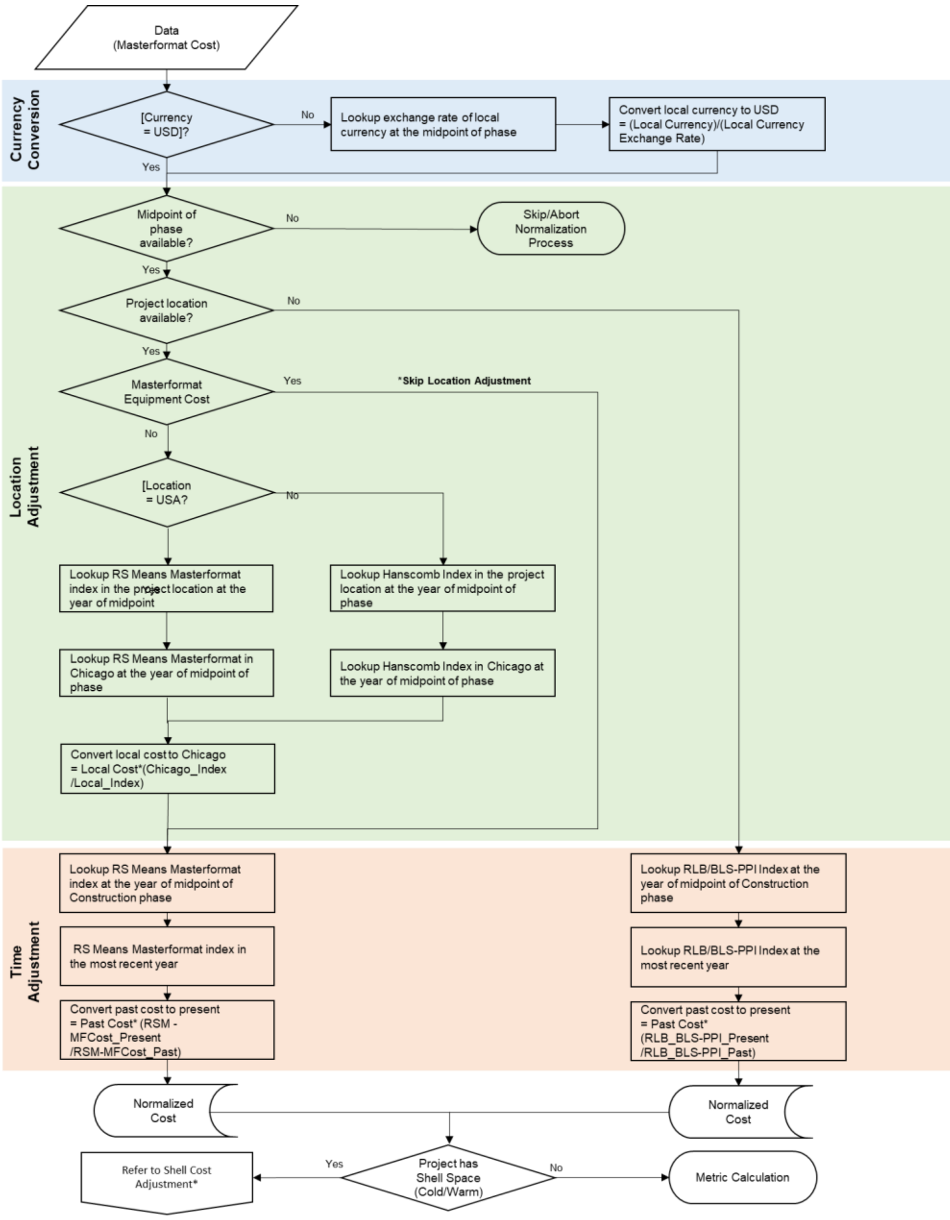

Figure 2. Normalization framework for CSIMF cost elements. * *If TIC is available, also calculate BGSF and consider the existence of cold/warm shell space. Adjust the BGSF using shell space adjustment factors and refer to space-based normalization.*

The Hanscomb Means International Cost Index should be used for location adjustment for international projects. Depending upon the availability of the project location, the process either continues for location adjustment using the RSMeans MasterFormat index or proceeds for time adjustment using the RLB/BLS-PPI index in the most recent year. Similarly, suppose the breakdown of MasterFormat costs is unavailable. In that case, this framework proposes that the available costs should be normalized for time using the RSMeans MasterFormat index at the midpoint of the construction phase. Both location and time adjustment should use the standard normalization equations. If a shell space, either warm or cold, exists within a structure, the framework proposes shell cost adjustment at this stage. The cost adjustment for the shell space cost is discussed in the next section. This initial framework (Figure 2) was validated using a case study illustrated in Appendix B and established post-discussion with the steering committee.

