Appendices

Appendix 1

Preliminaries of Grey Numbers

This section presents the basic definitions and arithmetic operations related to grey numbers.

-A grey number is an interval value defined as:

$\otimes A \in [\bar{A}, \underline{A}],\ \underline{A} < \bar{A}$ (1)

- The kernel (central value) of a grey number is given by:

$\otimes \hat{A} = ½\ (\underline{A} + \bar{A})$. (2)

-For two grey numbers $\otimes A$ and $\otimes B$, the arithmetic operations can be defined as:

$\otimes A + \otimes B = [\underline{A} + \underline{B},\ \bar{A} + \bar{B}]$, (3)

$\otimes A - \otimes B = [\underline{A} - \bar{B},\ \bar{A} - \underline{B}]$, (4)

$\otimes A \cdot \otimes B = [\text{Min}\ \{\underline{A}\underline{B}, \underline{A}\bar{B}, \bar{A}\underline{B}, \bar{A}\bar{B}\},\ \text{Max}\ \{\underline{A}\underline{B}, \underline{A}\bar{B}, \bar{A}\underline{B}, \bar{A}\bar{B}\}]$, (5)

$\otimes A\ /\ \otimes B = \otimes A \cdot \otimes B^{-1} = [\text{Min}\ \{\underline{A}/\underline{B}, \underline{A}/\bar{B}, \bar{A}/\underline{B}, \bar{A}/\bar{B}\},\ \text{Max}\ \{\underline{A}/\underline{B}, \underline{A}/\bar{B}, \bar{A}/\underline{B}, \bar{A}/\bar{B}\}]$, (6)

-The length of $\otimes A$ is calculated by:

$L(\otimes A) = \bar{A} - \underline{A}$. (7)

- To distinguish between grey numbers, the concept of greyness degree is used. This degree, denoted as $g^o(\otimes A)$, is defined as the ratio of the length of the grey number $\otimes A$ to the length of the background set Ω of all grey numbers:

$g^o(\otimes A) = \mu(\otimes A) / \mu(\Omega)$ (8)

Here, Ω represents the domain or background of grey numbers, and μ refers to the measure or length.

Considering two grey numbers $\otimes A = [\underline{A}, \bar{A}]$ and $\otimes B = [\underline{B}, \bar{B}]$, their comparison is made as follows:

- If $\otimes \hat{A} < \otimes \hat{B}$, then $\otimes A <G \otimes B$. (9)

- If $\otimes\hat{A} = \otimes\hat{B}$ and $g^o(\otimes A) = g^o(\otimes B)$, then $\otimes A =G \otimes B$. (10)

- If $g^o(\otimes A) < g^o(\otimes B)$, then $\otimes A >G \otimes B$. (11)

Moreover, the grey possibility degree $P\{\otimes A \leq \otimes B\}$, for two grey numbers $\otimes A = [\underline{A}, \bar{A}]$ and $\otimes B = [\underline{B}, \bar{B}]$, is calculated as follows:

$$P\{\otimes A \leq \otimes B\} = \text{Max}\{0, L(\otimes A) + L(\otimes B) - \text{Max}(0, \underline{A} - \bar{B})\} / (L(\otimes A) + L(\otimes B)) \quad (12)$$

Grey Best-Worst Method (GBWM)

Unlike classical BWM that uses precise values, here experts provide interval-based preferences (e.g., [4,6] instead of exact number 5) to capture judgment uncertainty. The optimization model then calculates final weights within these ranges. Consequently, the grey BO and OW vector will be expressed as follows:

$$\otimes A_B = (\otimes a_{B1}, \otimes a_{B2}, \ldots, \otimes a_{Bn}) \quad (13)$$

$$\otimes A_w = (\otimes a_{1W,} \otimes a_{2W,} \ldots, \otimes a_{nW})^T \quad (14)$$

Additionally, the experts' opinions were converted into grey numbers based on the Table (A4).

