

## Article

# Institutional Capacity and COVID-19 Response Among Romanian Public Health Directorates: An Exploratory Cross-Sectional Analysis of 20 Jurisdictions

Lenuța Silvia Nicoruț <sup>1</sup>, Timea Claudia Ghitea <sup>2,\*</sup> , Rareș Cristian Daina <sup>3</sup>, Eleia Zina Csákvári <sup>3</sup>, Mădălina Diana Fehér <sup>1</sup> , László Fehér <sup>1</sup> and Lucia Georgeta Daina <sup>4</sup>

<sup>1</sup> Doctoral School of Biomedical Sciences, Faculty of Medicine and Pharmacy, University of Oradea, 1 December Sq., 410081 Oradea, Romania; silvianicurut73@gmail.com (L.S.N.); diana\_daina98@yahoo.com (M.D.F.); feher.laszlo01@yahoo.com (L.F.)

<sup>2</sup> Pharmacy Department, Faculty of Medicine and Pharmacy, University of Oradea, 1 December Sq., 410081 Oradea, Romania

<sup>3</sup> Faculty of Medicine and Pharmacy, University of Oradea, 1 December Sq., 410081 Oradea, Romania; rares.daina06@gmail.com (R.C.D.); antic\_2017@yahoo.com (E.Z.C.)

<sup>4</sup> Department of Psycho-Neurosciences and Recovery, Faculty of Medicine and Pharmacy, University of Oradea, 1 December Sq., 410081 Oradea, Romania; lucidaina@gmail.com

\* Correspondence: timea.ghitea@csud.uoradea.ro

## Abstract

**Background:** Transparent measurement is essential when organizational capacity is compared across public health institutions. The supplied analytic dataset did not contain repeated annual scores or indicator-level evidence for the previously proposed five-domain maturity model. We therefore conducted a reproducible cross-sectional analysis limited to the variables available in the dataset. **Methods:** Twenty Romanian public health directorates (PHDs)—10 in counties with a university medical center (CU) and 10 in counties without one (FU)—were compared using structural indicators, eight binary COVID-19 re-sponse measures, and a composite capacity–response index. The index was the equally weighted arithmetic mean of four sample-normalized components: employees per 100,000 inhabitants, budget per capita, previous-crisis experience, and the number of documented COVID-19 measures. Results are presented as medians and interquartile ranges. Mann–Whitney U and Fisher exact tests were used, with Holm correction within comparison families. **Results:** The composite index was higher in CU than FU institutions (55.0 [38.0–66.3] vs. 22.0 [19.3–31.3];  $U = 93.0$ ;  $p = 0.0013$ ; Holm-adjusted  $p = 0.0077$ ; rank-biserial  $r = 0.86$ ). CU institutions also had larger populations, more employees, larger total budgets, higher per capita budgets, more previous-crisis experience, and more documented response measures. Employees per 100,000 inhabitants did not differ significantly. After multiplicity correction, vaccination-center involvement and communication/education were more frequently documented in the CU group. Digital platforms were recorded for only two institutions and cannot be interpreted as a digital-maturity domain. **Conclusions:** The available data support descriptive evidence of institutional disparities associated with the university-center context, but they do not support causal inference or validation of a maturity model. The composite index should be treated as an exploratory, sample-dependent benchmarking measure pending prospective instrument development, documented scoring rules, independent assessment, and external criterion validation. Its group difference largely reflects the four constituent components, which should remain the primary basis for interpretation.



Academic Editor: Seyed M. Karimi

Received: 31 July 2026

Revised: 27 August 2026

Accepted: 28 August 2026

Published: 29 August 2026

**Copyright:** © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and

conditions of the [Creative Commons](https://creativecommons.org/licenses/by/4.0/)

[Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

**Keywords:** public health preparedness; institutional capacity; COVID-19 response; composite index; public health directorates; Romania; organizational assessment

## 1. Introduction

Public health emergency preparedness depends on governance, trained personnel, surveillance, risk assessment, coordinated response, communication, and systematic learning. International frameworks approach these capabilities through explicit indicators and documented assessment procedures. The World Health Organization (WHO) International Health Regulations monitoring framework includes self-assessment and external evaluation mechanisms; the Joint External Evaluation is a voluntary, multisectoral process for identifying preparedness gaps [1,2]. The United States Centers for Disease Control and Prevention (CDC) defines 15 jurisdictional preparedness and response capabilities [3], while the European Centre for Disease Prevention and Control (ECDC) HEPsA tool uses indicator sets across seven preparedness domains and links assessment to post-event review and implementation of lessons learned [4,5].

The COVID-19 pandemic represented an unprecedented challenge for public health institutions worldwide, requiring rapid adaptation, continuous decision-making, and the implementation of large-scale interventions under conditions of uncertainty. While considerable attention has been devoted to healthcare-system performance and epidemiological outcomes, less emphasis has been placed on the organizational development processes that occurred within public health institutions during the prolonged crisis period [6–8].

Public health emergencies place exceptional demands on organizational structures. Institutions must rapidly coordinate resources, establish communication channels, formalize operational procedures, and adapt to changing epidemiological and regulatory conditions. Consequently, emergency-response effectiveness depends not only on personnel and financial resources, but also on the maturity of the organizational processes that support planning, coordination, communication, adaptation, and learning [9–11].