3.3. Space-Based Normalization Framework for TIC

To complete the normalization approach for healthcare facility costs, the effects of shell spaces on overall project costs were studied through background study. A shell space in a healthcare facility was observed to be crucial in normalizing the project cost per BGSF due to the additional square footage, irrespective of the finishes. A cold shell is a non-habitable space within a building with no finishes or mechanical systems, whereas a warm shell includes heating, ventilation, and air conditioning. A need for a separate normalization of shell space costs was established through background study, as inconsistencies were observed in the normalized cost per BGSF of healthcare projects with warm or cold shell spaces present. Two healthcare projects cannot be compared appropriately if one includes a shell space while the other does not. To be comparable, the shell space in one structure must be separated from the total square footage. Once separated, both the structures have a similar built-out program and finished spaces, and a more accurately comparable cost per BGSF can be evaluated.

This study conducted a detailed discussion with the steering committee and healthcare sector experts to understand the impact of shell space on the overall cost per BGSF. Dollar per square foot values for a 100,000-square-foot facility that is completely built out compared to another 100,000-square-foot facility with a 20,000-square-foot shell space will be distinct. Researchers populated similar examples of HCFs and normalized ratios by dividing the square footage of such spaces to calculate the overall impact on the BGSF. The steering committee was presented with the range of ratios resulting from the calculations for validation. Based on the feedback, to adjust the square footage or cost of such facilities for meaningful comparison, fixed cost adjustment rates of 0.35 for warm shell and 0.50 for cold shell were identified. The proposed cost adjustment factors were validated by implementing the adjustment rates into a case study. As shown in Table 7, a hypothetical healthcare project (MOB) is normalized for a shell space using a fixed adjustment rate of 0.5 or 0.35, depending upon the type of the shell space. This case study demonstrates the adjustment of total BGSF by deducting the adjusted square footage for a cold shell space using 0.5 as an adjustment factor. For a warm shell space, 0.35 would be used as the adjustment rate.

Table 7. Shell space adjustment.

Line Item	Value
Project BGSF (SF) =	250,000
TIC =	USD 50,000,000
Total Capital Medical Equipment Cost =	USD 10,000,000
Total A/E and Construction Management Cost =	USD 5,000,000
Cold Shell (SF) =	50,000
Adjust BGSF using the shell space adjustment factors—Cold shell (0.5) and warm shell (0.35)	
Step 1—Cold shell adjustment	
Equivalent Square Footage due to Shell (50,000 SF of cold shell × 0.5) =	25,000.00
Step 2—Final BGSF to be considered to evaluate USD /BGSF	
Final Equivalent SF of Building (250,000 SF–25,000 Equivalent SF) =	225,000.00

As the first step, the total square footage—BGSF–of the cold shell space was multiplied by the adjustment rate 0.5 to evaluate the cost of equivalent square footage due to shell space. This value is then deducted from the total project BGSF to evaluate the final equivalent square footage of a building—BGSF. The resulting value for the BGSF excludes unfinished shell spaces and will provide a more accurate and comparable BGSF for evaluating the cost per BGSF. A similar approach for other areas of space in healthcare facilities can be used to identify newer crosswalks for a better parametric assessment of cost and space.

4. Case Study—Methodology Demonstration and Validation—Normalization of CSIMF Cost Elements

This study proposed a tailored normalization framework for MasterFormat cost elements, as illustrated in Figure 2. This study conducted a detailed identification and assessment of individual cost elements to validate this framework. Further, depending on the data availability to ensure calculations for different scenarios, a healthcare project based in St. Louis, Missouri, was identified to implement the proposed framework. The project has been sourced from the Healthcare Facility Database (HCFD), which was developed as a resource for the healthcare community as part of the NHCFBP discussed in [1] to ensure reliability and accuracy in evaluations and generalization of findings. The identified HCF-specific and CSIMF cost elements were assigned individual steps in normalization, as the design, A/E, CM, and capital medical equipment costs would only require time adjustment. The previous framework for TIC was applied to individual phase costs and the HCF cost elements (Appendix A); however, a separate framework for CSIMF cost elements was applied as described in Appendix B based on Figure 2. From the summary of cost indices and the discussion with the steering team, the RSMeans CCI index was used for location adjustment, and BLS-PPI NAICS 236224 was used for time adjustment.

4.1. Normalization of CSIMF Cost Elements with Comparison to the Construction Phase Cost

Healthcare facilities are complex building structures that require flexible and adaptable solutions for effective facility management. Therefore, extra attention is required to the details of the design and project costs. The background study shows that this concern has been addressed before by proposing external benchmarking and cost normalization frameworks for HCFs. Previous research on the subject matter has established a normalization framework for TIC; however, it does not consider CSIMF cost elements.

