Knowledge Graph Evaluation Criteria and Peer Solution Analysis

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Background

We are learning Information Analysis and Content Management this semester and are researching the malnutrition management of residential aged care facilities in Australia. Previously assignments have found and simulated relevant nodes, relationships to build its knowledge graph by Neo4j. This report will research a set of knowledge graph evaluation criteria to assess peer cases. The peer graph consists of nine type nodes and seven type relationships, with 260 nodes and 620 relationships respectively.

1) Node

Node Type	Label
Resident	name, age, dietaryNeeds, gender, healthCondition, malnutritionRisk
Nurse	Name, role
FacilitiesManager	Name, manager_id, region, certification, experience_years
AcademicResearcher	Name, researcher_id, research_focus,institution
Assessment	assessmentId, condition, date, riskLevel
DietaryPlan	planName, description, interventionType
Dietitian	Name, role
Intervention	Date, description, interventionId, result
RegulatoryBody	regulatoryId, title

2) Relationship

Relationship Type	Node1 (Start)	Node2 (End)
COMPLIES_WITH	FacilitiesManager	RegulatoryBody
CONDUCTS_RESEARCH_ON	AcademicResearcher	Resident
EVALUATES	Dietitian	Assessment
HAS_DIETARY_PLAN	Resident	DietaryPlan
MANAGES	Dietitian	Resident
RECEIVES_INTERVENTION	Resident	Intervention
UNDERGOES_ASSESSMENT	Resident	Assessment

Component 1: Knowledge Graph Evaluation Criteria

A knowledge graph is a data system that consists of RDF triples in the form of “subject-predicate-object” between entities in the real world and their relationships. A “good knowledge graph” should define detailed categories and properties in its ontology, therefore, it can richly express the knowledge in the real world (Seo, S et al., 2022, p. 1). Its purpose is to model, store and organize complex information in a way that both humans and machines can easily understand, browse and use the knowledge contained therein.

This report focuses on data quality evaluation to explain specific indexes. Data quality evaluation is a method of defining data quality from multiple perspectives, including data accuracy and consistency (Seo, S et al., 2022, p. 2). A more detailed indicator, supported by Zaveri et al. (2018, p. 4-5), focus on four evaluation levels, namely intrinsic data quality, contextual data quality, representational data quality, and accessibility data quality, to systematically evaluate the data quality of the knowledge graph:

1.Accuracy

Definition: Whether the data is consistent with real-world conditions.

Criteria	Description	Grade
Excellent	The data is completely consistent with real-world conditions, with virtually no errors or false information.	90-100
Good	The data is mostly consistent with real-world conditions, with a few minor errors present but without significant impact on the overall analysis.	75-89
Satisfactory	The data is roughly consistent with the real world, with some errors, but within an acceptable range.	60-74
Needs Improvement	The data is inconsistent with real-world information and contains a large number of errors or false information, which affects the credibility of the data.	0-59

2.Completeness

Definition: Coverage of target domain information, that is, the comprehensiveness of the entities and relationships contained in the graph.

Criteria	Description	Grade
Excellent	Complete information in all key areas, with comprehensive coverage of entities and relationships.	90-100
Good	Most of the important information is complete, with a small amount of information missing that does not affect the main analysis.	75-89
Satisfactory	The basic information is complete, but some key points are missing.	60-74
Needs Improvement	There is a lot of missing information, resulting in insufficient data coverage and affecting overall understanding.	0-59

3.Consistency

Definition: Whether the data is contradictory or inconsistent.

Criteria	Description	Grade
Excellent	The data is completely consistent, with clear definitions of entities and relationships, and no conflicts or contradictions	90-100
Good	The data are mostly consistent, with some minor conflicts in some information, but they are negligible.	75-89

Satisfactory	There are some inconsistencies in the data. Some entities or relationships may be repeatedly defined or conflicting.	60-74
Needs Improvement	There are obvious contradictions and conflicts between the data, which leads to confusing or misleading information.	0-59

4.Precision of Representation

Definition: How data is presented or expressed, and whether the format and structure of the data can effectively convey information.

Criteria	Description	Grade
Excellent	The data is presented in a very clear and detailed manner, well-structured, easy to understand, and supports complex analysis.	90-100
Good	The data are clearly presented and reasonably structured, but some areas may require further explanation.	75-89
Satisfactory	The data presentation is understandable, but lacks detail, which may limit analysis.	60-74
Needs Improvement	The data is not clearly presented, has a chaotic structure, is difficult to understand, and cannot support effective analysis.	0-59

5.Appropriateness

Definition: The ability of a knowledge graph to adapt to changes, especially to assess data quality based on specific application scenarios or usage scenarios of data consumers.

