Development of Patient-Practitioner Assistive Communications (PPAC) Ontology for Type 2 Diabetes Management

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Abstract. Communication in primary care is a key area of healthcare slow to adopt new technology to improve understanding between the patient and healthcare practitioner. Patients whose cultural background and regular form of dialectal communication are far removed from that of mainstream society are particularly disadvantaged by this during the patient-practitioner interview encounter (PPIE). In this paper, we present an assistive communications technology (ACT) framework for PPIE developed using a Type-2 Diabetes Management Patient-Practitioner Assistive Communications (T2DMPPAC) ontology in order to help both Aboriginal patient and non-Aboriginal practitioner optimise their pre-encounter, during-encounter and post-encounter communication. The T2DMPPAC architecture provides knowledge and presents it in a manner that is easily accessible and understood by the user (patients and practitioners) as well as accompanying carers, and as appropriate, interpreters. An example of bi-directional mapping of concepts to language during a PPIE session is shown using the ontology.

Keywords: Type-2 diabetes management, ontology, assistive communication, Aboriginal English pragmatics

1 Introduction

Communication in primary care settings is one of the key areas of healthcare that is often slow to adopt new technology to improve understanding between the patient and healthcare practitioner. Previous work has shown extreme weakness in communications between practitioners and patients, particularly for patients whose cultural background and regular form of dialectal communication is far removed from that of mainstream society [1-3]. The use of the description 'practitioner' covers the medical professional who works directly with patients as a provider of healthcare. The focus of this paper is on primary care and specifically on face-to-face patient-practitioner interview encounters, which for convenience we term 'PPIE'.

The differences in cognitive capabilities, age factored illness, and cultural communication disparities together with PPIE time constraints, place a very high expectation of expertise and effectiveness on the practitioner when interacting with a patient. Rightly so as the practitioner, being the expert in his/her field, will have to determine the course of action to take to ensure the wellbeing of the patient.

However, the enormity of communicating the relevant information, of variable interpretations in conversation and in unpredictable contextual circumstances, brings its own complexity and risk of misunderstanding. Furthermore, tracking the history of the patient and assigning reliable meaning to occurrences should not just be limited to interactions in the PPIE. In this research, attention is paid to the potential value of pre-encounter and post-encounter communications surrounding the PPIE so that the patient is empowered with knowledge and prepared to contribute towards his/her own healthcare.

The calls for more education and training of providers in human skills as well as healthcare knowledge fails to acknowledge that expectations of advancement cannot be realised without technological tools to aid in primary healthcare. Health care is an information and knowledge intensive industry; but ICT investments found elsewhere are virtually absent in the primary care communications protocols.

In 2007, Kaiser Permanente's Southern California Region introduced a program named the Proactive Office Encounter (POE), to address the growing large scale patient need for preventive care and management of chronic disease[4]. However, the POE imposes a fairly high degree of labour intensity in spite of the inclusion of electronic information systems. The pre-encounter and post-encounter functions are carried out by nursing staff. The authors of a paper on the POE [4] make it clear that for optimal benefit, the POE will require modified processes, structures and management work changes employing smart tools. Our research brings this thought process into play with the added complication of intercultural health care communication. To this end, we have identified computer ontologies as providing the most versatile means to equip a form of assistive communications technology (ACT) to help both patient and practitioner communicate better so as to improve diagnosis and compliance for more beneficial healthcare outcomes.

The need for practitioners to communicate more effectively, particularly to patients from different cultural and language backgrounds is taking on more importance as the intake of refugee migrants from non-English speaking backgrounds increases. The English language proficiency of members within the minority groups in Australia are varied, with some being very proficient in English while others being quite poor. Thus, confronted with patients who are disadvantaged through the cultural disconnect of significant differences in ethnic values and practices; western dominated health literacy; and language/dialect, practitioners are also disadvantaged, by the lack of effective support systems that can counter these handicaps.

In terms of inter-cultural communications in healthcare, the Aboriginal history in and experiences of westernised health care interaction barriers has provided Australia with a strong but under-utilised grounding in the challenges that health care providers face when negotiating the health service needs of ethnic minorities. We assert that

Aboriginal English Home Talk (AEHT) can be used as a model for ethnic minority immigrant communications acculturation.