Maturity models can support structured assessment and improvement, but their utility depends on transparent domains, observable indicators, scoring rules, feasibility, integrity, completeness, actionability, and validation in the intended context. A multivocal review identified 68 healthcare maturity models across 101 sources, illustrating both the breadth of the field and the risk of creating context-specific models without adequate evaluation [12]. Woods et al. proposed that maturity models be evaluated in relation to context, feasibility, integrity, completeness, and actionability [13]. For German public health agencies, Doctor et al. developed and evaluated the continuous Public Health Agency Maturity Model (PHAMM) specifically for digitalization [14–20].

In Romania, public health directorates (PHDs) are the principal territorial institutions responsible for epidemiological surveillance, risk communication, implementation of public health interventions, and coordination of emergency-response activities. During the COVID-19 pandemic, they played central roles in case investigation, contact tracing, testing coordination, quarantine management, vaccination campaigns, and public information. The duration of the pandemic provided an opportunity to examine whether repeated exposure to operational pressure was accompanied by progressive organizational formalization [21,22].

Despite increasing interest in health system resilience and emergency preparedness, there is currently no standardized approach for assessing the organizational capacity of Romanian public health directorates using publicly available institutional information. Existing evaluations primarily emphasize structural indicators such as workforce availability,

financial resources, or service outputs, while providing limited insight into operational capabilities related to coordination, communication, digitalization, adaptability, and resource management [23].

Accordingly, the revised study has two objectives: (1) to describe the structural and documented COVID-19 response characteristics of 20 Romanian PHDs; and (2) to compare PHDs in counties with versus without university medical centers using the variables and composite index actually present in the dataset. The study is framed as an exploratory cross-sectional comparison, not as validation of a maturity instrument and not as evidence that the pandemic caused organizational maturation.

## 2. Materials and Methods

### 2.1. Study Design and Unit of Analysis

This was a secondary, cross-sectional, institution-level analysis. The PHD was the unit of analysis. The dataset contained one record per institution and did not contain a time variable or repeated annual observations. Consequently, no longitudinal trajectory, Friedman test, paired post hoc comparison, or pandemic-attributable change was estimated.

### 2.2. Institutional Sample and Generalizability

Romania comprises 41 counties plus the municipality of Bucharest, corresponding to 42 county-level territorial units [22,24]. The analytic file included 20 PHDs (47.6% of the national frame). The CU group comprised Bihor, Bucharest, Braşov, Cluj, Constanţa, Dolj, Iaşi, Mureş, Sibiu, and Timiş. The FU group comprised Alba, Botoşani, Călăraşi, Dâmboviţa, Galaţi, Harghita, Maramureş, Mehedinţi, Neamţ, and Sălaj.

The analytic sample was balanced at 10 institutions per contextual group. No sampling frame, eligibility log, or record-level inclusion/exclusion documentation accompanied the dataset. The sample must therefore be considered a non-probability analytic subset. The balanced group composition facilitates exploratory comparison but does not make the sample nationally representative and may reflect selection related to data availability or the intended CU–FU contrast. The CU/FU classification was taken directly from the Grup\_CU\_FU field in the supplied analytic dataset: CU denoted a PHD coded in that file as being located in a county (or the municipality of Bucharest) with a university medical center, whereas FU denoted a PHD coded as being located in a county without one. No separate classification source, decision rule, or verification record accompanied the dataset; therefore, the CU–FU coding could not be independently verified.

### 2.3. Variables and Data-Source Matrix

The analytic file contained structural variables, response indicators, derived rates, normalized components, and a composite index. Record-level documentary sources were not archived with the file; therefore, the provenance and completeness of each institutional entry could not be independently audited. Supplementary Material S1 provides the complete data dictionary, source data, index verification, group-comparison output, and a formal limitations matrix (Table 1). More specifically, the supplied file was a single institution-level CSV containing 20 named PHD records and 26 variables. No extraction form, data-collector or assessor identities, data-collection dates, website snapshots, archived institutional reports, or version history accompanied the file. Consequently, the original collection, coding, and adjudication process could not be reconstructed; only the internal consistency of the supplied variables and calculations could be checked.

**Table 1.** Variables available in the verified analytic dataset.

| Domain                   | Variables                                                                        | Scale               | Analytical Use                                                                                                                     |
|--------------------------|----------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Structural context       | Population; area; number of employees; estimated budget                          | Continuous          | Descriptive and CU–FU comparison                                                                                                   |
| Derived structural rates | Employees per 100,000 inhabitants; budget per capita                             | Continuous          | Descriptive, normalization, and CU–FU comparison                                                                                   |
| Experience               | Number of previous crises                                                        | Count               | Index component and comparison                                                                                                     |
| COVID-19 response        | Eight binary measures; total number of documented measures                       | Binary/count        | Response profile, index component, Fisher/Mann–Whitney tests                                                                       |
| Composite components     | Normalized staffing rate, budget per capita, previous crises, and total measures | 0–100               | Equal-weight exploratory index                                                                                                     |
| Source classifications   | CU/FU group; rank; efficiency label                                              | Ordinal/categorical | CU–FU comparison and traceability; the external basis for the group classification and the efficiency thresholds were undocumented |

#### 2.4. COVID-19 Response Indicators

The eight binary indicators were mass testing (M1), epidemiological investigations (M2), quarantine/isolation (M3), hospital coordination (M4), vaccination centers (M5), communication/education (M6), collaboration with emergency inspectorates and local authorities (M7), and digital platforms (M8). The total response count was the row-wise sum of M1–M8 and matched the stored total for all 20 institutions. M1 was zero for every institution, whereas M2 and M3 were one for every institution; these invariant indicators were retained for transparency but provide no discriminatory information. Throughout this manuscript, a value of 1 means that an activity was recorded in the supplied dataset and a value of 0 means that it was not recorded; neither code independently confirms the activity's actual presence or absence, intensity, coverage, quality, or effectiveness.

