Personalised Medical Content Delivery to Support Patient Empowerment based on Knowledge Graphs

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Abstract

Health literacy empowers people to access, understand and apply health information to effectively manage their own health and to be an active participant in healthcare decisions. In this paper we propose a conceptual model for cognitive factors affecting health literacy and related socioeconomic aspects. Then we develop the HEALIE Knowledge Graph to represent the model, drawing from various medical ontologies, resources, and insights from domain experts. Finally, we combine the Knowledge Graph with a Natural Language Generation tool to generate personalised medical content.

Keywords

Knowledge Graph, Natural Language Generation, Healthcare, Patient Empowerment, Health Literacy [1]

1. Introduction

Patient empowerment is strongly affected by heath literacy, i.e., the patient's capacity to navigate healthcare systems, make informed decisions, and engage effectively in promoting personal and community health [1], [2]. Considering the rapidly increasing availability of patient-facing health-related content [3], especially in digital settings, we focus on personalised medical content delivery to support patient empowerment. Our approach distinguishes itself by considering more profound elements affecting a patient's comprehension and engagement with the provided content, including cognitive competencies, socio-economic factors, and cultural insights. We leverage existing medical knowledge resources and patient education guidelines to propose and develop **HEALIE** (**HEAL**th **I**nformation **E**nhancement), a Knowledge Graph-enabled, personalised medical content generation system.

2. The HEALIE model: A Mapping Approach to Integrate Cognitive Factors and Socio-Economic Determinants of Health Literacy

We build on the integrated conceptual model established by Sørensen and colleagues [4], which consolidates four comprehensive evidence-based dimensions of health literacy, i.e. *Accessing*, *Understanding*, *Appraising*, and *Applying* information. In this work, we focus only on mapping the second (*Understand*) and third dimension (*Appraise*) and we add specific cognitive factors to Sørensen's model. Cognitive factors are characteristics of an individual that affect performance and learning, i.e. memory-related cognitive skills can affect a patient's ability to recall a medical text and require modifications, like repeating information multiple times or offering a bullet-point summary at the end. Or a low *Knowledge* factor implies the need for layman

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terms (e.g. replacing "*hematological cancer*" with "*blood cancer*"). Our model also includes some social determinants of health that impact well-being and health literacy. Each factor's importance has been ranked and incorporated into the model in the form of weights.

3. The HEALIE Knowledge Graph

The HEALIE KG's development started with an extensive literature review and identification of available data resources. Then the conceptual model was created, defining five major node clusters and diverse data types, e.g. textual descriptions of medical concepts, coupled with visual aids (diagrams, infographics, images) to accommodate to different cognitive profiles and to aid in conveying complex health information. Finally, the KG was instantiated with data points collected from the literature; ontologies and expert insights were organized and structured as nodes, properties, and relationships within the graph, following data harmonisation. Patient nodes with full profiles (clinical and demographic data, social determinants of health, cognitive factor scores etc.), corresponding to indicative use cases were also incorporated (see **Figure 1**).

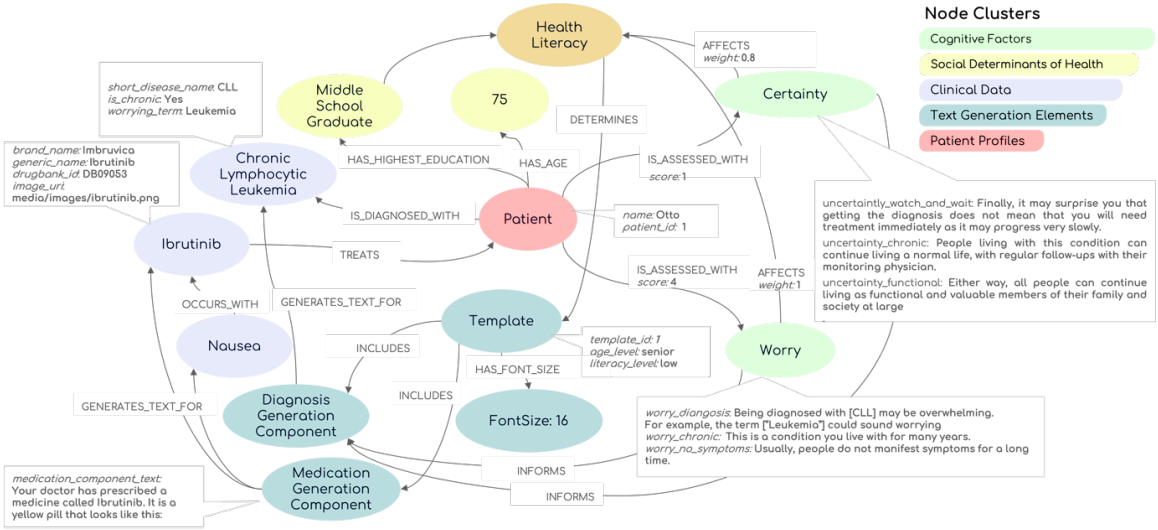

Figure 1. Example of Paths in the HEALIE Graph between the nodes for Chronic Lymphocytic Leukemia and the nodes constructing the content, for an elder, low-literacy patient with high worry and uncertainty scores.

Neo4j and its Cypher query language was used to store the KG, execute path navigation queries, and extract the necessary information. For the automatic content creation, we used RosaeNLG, a template-based NLG software. RosaeNLG dynamically ingests the KG queries' results, uses graph processing algorithms and bespoke rules curated by the domain experts to gather information for the text generation components and to identify the appropriate template type. The dynamic content spans from simple synonyms to entire text blocks of cognitive-related information, multimedia, and even customised appearance (font, font size, colour) for the generated content.

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