In this paper, we focus on the chronic disease type 2 diabetes mellitus in Aboriginal people. The evidence across the diverse cultures suggest that the Aboriginal community and other minorities are willing to trust the treatments they receive if the practitioners explains to them why and how a particular test, course of treatment and care plan is the best way to improve their quality of life; life expectancy; and self-management of the chronic disease condition type 2 diabetes mellitus (T2DM) or any other chronic disease for that matter [5-8]. This is an extremely demanding scenario and poorly managed Type 2 Diabetes Mellitus (T2DM) consequences are too often witnessed in emergency department and hospital admissions due to the failure of providing proper explanation to the patient.

The first step is to understand the implications of chronic disease T2DM. It is an incurable disease condition that can be managed. Such patient groups often fall short on adherence to medical advice and we attribute this to poor communication due to a combination of cognitive and health literacy barriers [9-12]. We consider that while practitioner training, re-training, cultural education and other supportive measures that include interpreter services are worthy, they are of very limited effect when the scale of the communications complexities and growth of chronic disease patients are factored in.

The use of assistive technology in particular of development of Type 2 Diabetes Management Patient-Practitioner Assistive Communications (T2DMPPAC) ontology is intended to augment these elements and optimise opportunity for patients, practitioners, carers and interpreters to share in a community knowledge capture and health literacy development set of tools. As explained by Gruber, ‘ontology defines a set of representational primitives with which to model a domain of knowledge or discourse’[13]. These are typically classes and their attributes / properties, and describe/qualify relationships among class members. Definitions include information such as annotations about meaning; and constraints on logical consistency in application. Domain ontologies can be mapped to other domain ontologies, thereby presenting the opportunity to create greater interactivity and versatility involving hitherto underdeveloped or non-existent discourse concepts and schemas.

The collision of clinical language and established western medical practice, with long established non-clinical and non-westernised cultures and modes of communications is a serious challenge to effective engagement pragmatics and health outcomes. The advantage presented to us through ontology development is accentuated by the existence and continued advancement of the Semantic Web, opening up the possibilities for independent and individual access, sharing and reuse of ontology supported communications systems via the increasingly ubiquitous smart devices such as mobile telephones and portable touchscreen tablets. The latter directly proffer pre-encounter and post-encounter, plus PPIE input, versatility.

This paper is comprised of sections. A review of previous work in developing ontologies for type-2 diabetes is presented in section 2. The Patient-Practitioner Assistive Communications architecture is shown in section 3 while the structure and

usage of the Type-2 Diabetes Management Patient-Practitioner Assistive Communications is shown in section 4. This paper concludes in section 5.

2 Literature Review

The term 'Ontology' is derived from its usage in philosophy where it means the study of being or existence as well as the basic categories [14]. Therefore it is used to refer to what exists in a system model. In computer science, ontology is the effort to formulate an exhaustive and rigorous conceptual schema within a given domain, typically a hierarchical data structure containing all the relevant concepts and relationships between those concepts. In artificial intelligence, ontology is an explicit specification of a conceptualisation [15, 16].

In this research an ontology is a domain knowledge representation formed upon a controlled, standardised vocabulary for describing classes and the semantic relationships between them. The T2DPPAC ontology aims to overcome communication barriers due to culture gaps between practitioner and Aboriginal patient. Hence in the ontology, a standardised vocabulary drawn from type-2 diabetes management guidelines is captured along with Aboriginal English home talk. The Aboriginal diabetic patient uses the ontology to understand diabetic concepts in their Aboriginal discourse. The practitioner and involved people e.g. interpreter, use the ontology to understand Aboriginal culture and find a way to communicate with the patient.