The CSIMF cost element normalization did not require currency conversion, as the chosen case study was based in the U.S. For step 1—Location Adjustment (LA), RSMeans MasterFormat index for St. Louis (Missouri) at the midpoint of construction—2012 was used to normalize the cost of CSIMF cost elements to a baseline location—Chicago at the midpoint of construction—2012. As the location of this project was known and based in the U.S., RSMeans MasterFormat indices for 2012 and 2022 were chosen as appropriate indices for time adjustment.

Table 8 illustrates an example of CSIMF cost elements and their normalization procedure. A similar approach was utilized for normalizing all other CSIMF cost elements (Appendix C). Since CSIMF cost elements represent a breakdown of the construction phase cost, the combined normalized cost of CSIMF cost elements is compared to the normalized construction phase cost. As illustrated in Table 9, a delta of USD 2,774,361 (Δ) was observed between the final normalized costs. This delta was further normalized using the RSMeans MasterFormat cost indices and added to the normalized cost of CSIMF cost elements. As evident in Table 9, the normalized costs of CSIMF cost elements and the construction phase cost reached a comparable final value and were validated through the proposed framework. It should be noted that no design, A/E, CM, or capital medical equipment costs were deducted for normalization since CSIMF cost elements primarily represent the construction phase costs only. For example, CSIMF Division 11 represents a total equipment cost; however, it is not equivalent to the capital medical equipment cost, and therefore, it should be normalized for location.

4.2. Normalization of HCF-Specific Cost Elements with Comparison to Project Life-cycle Phase Costs

In previous studies, implementing the normalization framework established for TIC has not considered normalizing individual phase costs and HCF-specific cost elements. Therefore, this study established applicability by a separate normalization framework tailored to HCF-specific cost elements.

In Table 10 above, the framework for TIC normalizes the individual phase costs and HCF-specific cost elements, presenting a robust approach towards normalization. Comparing the almost equivalent values obtained from the total normalized phase (of project life cycle) costs, i.e., USD 13,411,825, and the total of normalized HCF-specific cost elements, i.e., USD 13,411,827, validates the framework's approach (Table 10).

Table 8. Normalization of CSIMF cost elements—Example.

Case Study: Mercy Clinic, Zumbehl Road, St. Louis, MO.					
CSIMF Cost Element	**Cost to Be Normalized**	**Year of Midpoint of Construction**	**Normalization Steps [1]**	**Location Adjustment**	**Time Adjustment**
Division 03—Total Concrete	USD 437,850	2012	LA and TA	USD 550,477	USD 572,304
Division 21—Total Fire Suppression	USD 68,034	2012	LA and TA	USD 76,894	USD 84,536
Division 22—Total Plumbing	USD 284,185	2012	LA and TA	USD 321,191	USD 353,112
Division 23—Total HVAC	USD 480,775	2012	LA and TA	USD 543,380	USD 597,384
Division 26—Total Electrical	USD 564,130	2012	LA and TA	USD 616,096	USD 721,636
Division 31—Total Earthwork	USD 606,790	2012	LA and TA	USD 627,648	USD 699,704

[1] Calculation details in Table A3—Appendix B.

Table 9. Comparison of construction phase cost and CSIMF elements' costs.

Category	**Cost Normalization**	
Type	**Construction Phase Cost [1]**	**CSIMF Cost Elements [2]**
Cost to be normalized	USD 6,013,294 [1]	USD 6,013,286 [2]
Design/engineering, A/E, CM, medical equipment cost	Not Applicable	Not Applicable
Net cost to be normalized for location	USD 6,013,294	USD 6,013,286
Net cost after Location Adjustment	USD 6,869,733	USD 6,813,829
Net cost after Time adjustment (A)	USD 10,128,894	USD 7,354,533
Design/engineering, A/E, CM, medical equipment cost after time adjustment (B)	Not Applicable	Not Applicable
Total Normalized cost (A + B)	**USD 10,128,894**	**USD 7,354,533**
Δ = (Normalized Construction phase cost − Normalized CSIMF elements' cost)		USD 2,774,361
Normalized **Δ**		USD 3,364,420
Normalized CSIMF elements cost + Normalized Δ =		**USD 10,718,953**

[1] Calculation details in Table A1—Appendix B for construction phase cost. [2] Calculation details in Table A3—Appendix B for the total of CSIMF cost elements.

Table 10. Application of framework for TIC towards phase cost and HCF-specific elements.