Digitalization was not treated as an organizational domain. The dataset included only one binary digital item (use of digital platforms), which is insufficient to represent infrastructure, interoperability, governance, workforce capability, data analytics, security, or other dimensions addressed by established digital maturity models [13].

#### 2.5. Composite Capacity–Response Index

The composite index was reconstructed exactly from the dataset. Employees per 100,000 inhabitants and budget per capita were first calculated from the unrounded source values. Each was min–max normalized within the 20-institution sample:  $N(x) = 100 \times (x - x_{\min}) / (x_{\max} - x_{\min})$ , rounded to the nearest integer. Previous-crisis experience (range 0–3) and total response measures (range 2–7) were normalized using the same rule. The composite capacity–response index was then calculated as  $\text{ROUND}[(N_{\text{staff}} + N_{\text{budget}} + N_{\text{crises}} + N_{\text{measures}}) / 4]$ . Equal weights were used. The reconstructed index matched the stored value for all 20 records.

Because normalization used the minimum and maximum of the selected sample, the index is sample-dependent. It combines structural capacity, prior experience, and documented response activity; it is therefore not a pure measure of organizational maturity. No alternative weights, expert-derived weights, or outcome-based calibration were available.

## 2.6. Statistical Analysis

Continuous and count variables are reported as medians and interquartile ranges (IQRs), consistent with the small sample and non-normal or bounded scales. CU and FU groups were compared using two-sided Mann–Whitney U tests. Effect size was expressed as the rank-biserial correlation,  $rrb = 2U / (n_{CU} \times n_{FU}) - 1$ , with positive values indicating higher ranks in the CU group. Binary response indicators were compared using two-sided Fisher exact tests. Holm correction was applied separately to the family of continuous group comparisons and to the family of binary response comparisons. Unadjusted  $p$ -values and Holm-adjusted  $p$ -values are reported. Fisher's exact test was used for binary indicators. The reported effect sizes quantify rank separation only within this selected non-probability sample and should not be interpreted as population effect estimates.

The CU–FU comparisons were not adjusted for population, institutional size, resources, or regional context. A multivariable model was not fitted because  $n = 20$  provides limited degrees of freedom and several candidate covariates are mathematical components of the composite index; adjusting the index for its own components would be circular. The analysis is therefore descriptive and associational.

## 2.7. Measurement Validity and Reproducibility

The deterministic calculations in the dataset were reproducible, including the response count, the four normalized components, and the equal-weight composite index. However, content validity, inter-rater reliability, construct validity, and criterion validity of a maturity model could not be evaluated. The dataset contained no expert-panel or Delphi records, assessor identities or training information, independent duplicate ratings, disagreement-resolution log, item-level maturity rubric, or objective pandemic outcomes such as response timeliness, service continuity, morbidity, or mortality.

## 2.8. Ethical Considerations

The analysis used aggregated institution-level data and did not involve human participants, patients, clinical records, biological samples, or identifiable personal information. Ethical approval and informed consent were not applicable.

# 3. Results

## 3.1. Structural Characteristics

The CU group served larger populations and had more employees and larger estimated budgets than the FU group. Median staffing per 100,000 inhabitants was similar between groups, whereas median budget per capita, previous-crisis experience, and the number of documented COVID-19 measures were higher in CU institutions (Table 2). After Holm correction across the continuous comparison family, the difference in territorial area was no longer statistically significant (Figure 1).