Criteria	Description	Grade
Excellent	The data is closely related to the usage scenarios, truly meets user needs, and the content is updated in a timely manner.	90-100
Good	Most of the data is suitable for the current application scenario, with a small amount of content that is not completely relevant to the needs.	75-89
Satisfactory	The data are partially relevant to the application scenario, but some of the data are outdated or not fully applicable.	60-74
Needs Improvement	The data does not match the application scenario, is outdated or does not meet current needs.	0-59

6.Performance

Definition: Measures the accessibility of data to ensure that data is accessible to the appropriate users when needed.

Criteria	Description	Grade
Excellent	Data is quickly, easily and well protected with little to no delays or barriers to access.	90-100
Good	Data is easily accessible in most cases, but there are access delays or permission issues in a few cases.	75-89
Satisfactory	Data can be accessed, but there may be significant delays or special permissions may be required to obtain it.	60-74

Needs Improvement	Data is difficult to access and lacks appropriate security protection, or the access process is very complicated.	0-59

Component 2: Evaluating Peer's Knowledge Graphs

Based on the component 1 evaluation criteria, the full score is set to 100 (with explanation below), and the actual score of this case is 62. Specific evaluation and analysis:

Indicator	Actual Score	The main issues	Reasons	Proportion	Result
Accuracy	60	The **nutritional risk** of "Sandra Hall", a resident with **stage 2 diabetes**, is marked as **"medium",** which means that her **blood sugar control needs to be closely monitored.** The **Intervention did not** clearly **state whether her blood sugar was effectively controlled,** but in **the subsequent Assessment**, her **risk level** was **reduced to "low"** and her health status was marked as "stable".	**Low data credibility:** The management of stage 2 diabetes usually requires long-term, continuous monitoring and intervention. The intervention results did **not clearly state the blood sugar control situation**, and the **risk level was reduced in the subsequent evaluation**. This makes us **doubt the accuracy of the data,** especially when it comes to key data that affects nursing decisions.	35%	21
Completeness	50	1) **Missing key nodes**: General Practitioner, Facility;2) **Key relationships are missing** nurses caring for residents, nurses following up and assessing, Intervention generate Assessment.	This condition **cannot support the medical staff to make effective decisions** and affects the improvement of nutrition and health of residents.	25%	12.5
Consistency	70	The resident named	**The key node-**	15%	10.5

		"Michael Harris" is repeated twice, and both are male.	**Resident has conflicting definitions**, which can **easily cause confusion in care plans** and is not conducive to resident health care.		
Precision of Representation	50	**Key nodes lack key information**, for example, residents' labels lack BMI, weight, and dietary preference.	These data are crucial for assessing the overall health of residents and will directly **make it difficult for medical staff to fully understand** the health status of residents and **provide personalized medical care plans.**	10%	5
Appropriateness	80	**AcademicResearcher** - [: CONDUCTS_RESEARCH_ON]-> **Resident**	**The residents** here are mainly elderly people who **need nutritional care** from **professional staff who can directly provide care.** The authors define these researchers as university academic research.	5%	4
Performance	90		PROFILE MATCH (r:Resident)-[:HAS_DIETARY_PLAN]->(d:DietaryPlan) WHERE r.malnutritionRisk = "High" RETURN r.name, d.name; **Runtime: PIPELINED. 458 total db hits in 28**	10%	9

			ms Meet the performance requirements of group assignment Component 2: **key queries must return results within 1 second** and there must be **no permission issues**. However, due to insufficient data integrity and performance accuracy, this score is the lowest among the excellent scores.		
Totally					**62**

Explanation of weight distribution for the aged care facility filed:

This weighting reflects that accuracy, completeness, and consistency are the most critical indicators in aged care facilities because they directly affect the health and care decisions of residents. And precision of representation and performance are also important for actual operation and system response, because they affect the user experience. In this case, the Appropriateness weight is low because of the small size of the data, the topic is solidified, and the relatively stable data performance.

Component 3: Optimising Peer's Knowledge Graphs

Note: Use simulated values or default values and simplified methods to make optimization demonstrations. In the real world, it is necessary to enter the actual situation and residents' health data.