Project Life-cycle Phase Costs [1]		
Description	**Costs to be Normalized**	**Cost after Normalization**
Phase Costs normalized for Location and Time		
FEP (Front-End Planning) Cost	USD 10,806	USD 18,202
Construction Cost	USD 6,013,294	USD 10,128,894
Activation/Move-in Actual Cost	USD 31,701	USD 53,397

Table 10. *Cont.*

Project Life-cycle Phase Costs [1]		
Description	**Costs to be Normalized**	**Cost after Normalization**
Total for Phase Costs normalized for Location and Time (A)	USD 6,055,801	USD 10,200,493
Phase Costs normalized only for Time		
Detailed Design Cost Procurement Cost	USD 437,253 USD 1,740,773	USD 644,696 USD 2,566,636
Total for Phase Costs normalized for Time (B)	USD 2,178,026	USD 3,211,332
Total for Project Life-cycle Phase Costs (A + B)	**USD 8,233,827**	**USD 13,411,825**
HCF-specific cost elements [2]		
Description	**Costs to be Normalized**	**Cost after Normalization**
HCF Cost elements normalized for Location and Time [2]	USD 6,055,802	USD 10,200,496
HCF Cost elements normalized only for Time [2]	S2,178,027	USD 3,211,331
Total for HCF-specific cost elements	**USD 8,233,829**	**USD 13,411,827**

[1] Calculation details in Table A1—Appendix B for the total of all project life-cycle phase costs. [2] Calculation details in Table A2—Appendix B for the total of HCF-specific cost elements.

5. Results and Discussion

Healthcare projects require extreme precision during the design and construction phases. Therefore, a robust benchmarking program and a cost normalization framework are developed with the help of industry and real-life projects. The background study addresses a cost normalization framework for TIC but does not consider HCF-specific cost elements and CSIMF division costs. It suggests an alternative approach to normalizing healthcare cost elements such as medical equipment costs within HCF and CSIMF cost elements, such as HVAC and foundations, etc. Unlike previous benchmarking and normalization methods that lack guidance on adjusting space for two identical building structures, this research also establishes a foundation for the space normalization of healthcare facilities.

5.1. Selection of Cost Indices

The RSMeans CCI was selected for adjusting the location of HCF-specific and CSIMF cost elements. In evaluating their resilience following the 2008 economic downturn, it was observed that the RSMeans CCI demonstrated greater stability in economic growth compared to RLB. Additionally, it provided many cities (970) covering most of the US as options for normalization. For time adjustment, a hybrid index of RLB and BLS-PPI was selected for projects before 2012. Further, for projects after 2012, BLS-PPI NAICS 236224, with the base year of 2012, was chosen for normalization. BLS-PPI NAICS 236224 is designed specifically for healthcare projects with the added stability of the BLS index with expected permanence.

5.2. Normalization Framework for HCF-Specific Cost Elements and CSIMF Cost Elements

The study validated the proposed framework for TIC to normalize individual phase costs and HCF-specific cost elements. Further, the framework was tested by finding the values of normalized CSIMF cost elements and the construction phase cost comparable. The results indicated that 1) the final normalized cost of the healthcare facility remains the same irrespective of the approach used for normalization, i.e., using TIC, individual phase costs, or HCF-specific cost elements, and 2) the final normalized cost of the construction phase can be determined by normalizing the total construction phase cost or individual CSIMF cost elements (Table 9). However, a delta (Δ) difference, in Section 4.1, was observed between the final normalized construction phase cost and the total of individually normalized

CSIMF cost elements. This delta was further normalized and added to the normalized cost of CSIMF cost elements to arrive at a comparable value.

5.3. Space-Based Normalization

In the case study analysis and with feedback from the steering committee, the adjustment cost factors were identified as follows:

(1) Total BGSF modification is validated by subtracting the adjusted square footage for a cold shell space, employing a 0.5 adjustment factor.
(2) In the case of a warm shell space, the adjustment rate was identified as 0.35.

6. Conclusions and Path Forward

In conclusion, this research study aimed to develop a comprehensive normalization framework for HCF costs.

(1) The study identified and recommended a set of indices best suited for time and location adjustments to achieve this goal: RSMeans CCI index and BLS-PPI NAICS 236224, along with the expected results via a case study. Selection of the most suitable cost index can assist various stakeholders, such as estimators, healthcare system facility managers, etc., with early estimates and condition assessments of the facilities.

(2) These adjustments were determined by building upon a previously established framework, revealing a shortfall in applying CSIMF cost elements. Therefore, evaluating the normalization framework applicable to TIC for phase costs and HCF-specific cost elements informed the development of a specific normalization framework for CSIMF cost elements. The case study analysis justified the presence of a cost accuracy gap limited to the construction phase of a project. Normalization of the construction phase cost and mapping to total normalized costs using CSIMF cost elements validated the framework developed for CSIMF costs.

The current study outlined HCF cost normalization approaches for overall project costs, individual phase costs, and individual cost elements. The overarching findings have significant implications for HCF owners seeking to improve the accuracy of cost projections and benchmarking procedures. The CSIMF framework capitalizes on cost elements that enable pre-construction stakeholders to understand the detailed factors affecting overall project costs. The benefit of early cost indicators promotes positive overall project health in terms of cost accuracy. Further metrics calculated using the normalized costs are intended to understand if the project phase has efficiently used financial or human resources.