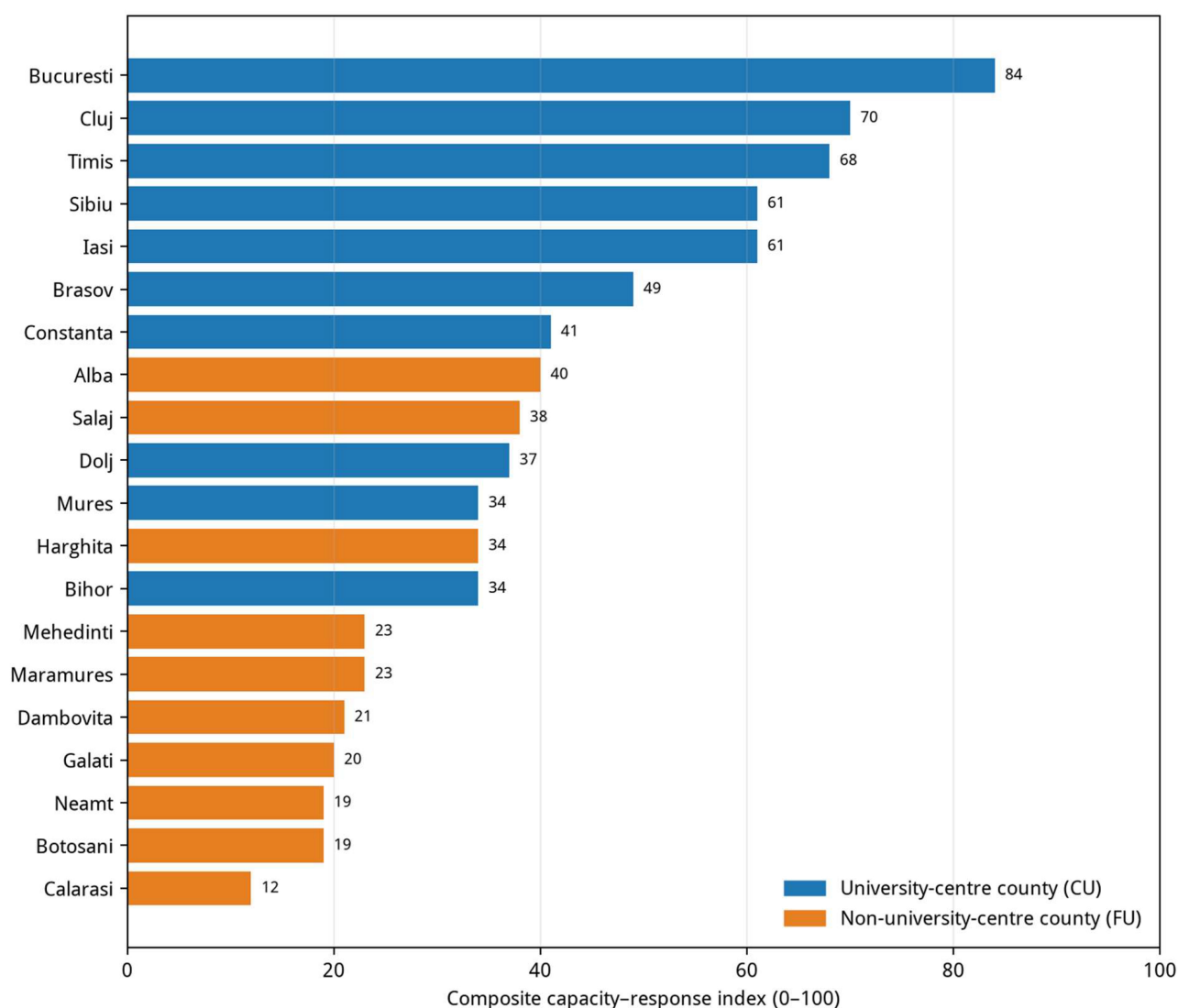
**Table 2.** Structural characteristics and response count by university-center context.

| Variable                       | CU Median [IQR]     | FU Median [IQR]     | U   | $p$    | Holm $p$ | $rrb$ |
|--------------------------------|---------------------|---------------------|-----|--------|----------|-------|
| Population (thousands)         | 674.5 [571.0–746.5] | 373.0 [297.8–436.8] | 95  | 0.0008 | 0.0054   | 0.90  |
| Area (km <sup>2</sup> )        | 6694 [5443–7328]    | 5037 [4583–6156]    | 78  | 0.0376 | 0.1129   | 0.56  |
| Employees ( $n$ )              | 110 [99–142]        | 69 [56–75]          | 99  | 0.0002 | 0.0020   | 0.98  |
| Estimated budget (million RON) | 17.4 [13.0–22.5]    | 7.9 [6.4–8.6]       | 100 | 0.0002 | 0.0016   | 1.00  |

Table 2. Cont.

| Variable                                  | CU Median [IQR]     | FU Median [IQR]     | U   | <i>p</i> | Holm <i>p</i> | rrb   |
|-------------------------------------------|---------------------|---------------------|-----|----------|---------------|-------|
| Employees per 100,000                     | 17.52 [16.27–19.07] | 17.80 [17.15–20.11] | 34  | 0.2413   | 0.4819        | −0.32 |
| Budget per capita (RON)                   | 27.0 [24.8–30.3]    | 20.5 [19.0–22.8]    | 89  | 0.0035   | 0.0139        | 0.78  |
| Previous crises ( <i>n</i> )              | 2.0 [2.0–3.0]       | 1.0 [1.0–1.0]       | 100 | <0.0001  | 0.0011        | 1.00  |
| Documented COVID-19 measures ( <i>n</i> ) | 5.0 [5.0–6.0]       | 3.0 [2.3–3.8]       | 100 | 0.0001   | 0.0015        | 1.00  |

CU, county with university medical center; FU, county without university medical center; IQR, interquartile range; rrb, rank-biserial correlation. Holm correction was applied across the 13 continuous/index group comparisons reported in Tables 2 and 3. Effect sizes describe the selected non-probability sample and are not population estimates.



**Figure 1.** Composite capacity-response index for the 20 public health directorates. Values are the stored and independently reproduced equal-weight index. Colors denote university-center context; they do not imply causality.