There are researchers putting effort towards diabetes ontology development. Chalortham et al. developed diabetes mellitus ontology which covers risk assessment, diagnosis and complication, treatment, and follow-up [17]. Based on the ontology reminding system was developed as part of type 2 diabetes mellitus clinical support system. The diabetes mellitus ontology was developed based on Thailand Diabetes Mellitus Clinical Practice Guideline 2008 and suggestion of medical experts. Buranarach et al. introduced the synopsis of chronic disease healthcare framework in which the important of ontology for healthcare knowledge management system was pointed out [18]. Lin and Sakamoto developed Glucose Metabolism Disorder ontology which was classified into diabetes mellitus, diabetes complication, hyperglycaemia, hyperrinsulinism, etc. [19]. The ontology was also linked to Geographical regions ontology and Genetic Susceptibility Factor ontology to describe the genetic susceptibility factors to Diabetes Mellitus. Ganendran et al. developed ontology based multi-agent systems in which diabetes management was applied as a case study involving three agents i.e. specialist agent, patient agent, and web agent [20]. Shahar et al. developed Knowledge Based Temporal Abstraction (KBTA) focusing on shared knowledge representation and reuse [21]. However, none of work focuses on assistive communications particularly for ethnic minority immigrant communications acculturation. In addition there is no existing T2DM ontology developed based on Australian recognised professional healthcare standard guidelines.

There are a number of ontology methodologies including NeOn, Knowledge Engineering, DOGMA, TOVE, Methontology, SENSUS, DILIGENT, etc. NeOn methodology is a scenario based methodology that provides direction for all key aspects of the ontology engineering process [22]. In contrast to other methodologies those provide methodological guidance for ontology engineering, the NeOn methodology does not suggest a rigid workflow but it prescribes pathways instead as well as processes and activities for a variety of scenarios [23]. The nine scenarios identified in the NeOn methodology are for ontology engineering and special emphasis is placed on reusing and re-engineering knowledge resources both ontological and non-ontological [24]. We use the NeOn methodology as it provides the most flexibility for development of the ontology. The tool used in the implementation process is protégé 4.2.

3 Patient-Practitioner Assistive Communications (PPAC) Architecture

This section provides a new approach to using ICT technology for enabling patient-practitioner assistive communications (PPAC) in primary care. The PPAC architecture shown in Figure 1 is an ontology based system that provides knowledge and presents it in a manner that is easily accessible and understood by the user (patients and practitioners). In this paper, we use type-2 diabetes as the health domain that is represented by a type-2 diabetes management (T2DM) ontology. The T2DM ontology is developed from scratch using available non-ontological resources namely the Royal Australian College of General Practitioners (RACGP) T2DM Guidelines for management of Type 2 diabetes. An ontology to represent the Aboriginal language, in this case Aboriginal English Home Talk, is also developed from scratch. Aboriginal words and phrases which are gradually populating the ontology include contributions from the members of an Aboriginal Nyungar focus group of trainee nurses who gathered to assist the authors in April of 2011. The work of this focus group was led by a moderator who used the RACGP T2DM Guidelines to help validate mappings of semantics between the clinical English diagnosis processes and the undocumented pragmatic cultural expressions. In other words, the guidelines provided an orderly track to prompt discussion that sought responses that included Aboriginal English words, phrases and advisory explanations.

Australia's Aboriginal cultural history exceeds 40,000 years yet little is documented in health care literature that accommodates the unique characteristics of beliefs, perceptions and practices to help deliver effective care and wellbeing outcomes. A substantial source of Aboriginal English Home Talk research literature, emanating from the field of education as opposed to medicine or healthcare is being employed to bolster the communications gaps through this ontology development. This work is unique as there has not been a representation of Aboriginal English for medicine in an ontology. The ontology will provide a mapping of terms from the formal clinical T2DM to Aboriginal English, allowing improved two-way