(3) Additionally, establishing fixed cost adjustment rates for cold (0.5) and warm (0.35) shell spaces reveals significant impacts when included in the overall project costs. Therefore, cost adjustments for shell spaces must further consider time and location constraints separately in the overall project cost to improve normalization accuracy.

Looking to the future, the study identified combinations of input and output indices inclusive of factors such as escalation. To best understand escalation and its relationship to the input and output indices of the normalization framework, a sensitivity analysis is recommended for various scenarios. While this study does not provide an in-depth analysis of escalation, it does provide foundational elements that lead toward applications of indices affecting healthcare cost predictions for accuracy in determining overall project costs.

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Data Availability Statement: Data is contained within the article and Appendices A–C. The data presented in this study are available in Appendices A–C.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Figure A1 discusses the normalization procedure and framework for Total Installed Cost (TIC).

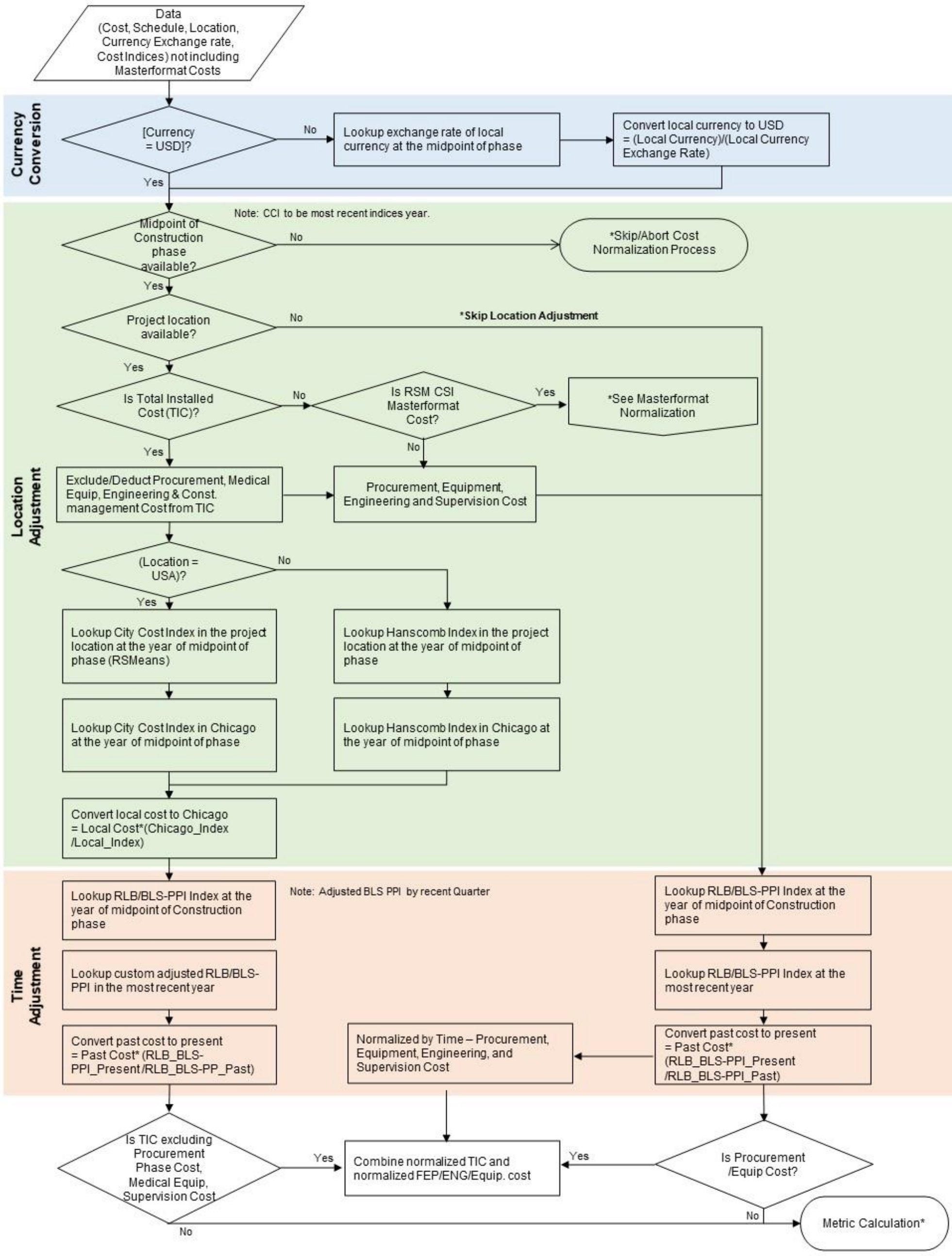

Figure A1. Normalization procedure and framework for TIC. (* *refer to Section 2.2 for Cost normalization procedure and Table 4 for calculation*).