**Table 3.** Composite-index components by university-center context.

| Variable                          | CU Median [IQR]  | FU Median [IQR]  | U   | <i>p</i> | Holm <i>p</i> | rrb   |
|-----------------------------------|------------------|------------------|-----|----------|---------------|-------|
| Normalized staffing rate          | 26.5 [5.0–52.3]  | 31.5 [20.5–70.5] | 34  | 0.2410   | 0.4819        | −0.32 |
| Normalized budget per capita      | 26.5 [19.8–35.0] | 7.0 [3.0–13.5]   | 90  | 0.0028   | 0.0139        | 0.80  |
| Normalized previous crises        | 67 [67–100]      | 33 [33–33]       | 100 | <0.0001  | 0.0011        | 1.00  |
| Normalized response measures      | 60 [60–80]       | 20 [5–35]        | 100 | 0.0001   | 0.0015        | 1.00  |
| Composite capacity–response index | 55.0 [38.0–66.3] | 22.0 [19.3–31.3] | 93  | 0.0013   | 0.0077        | 0.86  |

All normalized variables range from 0 to 100 and are sample-dependent. The composite index uses equal weights. Component-level results should be interpreted before the composite summary.

### 3.2. Composite Index

The median composite capacity–response index was 55.0 [38.0–66.3] in the CU group and 22.0 [19.3–31.3] in the FU group ( $U = 93.0$ ;  $p = 0.0013$ ; Holm-adjusted  $p = 0.0077$ ;  $rrb = 0.86$ ). The difference was driven by budget, previous-crisis, and response-measure components; the normalized staffing-rate component did not differ significantly (Table 3). Bucharest had the highest stored index (84), followed by Cluj (70), Timiș (68), Iași and Sibiu (61 each). The institutional distribution is shown in Figure 1. Component-level comparisons should be prioritized over this aggregate result. Because the index is the arithmetic mean of its four components, the CU–FU difference largely restates the component differences and does not constitute independent evidence.

### 3.3. Documented COVID-19 Response Measures

Epidemiological investigations and quarantine/isolation were documented for all 20 institutions, while mass testing was documented for none. Hospital coordination was recorded for all CU and seven FU institutions. After Holm correction, vaccination-center involvement (10/10 vs. 3/10) and communication/education (10/10 vs. 0/10) remained statistically different between groups. Collaboration with emergency inspectorates/local authorities and digital-platform use were uncommon and did not remain statistically different after multiplicity correction (Table 4). In this section, “documented” refers only to the coding in the supplied file and does not verify that an activity was actually present or absent.

**Table 4.** Documented binary COVID-19 response measures.

| Measure                                  | CU <i>n</i> (%) | FU <i>n</i> (%) | Fisher <i>p</i> | Holm <i>p</i> |
|------------------------------------------|-----------------|-----------------|-----------------|---------------|
| Mass testing                             | 0 (0)           | 0 (0)           | 1.0000          | 1.0000        |
| Epidemiological investigations           | 10 (100)        | 10 (100)        | 1.0000          | 1.0000        |
| Quarantine/isolation                     | 10 (100)        | 10 (100)        | 1.0000          | 1.0000        |
| Hospital coordination                    | 10 (100)        | 7 (70)          | 0.2105          | 1.0000        |
| Vaccination centers                      | 10 (100)        | 3 (30)          | 0.0031          | 0.0217        |
| Communication/education                  | 10 (100)        | 0 (0)           | <0.0001         | <0.0001       |
| Collaboration with ISU/local authorities | 4 (40)          | 0 (0)           | 0.0867          | 0.5201        |
| Digital platforms                        | 2 (20)          | 0 (0)           | 0.4737          | 1.0000        |

ISU, county emergency inspectorate. Holm correction was applied across eight binary comparisons. Indicator values represent documentation in the supplied dataset, not verified presence or absence of the activities.

## 4. Discussion

### 4.1. Principal Findings

This reanalysis found substantial cross-sectional differences between the CU and FU groups in the population served, absolute workforce, total and per capita budget, previous-crisis experience, documented COVID-19 measures, and the exploratory composite index. Staffing density did not differ significantly, suggesting that the larger absolute workforce in CU institutions largely reflected the larger populations served. The composite-index difference should be interpreted in light of its construction: three of its four components—budget, previous-crisis experience, and response count—were markedly higher in the CU group. Accordingly, substantive interpretation should rest on the individual components rather than on the aggregate index.

These findings do not establish that university medical centers caused stronger institutional performance. University-center status may proxy a broader institutional ecosystem, including population size, hospital and laboratory networks, academic partnerships, workforce specialization, infrastructure, and prior exposure to complex events. Romanian sub-national research has likewise documented marked territorial heterogeneity in resources, administrative capacity, and pandemic impact [22].

The binary response indicators also require careful interpretation. They indicate whether an activity was recorded, not its intensity, timeliness, coverage, quality, or effectiveness. The absence of a documented activity may reflect incomplete source documentation. Conversely, a recorded activity does not establish successful implementation or improved population outcomes. Accordingly, extreme contrasts—such as communication/education recorded for 10/10 CU versus 0/10 FU institutions—and the invariant absence of recorded mass testing ( $M1 = 0$  for all institutions) may reflect incomplete source documentation or differential reporting rather than genuine performance differences or confirmed non-performance.

### 4.2. Positioning Relative to Established Frameworks

The revised index is substantially narrower than established preparedness and maturity frameworks. WHO SPAR/JEE assesses multiple national health-security capacities and incorporates structured self-assessment or external evaluation [1,2]. CDC preparedness standards organize 15 interrelated jurisdictional capabilities [3]. ECDC HEPSA contains baseline and comprehensive indicators across governance, trained workforce, surveillance, risk assessment, response management, post-event review, and implementation of lessons learned; its development included literature review and international expert consensus [4].