Table A4. grey scale value

linguistic term	**grey scale**
none	[0,2]
very low	[1,3]
low	[2,4]
fairly low	[3,5]
moderate	[4,6]
fairly high	[5,7]
high	[6,8]
very high	[7,9]
extremely high	[8,10]

Given the use of grey numbers (interval-valued comparisons) in GBWM, the conventional BWM linear model is extended as follows:

$$\min \xi \tag{15}$$

$$\left|\overline{w}_B - \bar{a}_{Bj}{}^{d}.\underline{w}_j\right| \le \xi$$

$$\left|\underline{w}_B - \underline{a}_{Bj}{}^{d}.\overline{w}_j\right| \le \xi$$

$$\left|\overline{w}_j - \overline{a}_{jw}{}^{d}.\underline{w}_w\right| \le \xi$$

$$\left|\underline{w}_j - \overline{a}_{jw}{}^{d}.\overline{w}_w\right| \le \xi$$

$$\sum_{j=1}^{n} \otimes w_j,$$

$$\overline{w}_j \ge (1+\boldsymbol{\varepsilon})\underline{w}_j,$$

$$\overline{w}_j \ge 0\,, \underline{w}_j \le 0\ \forall j$$

In this model, d denotes the d-th decision maker, and to ensure the constraint that the upper bound is greater than or equal to the lower bound, a small positive epsilon (ε) is used in the model.

Also, the Consistency Ratio (CR) is calculated as:

$$CR = R(\otimes\xi) / CI \tag{16}$$

Here, R(⊗ξ) refers to the whitened value of the grey number ⊗ξ, obtained in a prior step, while CI represents the consistency index.

The consistency index (CI) is calculated by solving the quadratic equation below:

$$CI^2 - (1+2\overline{a}_{BW})\,CI + (\overline{a}_{BW}{}^{2} - \overline{a}_{BW}) = 0 \tag{17}$$

Where:

$$\otimes\overline{a}_{BW} = \max(\otimes a_{Bj}, \otimes a_{jW}) \tag{18}$$

The comparison matrix is consistent when the CR value is close to zero.

At the end, the white value of the grey number is calculated by equation below:

$$W(\otimes w_{dj}) = (\underline{w}_{dj} + \overline{w}_{dj})/2 \quad (19)$$

Appendix 2

Dear Respondent,

Greetings and respect,

This questionnaire is designed to assess and weigh the dimensions of the readiness assessment model for Hospital 5.0, in line with a research project titled ". **Designing the Model of Evaluating the Readiness of Hospital 5.0 Implementation** " The dimensions and subdimensions of the model are presented in Table 1.

To complete the questionnaire, please first identify the best (most significant) and the worst (least significant) dimensions in Tables 2 and 3. Then, indicate the preference of the best dimension relative to the other dimensions using numbers from 1 to 9, where a ranking of 1 indicates equal importance to itself. Next, specify the preference of all indicators relative to the worst dimension on the same scale, noting that the ranking of the worst dimension relative to itself is also 1. Following this, please compare the subdimensions in the relevant tables.

Your honest responses are greatly appreciated and will significantly aid in the success of this research. Thank you in advance for your cooperation.

Table 1: Dimensions and Sub-dimensions of the Hospital 5.0 Implementation Assessment Model

Dimension	Subdimension	Description
technology readiness	Technological Infrastructure	This subdimension refers to the systems and technologies necessary for implementing and supporting digital and intelligent processes in hospitals.
	Emerging Technologies	It includes technologies that have recently been introduced and have the capability to enhance the efficiency and quality of health services, such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data.
	Security and Privacy	This dimension refers to the principles and procedures related to the protection of patient data and sensitive information.
	Automatization of Management Processes	It involves the use of technology to optimize and automate management processes in hospitals to enhance efficiency and reduce human errors.
	Personalized treatments	It refers to treatment approaches that are designed based on the unique characteristics of each patient.
	Telemedicine	It includes medical services and health consultations provided through communication technologies, enabling patients to access health services remotely.
Human-Centered Organizational Development	Human-centered strategy	t emphasizes the design and implementation of systems and processes based on human needs and desires to provide a better experience for patients and staff.
	Advanced Technology Training	It includes educational programs that assist hospital staff in becoming familiar with new technologies and using them effectively.