Appendix B

This appendix tabulates the normalization of Phase costs, HCF-specific and CSIMF cost elements through a case study.

Table A1. Case study—Normalization of Phase costs [1].

ID	Cost Category	Question Name—Revised	Cost (USD)	Normalization Method	Location Adjustment [2]	Time Adjustment [3]
					Cost after LA (USD)	**Final Normalized Cost (USD)**
101	Phase cost	FEP—Actual Cost	USD 10,806	LA and TA	USD 12,345	USD 18,202
103	Phase cost	Detail Design (DD)—Actual Cost [1]	USD 437,253	TA	-	USD 644,696
105	Phase cost	Procurement—Actual Cost [1]	USD 1,740,773	TA	-	USD 2,566,636
107	Phase cost	Construction—Actual Cost [1]	USD 6,013,294	LA and TA	USD 6,869,733	USD 10,128,894
113	Phase cost	Activation/Move-in—Actual Cost	USD 31,701	LA and TA	USD 36,216	USD 53,397
TOTAL			**USD 8,233,827**		**USD 6,918,294**	**USD 13,411,825**

[1] Using normalization framework for TIC. [2] LA: RSMeans Missouri 2012 = 199.5; RSMeans Chicago 2012—226.9. [3] TA: BLS-PPI 2012 = 100; BLS-PPI 2021 = 132.7.

Table A2. Case study—Normalization of HCF-specific cost elements [1].

ID	Cost Category	Question Name—Revised	Cost (USD)	Normalization Method	Location Adjustment [2]	Time Adjustment [3]
					Cost after LA (USD)	**Final Normalized Cost (USD)**
2147	HC-specific costs	Total Site development on-site	USD 348,781	LA and TA	USD 398,456	USD 587,493
2148	HC-specific costs	Site development off-site	USD 258,009	LA and TA	USD 294,756	USD 434,595
2149	HC-specific costs	Building Construction (including excavation within 5′ of the building)	USD 5,025,365	LA and TA	USD 5,741,099	USD 8,464,810
2155	HC-specific costs	Furnishings	USD 13,001	LA and TA	USD 14,853	USD 21,899
2152	HC-specific costs	Owner's miscellaneous	USD 124,198	LA and TA	USD 141,886	USD 209,201
2156	HC-specific costs	Artwork and plants	USD 26,417	LA and TA	USD 30,179	USD 44,497
2157	HC-specific costs	IT	USD 108,822	LA and TA	USD 124,321	USD 183,302
2195	HC-specific costs	Roof garden	USD 1,300	LA and TA	USD 1,485	USD 2,190
2197	HC-specific costs	Mechanical tunnel	USD 118,208	LA and TA	USD 135,044	USD 199,112
2159	HC-specific costs	Commissioning cost	USD 31,701	LA and TA	USD 36,216	USD 53,397
2151	HC-specific costs	CM Pre-construction fees	USD 35,194	TA	-	USD 51,891
2158	HC-specific costs	Project management and agent fees	USD 178,589	TA	-	USD 263,316
2150	HC-specific costs	Professional fees (A/E and Consulting Engineers)	USD 448,059	TA	-	USD 660,629

Table A2. *Cont.*

ID	Cost Category	Question Name—Revised	Cost (USD)	Normalization Method	Location Adjustment [2]	Time Adjustment [3]
					Cost after LA (USD)	Final Normalized Cost (USD)
2153	HC-specific costs	Capital Medical equipment	USD 947,070	TA	-	USD 1,396,381
2338	Medical equipment	Reused medical equipment	USD 131,365	TA	-	USD 193,687
2339	Medical equipment	Food service equipment	USD 75,164	TA	-	USD 110,824
2340	Medical equipment	Security Systems	USD 37,269	TA	-	USD 54,950
2341	Medical equipment	Scrub sinks	USD 4,419	TA	-	USD 6,515
2342	Medical equipment	Sterilization equipment	USD 45,750	TA	-	USD 67,455
2343	Medical equipment	Cart washer	USD 3,997	TA	-	USD 5,893
2344	Medical equipment	Laboratory or pharmacy casework	USD 22,135	TA	-	USD 32,636
2345	Medical equipment	Patient monitoring system	USD 71,870	TA	-	USD 105,967
2346	Medical equipment	Nurse Call Systems	USD 5,712	TA	-	USD 8,421
2347	Medical equipment	OR lighting	USD 34,627	TA	-	USD 51,055
2348	Medical equipment	Headwalls	USD 33,795	TA	-	USD 49,828
2351	Medical equipment	Paper Towels, toilet accessories, soap dispensers	USD 13,413	TA	-	USD 19,776
2352	Medical equipment	Equipment seismic bracing	USD 5,524	TA	-	USD 8,145
2353	Medical equipment	Other	USD 84,075	TA	-	USD 123,962
	TOTAL		**USD 8,233,829**		**USD 6,918,295**	**USD 13,411,827**

[1] Using normalization framework for TIC. [2] LA: RSMeans Missouri 2012 = 199.5; RSMeans Chicago 2012—226.9. [3] TA: BLS-PPI 2012 = 100; BLS-PPI 2021 = 132.7.