Similarly, PHAMM is a dedicated continuous digitalization maturity model for public health agencies [20]. By contrast, the present dataset includes only a single binary digital-platform item. The finding that 2 of 20 institutions had this item recorded may indicate limited documented use in the source file, but it cannot support a digitalization score or a conclusion that digitalization was the lowest-performing organizational domain.

The defensible added value of the present analysis is therefore limited but clear: it provides a transparent, fully reproducible description of a 20-institution dataset and an explicit equal-weight index. It does not claim to replace WHO, CDC, ECDC, or PHAMM, and it should not be described as a validated maturity model.

### 4.3. Measurement Development and Validation Requirements

A future MMDC-DSP could be scientifically developed, but it would require a separate prospective instrument-development study. The construct and intended use should first be specified, followed by systematic item generation from established frameworks and Romanian legal/operational requirements. A multidisciplinary expert panel or Delphi

process should assess relevance, comprehensiveness, and clarity, with quantitative content-validity indices reported.

The complete instrument should provide observable indicator definitions, acceptable documentary evidence, scoring anchors for each level, missing-data rules, weighting rules, and worked examples. At least two trained assessors should independently score a predefined sample while blinded to each other's ratings. Agreement should be reported using weighted kappa or intraclass correlation, as appropriate, together with a documented disagreement-resolution procedure.

Construct validity should be tested through prespecified hypotheses, and criterion validity should be examined against objective outcomes not used to build the score, such as reporting timeliness, outbreak-investigation timeliness, service continuity, exercise performance, or implementation of after-action recommendations. WHO defines after-action review as a structured process for documenting good practices, challenges, and improvement actions, making it a plausible source of external learning indicators [25–29].

#### *4.4. Practical Implications*

The current analysis can be used to identify data-collection priorities rather than to rank institutional maturity. A national assessment should cover all 42 county-level units, retain auditable source documents, distinguish resources from processes and outcomes, and record the intensity and quality—not only the presence—of response activities. Digital capacity should be assessed through a dedicated multidimensional module rather than one binary item. Lower-resource jurisdictions may require targeted support, but allocation decisions should not rely on this sample-dependent index alone [30,31].

#### *4.5. Strengths and Limitations*

The principal strength is complete computational transparency. The supplied data contain 20 unique institutional records; the response total equals the sum of the eight binary measures for every record; the four normalization columns can be reconstructed from unrounded source-derived rates and observed sample ranges; and the equal-weight composite index is exactly reproducible.

The limitations are substantial. First, the sample covers only 20 of 42 county-level units and was not probability-based. The absence of an eligibility and selection log prevents assessment of how included institutions differ from those omitted. Second, the balanced 10-versus-10 group structure may have been created for comparison and may accentuate selection bias. Generalization to all Romanian PHDs is not warranted. The analytic file did not contain variable-specific reference dates; therefore, the temporal alignment of structural indicators and documented COVID-19 measures could not be independently verified.

Third, the study is cross-sectional. There are no pre-pandemic baseline and no repeated annual data; temporal change and pandemic-attributable maturation cannot be estimated. Fourth, CU–FU comparisons are unadjusted and may be confounded by population, resources, hospital density, laboratories, academic networks, regional development, and previous crisis experience.

Fifth, the composite index is sample-dependent, uses equal weights without empirical or expert justification, and combines input, experience, and activity variables. It has not undergone content, construct, or criterion validation. Sixth, record-level source documents were unavailable, preventing independent verification of the binary measures. Finally, several indicators were invariant or sparse, limiting discriminatory power and statistical precision.

## 5. Conclusions

Within this non-probability sample of 20 Romanian public health directorates, institutions in university-center counties had higher budgets, more previous-crisis experience, more documented COVID-19 response measures, and a higher exploratory composite capacity–response index than institutions in non-university-center counties. These differences are cross-sectional associations and may reflect broader contextual and resource disparities. The higher composite value is a secondary summary of differences in its constituent measures, not an additional independent finding. Because the index is exploratory and sample-dependent, it should not be used in isolation for resource-allocation or institutional-prioritization decisions.

The available dataset does not support a five-domain longitudinal MMDC-DSP, causal claims of pandemic-driven maturation, or conclusions about digital maturity. Future work should develop and validate a complete indicator-level instrument prospectively, use independent assessors, document source evidence, test reliability and validity, and include all Romanian PHDs or a justified representative sample.

**Supplementary Materials:** The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/covid6090155/s1>, Supplementary Table S1. Institutional Characteristics, Documented COVID-19 Response Measures, and Exploratory Capacity–Response Index across 20 Romanian Public Health Directorates.

**Author Contributions:** Conceptualization, L.S.N. and T.C.G.; methodology, L.S.N.; software, L.F.; validation, L.F., T.C.G. and L.G.D.; formal analysis, M.D.F.; investigation, M.D.F.; resources, R.C.D. and E.Z.C.; data curation, R.C.D. and E.Z.C.; writing—original draft preparation, T.C.G.; writing—review and editing, T.C.G.; visualization, L.S.N.; supervision, L.G.D.; project administration, L.G.D.; funding acquisition, L.G.D. All authors have read and agreed to the published version of the manuscript.

**Funding:** The APC was funded by the University of Oradea, Oradea, Romania. The funder had no role in the study design, data collection, analysis, interpretation, writing of the manuscript, or decision to publish the results.