1.Optimization Plan and Process

1)Accuracy

Solution:

a) Resident Sandra Hall's risk assessment was adjusted back to "moderate". The intervention did not effectively control blood sugars, and her health status in the assessment should not be marked as "stable" and her risk level should not be reduced.

b) Add intervention for residents with diabetes - glycemic status.

Expected outcomes: Evaluation results should be consistent with previous interventions.

Optimisation process and operations:

Step1: Intervention added “blood sugar control” description

```
MATCH (r:Resident)
WHERE r.healthCondition = "Diabetes" OR r.healthCondition = "Type 2 Diabetes"
MERGE (i:Intervention {description: "Blood Sugar Control", interventionId: "INT001",
result: "Improvement"})
MERGE (r)-[:RECEIVES_INTERVENTION]->(i)
RETURN r, i
```

Step2: The risk level of the revised assessment is "Moderate"

```
MATCH (r:Resident{name:"Sandra
Hall"})-[:UNDERGOES_ASSESSMENT]->(a:Assessment)
SET a.riskLevel="Moderate", a.condition="Unstable"
Return r,a
```

2)Completeness

Solution: Add GP (General Practitioner), Facility nodes. At the same time, add key relationships in the graph: residents treated by GP, FacilitiesManager managing Facility, residents located in Facility, GP and nurses working in Facility, nurses caring for residents, GP and nurses tracking assessments, and Intervention generating Assessments.

Expected outcomes: Enhance the completeness of the graph and the ability of multi-dimensional analysis. Medical staff can track the nursing process, understand the evaluation results, and understand the effect of intervention. This will help medical staff make more scientific decisions.

Optimisation process and operations:

a) Execute the sample data addition of GP and facility:

```
MERGE (gp:GP {name: "Dr. Smith", gpId: "GP001"})
MERGE (f:Facility {name: "Sunshine Care Center", facilityId: "FAC001"})
```

b)Relationship of Executive GP treating resident "Sandra Hall":

```
MATCH (r:Resident {name:"Sandra Hall"}), (gp:GP {name: "Dr. Smith"})
MERGE (gp)-[:TREATS]->(r)
```

c) Implement the FacilitiesManager named "Grace Lee" to manage the Facility relationships:

```
MATCH (fm:FacilitiesManager {name: "Grace Lee"}), (f:Facility {name: "Sunshine Care Center"})
MERGE (fm)-[:MANAGES]->(f)
```

d) Implement the location information relationship between residents and facilities:

```
MATCH (r:Resident {name:"Sandra Hall"}), (f:Facility {name: "Sunshine Care Center"})
MERGE (r)-[:LOCATED_IN]->(f)
```

e) Implement the relationship between GP and Nurse working in Facility:

```
MATCH (gp:GP), (f:Facility)
MERGE (gp)-[:WORKS_IN]->(f)
WITH gp, f
MATCH (n:Nurse), (f:Facility)
MERGE (n)-[:WORKS_IN]->(f)
```

f) Implement the relationship between Nurse and Resident:

```
MATCH (n:Nurse {name: “NPaul”), (r:Resident {name:"Sandra Hall"})
MERGE (n)-[:CARES_FOR]->(r)
```

g) Relationship between GP and Nurse follow-up assessment:

```
MATCH (gp:GP), (a:Assessment)
MERGE (gp)-[:TRACKS]->(a)
WITH gp, a
MATCH (n:Nurse), (a:Assessment)
MERGE (n)-[:TRACKS]->(a)
```

h) The relationship between executing Intervention and generating Assessment:

```
MATCH (i:Intervention), (a:Assessment)
MERGE (i)-[:GENERATES]->(a)
```

i) Execute the EVALUATES relationship between Dietitian and DietaryPlan

```
MATCH (d:Dietitian), (dp:DietaryPlan)
MERGE (d)-[:EVALUATES]->(dp)
```