Table A3. Case study—Normalization of CSIMF cost elements [1].

ID	Cost Category	Question Name—Revised	Cost (USD)	Normalization Method	Location Adjustment [2]	Time Adjustment [3]
					Cost after LA (USD)	Final Normalized Cost (USD)
2165	MasterFormat costs	Division 01—Total General Requirements	USD 172,907	LA and TA	USD 196,692	USD 209,681
2166	MasterFormat costs	Division 03—Total Concrete	USD 437,850	LA and TA	USD 550,477	USD 572,304
2167	MasterFormat costs	Division 04—Total Masonry	USD 372,291	LA and TA	USD 461,599	USD 529,893
2168	MasterFormat costs	Division 05—Total Metals	USD 340,158	LA and TA	USD 338,903	USD 326,677
2169	MasterFormat costs	Division 06—Total Wood and Plastics	USD 209,956	LA and TA	USD 281,142	USD 242,371
2170	MasterFormat costs	Division 07—Total Thermal and Moisture Protection	USD 324,250	LA and TA	USD 369,136	USD 415,592
2171	MasterFormat costs	Division 08—Total Doors and Windows	USD 350,859	LA and TA	USD 391,892	USD 422,840
2172	MasterFormat costs	Division 09—Total Finishes	USD 413,720	LA and TA	USD 535,522	USD 546,890
2173	MasterFormat costs	Division 10—Total Specialties	USD 1,713	LA and TA	USD 1,790	USD 1,875
2174	MasterFormat costs	Division 11—Total Equipment	USD 16,502	LA and TA	USD 17,241	USD 18,062
2175	MasterFormat costs	Division 12—Total furnishings	USD 13,001	LA and TA	USD 13,583	USD 14,230
2176	MasterFormat costs	Division 13—Total Special Construction	USD 17,724	LA and TA	USD 18,518	USD 19,399
2177	MasterFormat costs	Division 14—Total conveying systems	USD 112,876	LA and TA	USD 117,930	USD 123,546
2178	MasterFormat costs	Division 21—Total Fire Suppression	USD 68,034	LA and TA	USD 76,894	USD 84,536
2179	MasterFormat costs	Division 22—Total Plumbing	USD 284,185	LA and TA	USD 321,191	USD 353,112
2180	MasterFormat costs	Division 23—Total HVAC	USD 480,775	LA and TA	USD 543,380	USD 597,384
2182	MasterFormat costs	Division 26—Total Electrical	USD 564,130	LA and TA	USD 616,096	USD 721,636
2183	MasterFormat costs	Division 27—Total communications	USD 106,822	LA and TA	USD 116,662	USD 136,647
2184	MasterFormat costs	Division 28—Total electrical safety and security	USD 52,287	LA and TA	USD 54,628	USD 57,230
2186	MasterFormat costs	Division 31—Total Earthwork	USD 606,790	LA and TA	USD 627,648	USD 699,704
2187	MasterFormat costs	Division 32—Total Exterior Improvements	USD 323,291	LA and TA	USD 334,404	USD 372,795

Table A3. *Cont.*

ID	Cost Category	Question Name—Revised	Cost (USD)	Normalization Method	Location Adjustment [2]	Time Adjustment [3]
					Cost after LA (USD)	Final Normalized Cost (USD)
2188	MasterFormat costs	Division 33—Total Utilities	USD 112,766	LA and TA	USD 116,642	USD 130,033
2191	MasterFormat costs	Division 007200—Contractor's General Conditions	USD 323,223	LA and TA	USD 367,685	USD 391,967
2192	MasterFormat costs	Division 008100—Contractor's Fee	USD 138,214	LA and TA	USD 157,227	USD 167,610
2193	MasterFormat costs	Division 007316—Insurance	USD 56,423	LA and TA	USD 64,184	USD 68,423
2602	MasterFormat costs	Division 25—Total integrated automation	USD 51,755	LA and TA	USD 54,072	USD 56,647
2603	MasterFormat costs	Division 02—Total Existing Conditions (natural)	USD 4,396	LA and TA	USD 4,547	USD 5,069
2607	MasterFormat costs	Division 007318—Bonds	USD 56,388	LA and TA	USD 64,144	USD 68,380
TOTAL			**USD 6,013,286**		**USD 6,813,829**	**USD 7,354,533**

[1] Using normalization framework for CSIMF cost elements. [2] LA: RSMeans CSIMF Missouri 2012; RSMeans CSIMF Chicago 2012. [3] TA: BLS-PPI 2012 = 100; BLS-PPI 2021 = 132.7.