**Institutional Review Board Statement:** Ethical review and approval were not required because the study used aggregated institution-level data and did not involve human participants or identifiable personal information.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The institution-level analytic dataset, data dictionary, index reconstruction, and statistical comparison tables are provided in Supplementary Material S1.

**Acknowledgments:** The authors thank the University of Oradea, Oradea, Romania, for supporting the APC.

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

## Abbreviations

The following abbreviations are used in this manuscript:

| Abbreviation | Definition                                         |
|--------------|----------------------------------------------------|
| CDC          | Centers for Disease Control and Prevention         |
| CU           | Counties with university medical centers           |
| ECDC         | European Centre for Disease Prevention and Control |
| FU           | Counties without university medical centers        |
| HEPSA        | Health Emergency Preparedness Self-Assessment      |
| IHR          | International Health Regulations                   |
| IQR          | Interquartile range                                |

|          |                                                                 |
|----------|-----------------------------------------------------------------|
| JEE      | Joint External Evaluation                                       |
| MMDC-DSP | Proposed Maturity Model for Romanian Public Health Directorates |
| PHD      | Public Health Directorate                                       |
| PHAMM    | Public Health Agency Maturity Model                             |
| SPAR     | States Parties Self-Assessment Annual Reporting                 |
| WHO      | World Health Organization                                       |

## References

1. World Health Organization. IHR States Parties Self-Assessment Annual Reporting (SPAR). Available online: <https://www.who.int/emergencies/operations/international-health-regulations-monitoring-evaluation-framework/states-parties-self-assessment-annual-reporting> (accessed on 20 August 2026).
2. World Health Organization. Joint External Evaluation (JEE). Available online: <https://www.who.int/emergencies/operations/international-health-regulations-monitoring-evaluation-framework/joint-external-evaluations> (accessed on 20 August 2026).
3. Centers for Disease Control and Prevention. Public Health Emergency Preparedness and Response Capabilities: National Standards for State, Local, Tribal, and Territorial Public Health. Updated 2019. Available online: <https://www.cdc.gov/readiness/php/capabilities/index.html> (accessed on 20 August 2026).
4. Hayes, J.S.; Barreto, M.; Kalin-Mänttari, L.; Mexia, R.; Connolly, M.A.; Voutilainen, L. Development of a workforce self-assessment tool for public health emergency preparedness. *Eur. J. Public Health* **2024**, *34*, 482–489. [\[CrossRef\]](#)
5. European Centre for Disease Prevention and Control. *HEPSA—Health Emergency Preparedness Self-Assessment Tool: User Guide*; ECDC: Stockholm, Sweden, 2018. Available online: <https://www.ecdc.europa.eu/en/publications-data/hepsa-health-emergency-preparedness-self-assessment-tool-user-guide> (accessed on 20 August 2026).
6. Filip, R.; Gheorghita Puscaselu, R.; Anchidin-Norocel, L.; Dimian, M.; Savage, W.K. Global Challenges to Public Health Care Systems during the COVID-19 Pandemic: A Review of Pandemic Measures and Problems. *J. Pers. Med.* **2022**, *12*, 1295. [\[CrossRef\]](#)
7. Kwon, Y.J.; Forthal, D. COVID-19: An unprecedented challenge and an opportunity for change. *Adv. Drug Deliv. Rev.* **2021**, *171*, 48–49. [\[CrossRef\]](#)
8. Cheng, Q.; Zheng, S.; Xiong, Z.; Lin, M. Characterizing the Dynamic Evolution of Interagency Collaborative Decision-Making Networks in Response to COVID-19 in China: A Policy Document Analysis. *Healthcare* **2022**, *10*, 590. [\[CrossRef\]](#)
9. Ongesa, T.N.; Ugwu, O.P.; Ugwu, C.N.; Alum, E.U.; Eze, V.H.U.; Basajja, M.; Ugwu, J.N.; Ogenyi, F.C.; Okon, M.B.; Ejemot-Nwadiaro, R.I. Optimizing emergency response systems in urban health crises: A project management approach to public health preparedness and response. *Medicine* **2025**, *104*, e41279. [\[CrossRef\]](#)
10. Sydnes, M.; Kjeve, M.; Sydnes, A.K. Interorganizational coordination during emergencies and crises. *Int. J. Disaster Risk Reduct.* **2025**, *121*, 105310. [\[CrossRef\]](#)
11. Holroyd, T.A.; Oloko, O.K.; Salmon, D.A.; Omer, S.B.; Limaye, R.J. Communicating Recommendations in Public Health Emergencies: The Role of Public Health Authorities. *Health Secur.* **2020**, *18*, 21–28. [\[CrossRef\]](#)
12. Kolukisa Tarhan, A.; Garousi, V.; Turetken, O.; Söylemez, M.; Garossi, S. Maturity assessment and maturity models in health care: A multivocal literature review. *Digit. Health* **2020**, *6*, 2055207620914772. [\[CrossRef\]](#)
13. Woods, L.; Eden, R.; Duncan, R.; Kodiyattu, Z.; Macklin, S.; Sullivan, C. Which one? A suggested approach for evaluating digital health maturity models. *Front. Digit. Health* **2022**, *4*, 1045685. [\[CrossRef\]](#)
14. Gomes, J.; Romão, M. Evaluating Maturity Models in Healthcare Information Systems: A Comprehensive Review. *Healthcare* **2025**, *13*, 1847. [\[CrossRef\]](#)
15. Ouazzani-Chahidi, A.; Abdellatif, L.; Jimenez, J.-F.; Berrah, L. Maturity levels of management process for improving industrial performance. *Sci. Afr.* **2023**, *21*, e01852. [\[CrossRef\]](#)
16. Manzini, D.; Oosthuizen, R.; Chikwanda, H. Enhancing organisational resilience through systems thinking. *Soc. Sci. Humanit. Open* **2025**, *12*, 101783. [\[CrossRef\]](#)
17. Conz, E.; Levanti, G.; Magnani, G.; Ferraris, A. Navigating organizational resilience in SMEs: Integrating cognitive, technological, and value chain perspectives. *Rev. Manag. Sci.* **2026**, 1–22. [\[CrossRef\]](#)
18. Ignatowicz, A.; Tarrant, C.; Mannion, R.; El-Sawy, D.; Conroy, S.; Lasserson, D. Organizational resilience in healthcare: A review and descriptive narrative synthesis of approaches to resilience measurement and assessment in empirical studies. *BMC Health Serv. Res.* **2023**, *23*, 376. [\[CrossRef\]](#)
19. Ewertowski, T.; Kuźmiński, P. The Safety Management and Organizational Resilience System Maturity of Aviation Organizations during the COVID-19 Pandemic: Comparison of Two Approaches to Achieving Safety. *Sustainability* **2024**, *16*, 1682. [\[CrossRef\]](#)
20. Doctor, E.; Eymann, T.; Fürstenau, D.; Gersch, M.; Hall, K.; Kauffmann, A.L.; Schulte-Althoff, M.; Schlieter, H.; Stark, J.; Wyrski, K. A Maturity Model for Assessing the Digitalization of Public Health Agencies. *Bus. Inf. Syst. Eng.* **2023**, *65*, 539–554. [\[CrossRef\]](#)