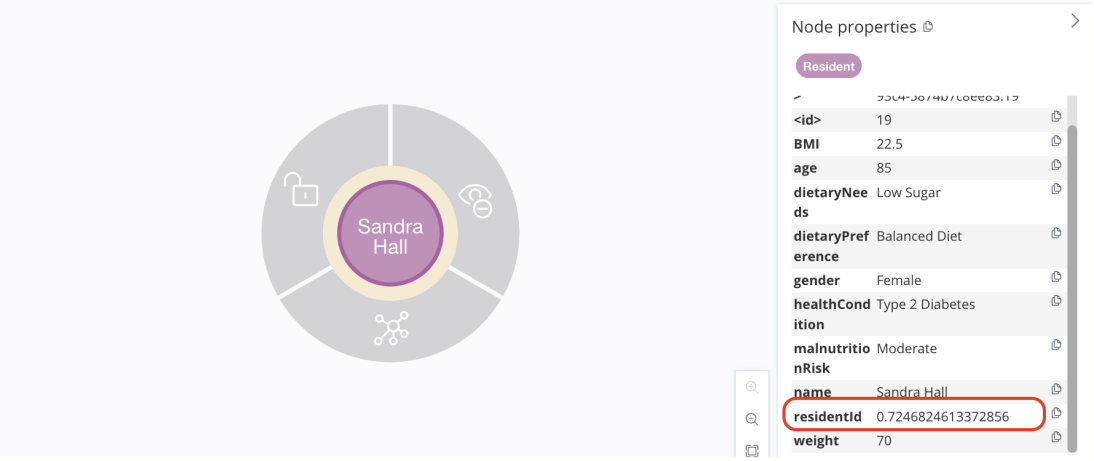
3)Consistency

Solution: Create a unique constraint and add a unique identifier residentId to the resident node.

Expected outcomes: Resolve data conflict issues so that in the future, there will be no nursing incidents caused by duplicate resident names.

Optimisation process and operations:

```
MATCH (r:Resident)
SET r.residentId = toString(rand())
RETURN r.name, r.residentId
```



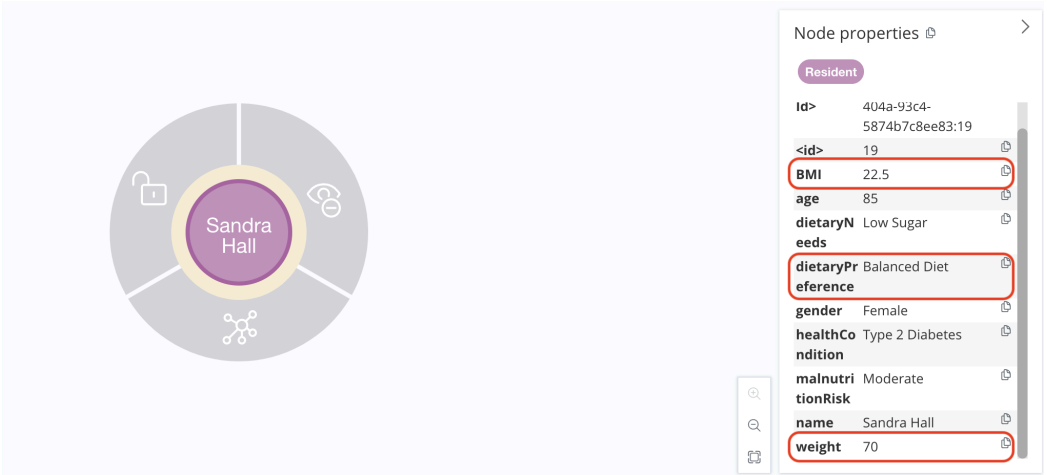
4)Precision of Representation

Solution: Complete key information on residents' BMI, weight, and dietary preference.

Expected outcomes: Comprehensively understand the health status of residents and provide a basis for personalized nutrition management and medical intervention.

Optimisation process and operations:

```
MATCH (r:Resident)
SET r.BMI = 22.5,
r.weight = 70,
r.dietaryPreference = "Balanced Diet"
RETURN r
```



5)Appropriateness

Solution: Remove the relationship between academic researchers and residents and add a relationship for academic researchers to obtain Facility data.

Expected outcomes: Academic researchers obtain data directly from various elderly care facilities.