Appendix C

This appendix tabulates the data mapping for the MasterFormat divisions prior to 2005 and after 2005.

Table A4. MasterFormat divisions—data mapping.

RSMEANS CSI DIVISIONS (PRIOR TO 2005)		RSMEANS CSI DIVISIONS (2005)		QUESTIONNAIRE DESCRIPTION (16.2)		CSI Division ID
01590	Equipment Rental	015433	Contractor Equipment	None	None	1
02	Site Construction	0241, 31–34	Site and Infrastructure, Demolition	Div. 2	Total Existing Conditions (natural)	2
02	Site Construction	0241, 31–35	Site and Infrastructure, Demolition	Div. 31	Total Earthwork	2
02	Site Construction	0241, 31–36	Site and Infrastructure, Demolition	Div. 32	Total Exterior Improvements	2
02	Site Construction	0241, 31–37	Site and Infrastructure, Demolition	Div. 33	Total Utilities	2

Table A4. *Cont.*

RSMEANS CSI DIVISIONS (PRIOR TO 2005)		RSMEANS CSI DIVISIONS (2005)		QUESTIONNAIRE DESCRIPTION (16.2)		CSI Division ID
02	Site Construction	0241, 31–38	Site and Infrastructure, Demolition	Div. 34	Total Transportation	2
03	Concrete	03	Concrete	Div. 3	Total Concrete	3
04	Masonry	04	Masonry	Div. 4	Total Masonry	4
05	Metals	05	Metals	Div. 5	Total Metals	5
06	Wood & Plastics	06	Wood, Plastics, and Composites	Div. 6	Total Wood and Plastics	6
07	Thermal and Moisture Protection	07	Thermal and Moisture Protection	Div. 7	Total Thermal and Moisture Protection	7
08	Doors and Windows	08	Openings	Div. 8	Total Doors and Windows	8
09	Finishes	09	Finishes	Div. 9	Total Finishes	9
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 46	Div. 10	Total Specialties	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 47	Div. 11	Total Equipment	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 48	Div. 12	Total Furnishings	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 49	Div. 13	Total Special Construction	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 50	Div. 14	Total Conveying Systems	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 51	Div. 25	Total Integrated Automation	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 52	Div. 28	Total Electrical Safety and Security	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 53	Div. 41	Total Material Processing and Handling Equip	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 54	Div. 44	Total Pollution and Waste Control Equipment	10
10–14	Divs. 10–14	Covers	Divs. 10–14, 25, 28, 41, 43, 44, 55	Div. 46	Total Water and Wastewater Equip.	10
15	Mechanical	21, 22, 23	Fire Suppression, Plumbing and HVAC	Div. 21	Total Fire Suppression	11
15	Mechanical	21, 22, 24	Fire Suppression, Plumbing and HVAC	Div. 22	Total Plumbing	11
15	Mechanical	21, 22, 25	Fire Suppression, Plumbing and HVAC	Div. 23	Total HVAC	11

Table A4. *Cont.*

RSMEANS CSI DIVISIONS (PRIOR TO 2005)		RSMEANS CSI DIVISIONS (2005)		QUESTIONNAIRE DESCRIPTION (16.2)		CSI Division ID
16	Electrical	26, 27, 3370	Electrical, Communications and Util.	Divi. 26	Total Electrical	12
16	Electrical	26, 27, 3371	Electrical, Communications and Util.	Div. 27	Total Communications	12
16	Electrical	26, 27, 3372	Electrical, Communications and Util.	Div. 48	Total Electrical Power Generation	12
0–16	Weighted Average	MF2010	Weighted Average	Div. 01	Total General Requirements	13
0–16	Weighted Average	MF2010	Weighted Average	Div. 008300	Construction Contingency	13
0–16	Weighted Average	MF2010	Weighted Average	Div. 007200	Contractor's General Conditions	13
0–16	Weighted Average	MF2010	Weighted Average	Div. 007210	Supervision Cost	
0–16	Weighted Average	MF2010	Weighted Average	Div. 008100	Contractor's Fee	13
0–16	Weighted Average	MF2010	Weighted Average	Div. 007316	Insurance	13
0–16	Weighted Average	MF2010	Weighted Average	Div. 007318	Bonds	13
0–16	Weighted Average	MF2010	Weighted Average	Div. 008700	Local Taxes	13
0–17	Weighted Average	MF2010	Weighted Average	Div. 00	USD Subtotal Division 0 Cost	13

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