21. Hategan, C.D.; Cureau-Pitorac, R.I.; Hategan, V.P. Responsible Communication of Romanian Companies for Ensuring Public Health in a COVID-19 Pandemic Context. *Int. J. Environ. Res. Public Health* **2020**, *17*, 8526. [CrossRef]
22. Ștefan, G.; Bodislav, D.A.; Arsăni Chiriță, A.; Hrebenciuc, A.; Paierale, A.; Paraschiv, A.; Virjan, D. The intervention of local public authorities and the impact of the COVID-19 pandemic in Romania: A subnational analysis. *Front. Public Health* **2024**, *12*, 1105518. [CrossRef]
23. Blidaru, T.C.; Forray, A.I.; Garofil, D.; Mezinu-Bălan, L.; Lazăr, O.; Stoea, I.; Vlădescu, C.; Dașcă, L.; Iordache, G.; Iliescu, R.; et al. Building health system resilience in Romania: A consensus on policy priorities. *J. Med. Life* **2025**, *18*, 1083–1093. [CrossRef]
24. National Institute of Statistics of Romania. Technical and Methodological Report: European Health Interview Survey. The territorial structure comprises 41 counties and the Municipality of Bucharest. Available online: [https://insse.ro/cms/files/Rapoarte%20de%20calitate/ASAN-EHIS/EN\\_EHIS\\_TECHNICAL%20AND%20METHODOLOGICAL%20REPORT.pdf](https://insse.ro/cms/files/Rapoarte%20de%20calitate/ASAN-EHIS/EN_EHIS_TECHNICAL%20AND%20METHODOLOGICAL%20REPORT.pdf) (accessed on 20 August 2026).
25. Wahdaniyah, N.; Nurmandi, A.; Younus, M. A meta-analysis of the relationship between digital maturity and digital transformation. *Society* **2025**, *13*, 628–644. [CrossRef]
26. Rodriguez-Arrastia, M.; García-Martín, M.; Romero-López, A.; Ropero-Padilla, C.; Ruiz-Gonzalez, C.; Roman, P.; Sanchez-Labraca, N. Evolution of the Public-Health Response to COVID-19 Pandemic in Spain: A Descriptive Qualitative Study. *Int. J. Environ. Res. Public Health* **2022**, *19*, 3824. [CrossRef]
27. Zadeh, H.S.; Ansaripoor, A.H.; Chowdhury, M.H.M.; Haghparast, A. Public health interventions for developing resilience to contagious diseases: A system dynamics approach. *Health Care Manag. Sci.* **2025**, *28*, 622–643. [CrossRef]
28. Moser, C.; Smaldino, P.E. Organizational Development as Generative Entrenchment. *Entropy* **2022**, *24*, 879. [CrossRef]
29. World Health Organization. After Action Review. Available online: <https://www.who.int/emergencies/operations/emergency-response-reviews/after-action-review> (accessed on 20 August 2026).
30. Myrberg, K.; Wiger, M.; Björkman, A. Development of a maturity model for demand and capacity management in healthcare. *BMC Health Serv. Res.* **2024**, *24*, 1109. [CrossRef]
31. Brennan, E.; Abimbola, S. A conceptual learning analysis of paired after action and intra action reviews for health emergencies. *Learn. Health Syst.* **2024**, *8*, e10447. [CrossRef]

**Disclaimer/Publisher’s Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.