Optimisation process and operations:

Step1: To delete the relationship between an academic researcher and a resident:

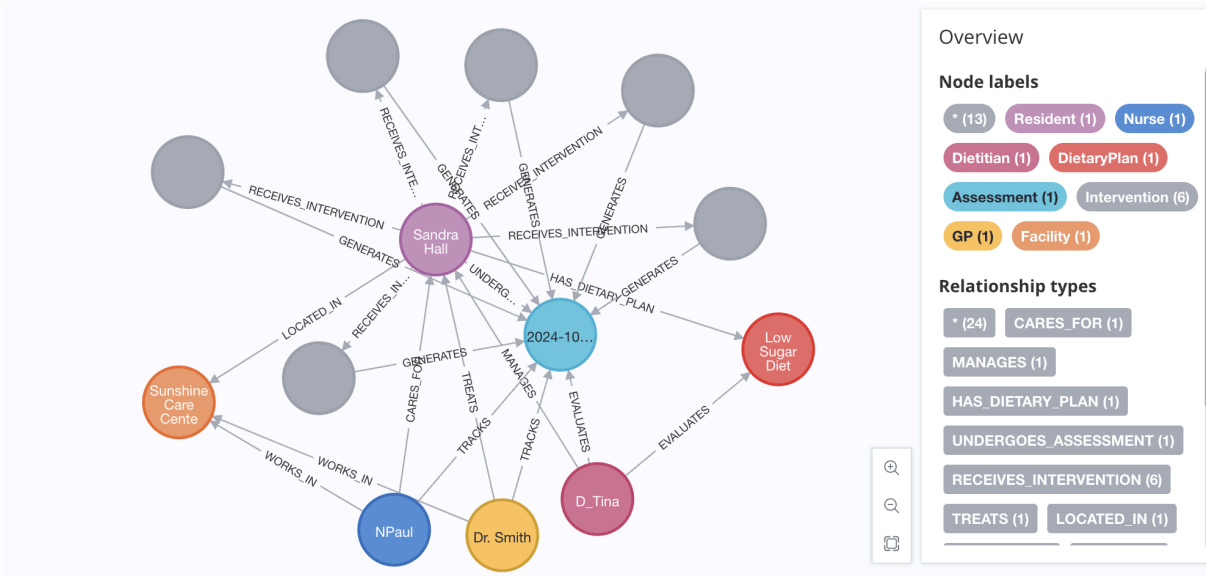
```
MATCH (ar:AcademicResearcher)-[rel:CONDUCTS_RESEARCH_ON]->(r:Resident)
DELETE rel
```

Step2: Add a relationship for academic researchers to get Facility data:

```
MATCH (ar:AcademicResearcher), (f:Facility)
MERGE (ar)-[:OBTAINS_DATA_FROM]->(f)
```

2.Optimized Knowledge Graph Display

After implementing the above optimization plan, the graph of nutritional care centred on residents has achieved a relatively complete organization and display:



3. Re-evaluate the Optimized Case

The current score is 82.6, which is 33.23% higher than the previous evaluation. The specific analysis is as follows:

Indicator	Previous Score	Present Score	Reasons	Proportion	Result
Accuracy	60	80	Add necessary intervention conditions by modifying the assessed **responses of relevant real-world conditions.**	35%	28

Completeness	50	85	Medical staff can conduct scientific and **relatively comprehensive analysis of resident data**.	25%	21.25
Consistency	70	80	**Corrected the information conflict problem of key nodes-Resident**. Although it is a serious problem, **it is relatively easy to fix.**	15%	12
Precision of representation	50	74	The information for the key node - **Resident has been improved, but the labels of other nodes still need to enhance clarity and hierarchy.**	10%	7.4
Appropriateness	80	89	**Academic Researchers** should use data **from medical facilities to conduct larger studies** to help academic trend analysis, and their work cannot directly improve residents' health care outcomes compared to medical staff.	5%	4.45
Performance	90	95	PROFILE MATCH (r:Resident)-[:HAS_DIETARY_PLAN]->(d:DietaryPlan) WHERE r.malnutritionRisk = "High" RETURN r.name, d.name; **Runtime: PIPELINED.** **1058 total db hits in 25 ms.** **Compared with before optimization, the running time is reduced by 3ms.**	10%	9.5
Totally					**82.6**

4.Conclusion

The strategies and categories of knowledge graph evaluation are diverse and need to fit the scenarios and user needs. In this case, the precision of representation index still has room for improvement, because the field of combining medical and nursing care includes

cross-professional fields, and the relationship between the disciplines is rich and complex. Furthermore, research and learning need to be purposeful and focused on a certain industry, and understanding the industry knowledge can help to produce high-quality knowledge graphs to better serve the industry.

References

Seo, S, Cheon, H, Kim, H & Hyun, D 2022, 'Structural Quality Metrics to Evaluate Knowledge Graphs', *arXiv (Cornell University)*.

'Linked data quality of DBpedia, Freebase, OpenCyc, Wikidata, and YAGO' 2018,.