	Organizational Collaboration	It refers to the interaction and collaboration between different departments of the hospital, which can contribute to improving service quality and reducing response times
	Organizational Innovation	It refers to the ability of hospitals to create and implement innovative ideas and solutions to improve services and processes.
	Change Acceptance	It refers to the willingness and ability of staff and management to accept and adapt to changes and new innovations in work processes.
	democracy	It refers to creating an environment for the involvement of staff and patients in decision-making and hospital policymaking.
	Employee Reward and Recognition	It includes incentive and recognition systems that contribute to the motivation and job satisfaction of staff.
sustainability	Sustainable Strategy	It refers to strategies that focus on conserving resources and protecting the environment within hospital processes.
	Resource Efficiency	It refers to the optimal use of human, financial, and physical resources in hospitals.
	Digital Sustainability	It refers to the extent of the use of digital solutions and emerging technologies that help reduce environmental impacts and enhance resource efficiency.
	Waste Reduction	It includes actions aimed at reducing waste of resources and time in therapeutic and managerial processes.
resilience	Resource Flexibility	It refers to multi-skilled employees who can be deployed in various departments of the hospital.
	Organizational Agility	It refers to the hospitals' ability to respond quickly and effectively to environmental changes and challenges.
	Technological Adaptability	It refers to the hospitals' capability to integrate and utilize new technologies within existing systems.
	Crisis Management Capabilities	It refers to the hospitals' ability to plan for and manage crises and emergency situations.
	Continuous Improvement	It refers to the ongoing processes of evaluating and optimizing services and performance in hospitals.
	Stakeholder engagement	It refers to collaboration and interaction with all stakeholders, including patients, staff, and the community, to improve the quality of services.
	Redundancy	It refers to the existence of systems and processes that enable the continuation of services in the event of a malfunction or issue.
	Individual Empowerment	It refers to the creation of opportunities for the development of skills and knowledge among staff to enhance both individual and collective performance.
	Financial robustness	It refers to the ability of hospitals to maintain financial resources and provide sustainable health and medical services.

Table 2 - Selection of the Best Dimension and Comparison of Other Dimensions with It

The best dimension	technology readiness	Human-Centered Organizational Development	sustainability	resilience
???				

Table 3 - Selection of the Worst Dimension and Comparison of Other Dimensions with It

the worst dimension	???
technology readiness	
Human-Centered Organizational Development	
sustainability	
resilience	

Table 4 - Selection of the Best Sub-Dimension of the Technology Readiness Dimension and Comparison of Other Sub-Dimensions with It

The best sub-dimension	Health technology infrastructure	Emerging health technologies	Patient data protection	Automation of hospital processes	Personalized treatments	Telemedicine
???						

Table 5 - Selection of the Worst Sub-Dimension of the Technology Readiness Dimension and Comparison of Other Sub-Dimensions with It

the worst sub-dimension	???
Health technology infrastructure	
Emerging health technologies	
Patient data protection	

The best sub-dimension	Human-cantered care	Technological empowerment of staff	Intersectoral collaboration	Innovation in healthcare services	Cultural readiness	Participatory hospital governance	Employee motivation and well-being
???							
		Telemedicine					

Table 6 - Selection of the Best Sub-Dimension of the Human-Centered Organizational Development Dimension and Comparison of Other Sub-Dimensions with It

Table 7 - Selection of the Worst Sub-Dimension of the Human-Centered Organizational Development Dimension and Comparison of Other Sub-Dimensions with It

the worst sub-dimension	???
Human-cantered care	
Technological empowerment of staff	
Intersectoral collaboration	
Innovation in healthcare services	
Cultural readiness	

Participatory hospital governance	
Employee motivation and well-being	

Table 8 - Selection of the Best Sub-Dimension of the Sustainability Dimension and Comparison of Other Sub-Dimensions with It

The best sub-dimension	**Hospital environmental sustainability**	**Optimal resource efficiency**	**Digital sustainability**	**Hospital waste management**
???				

Table 9 - Selection of the Worst Sub-Dimension of the Sustainability Dimension and Comparison of Other Sub-Dimensions with It

the worst sub-dimension	**???**
Hospital environmental sustainability	

Optimal resource efficiency	
Digital sustainability	
Hospital waste management	

Table 10 - Selection of the Best Sub-Dimension of the resilience Dimension and Comparison of Other Sub-Dimensions with It

The best sub-dimension	**Hospital resource flexibility**	**Hospital agility**	**Technological adaptability**	**Hospital crisis resilience**	**Continuous healthcare quality improvement**	**Healthcare system stakeholder engagement**	**Redundancy in critical hospital services**	**Empowerment of healthcare staff**	**Financial robustness**
???									

Table 11 - Selection of the Worst Sub-Dimension of the resilience Dimension and Comparison of Other Sub-Dimensions with It

the worst sub-dimension	**???**
Hospital resource flexibility	
Hospital agility	
Technological adaptability	
Hospital crisis resilience	
Continuous healthcare quality improvement	
Healthcare system stakeholder engagement	
Redundancy in critical hospital services	
Empowerment of healthcare staff	
Financial robustness	