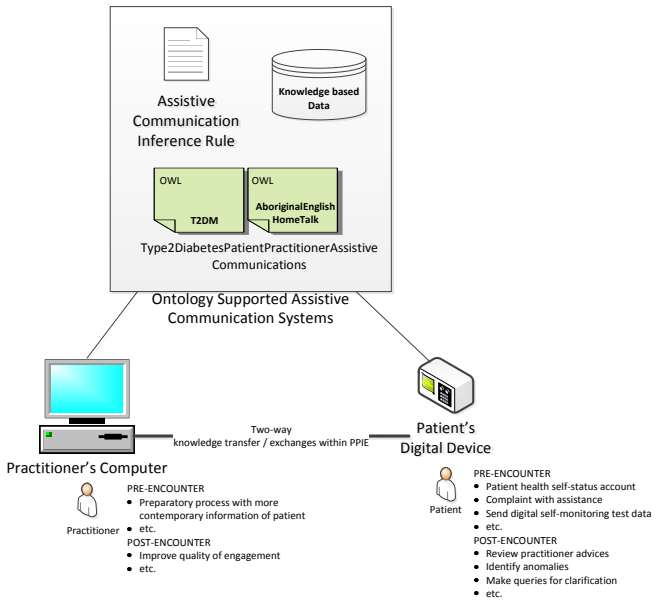

Fig. 1. Patient-Practitioner Assistive Communication Architecture for Type-2 Diabetes Management

communication between the patient and practitioner through the ontology intermediary. The T2DMPPAC ontology, comprised of the T2DM and AEHT ontology vocabularies, effectively surrounds the PPIE and empowers the patient but does not intrude on clinical skills. Its use will help to overcome the barriers in communication by facilitating patient PPIE preparation and post-PPIE review, which implicitly brings other shared knowledge benefits. This modular architecture allows for different language ontologies or health care ontologies to be used in any healthcare setting, thus providing a robust tool for improving communication and understanding during the PPIE for other medical conditions.

3.1 Stages in Patient-Practitioner Interview Encounter

While previous work was concerned with the PPIE in the context of interaction, we found that breaking this process into three phases, pre-encounter, during-encounter and post-encounter, actually aids in better communication and understanding for both patient and practitioner.

The pre-encounter enhances PPIE effectiveness through separate preparations by the patient and by the practitioner. Preparation for the patient is a mental exercise in rehearsing the intended patient health self-status account or complaint through a digital assistant that may also become an educational process and an opportunity to send digital self-monitoring test data. Data enrichment can then elevate the practitioner's preparatory process with more contemporary information than merely

the record of prior consultation. The difference is one of timing, in that practitioner preparation may be minutes before the PPIE and the patient's preparation is likely to be many hours or days before.

In the during-encounter stage, the practitioner will collect information from the patient, clarify ambiguity in information, examine the patient, decide on action to be taken and present course of action to the patient. The information collected during the pre-encounter stage will greatly improve communication between patient and practitioner as both sides have a better understanding of the ailment. However, the final decision rests with the practitioner on the nature of the ailment and action required to address it.

Acknowledging the fact that detail of the exchanges within the PPIE are not so easily or reliably recalled by the patient as opposed to almost instant data entry by the practitioner(s), a post-encounter facility to accommodate a patient review can add to that educational value. It can also facilitate improved quality of further practitioner engagement by allowing the patient to identify anomalies, raise queries for clarification and even influence the mode of engagement by the practitioner in future PPIEs.

The ontology aids all three processes by providing a comprehensive set of standards and guidelines for patients and practitioners to follow as well as present it in a manner that is comprehensible to all users.

4 Type-2 Diabetes Management Patient Practitioner Assistive Communications (T2DMPPAC) Ontology Development

This section aims to show how we built the T2DMPPAC ontology. There are two main parts in the ontology i.e. Type 2 Diabetes concepts which classify all concepts related to type 2 diabetes and Aboriginal English Home Talk concepts which classify all concepts used in Aboriginal communications as shown in Figure 2. These two main parts are formed into two main ontology classes which are linked together through ontology relations and constraints. The two classes are self-standing concepts which we form them as sub classes of class Independent_Concept.

The relations i.e. object properties mapped the two classes are inAboriginalEnglishHomeTalk and inType2DiabetesConcept in which they are inverse to each other. Figure 3 shows relations between classes Aboriginal_English_Home_Talk and Signs_and_Symptoms through object properties inAboriginalEnglishHomeTalk and inType2DiabetesConcept.

4.1 Case Study: Aboriginal Patient With Blurred Vision

We provide a simple case study to illustrate how the ontology can be used in PPIE. Diabetes patients with high blood sugar may suffer from blurred vision. This might be a temporary condition or a precursor to more serious conditions such as retinopathy, glaucoma or cataract. An Aboriginal patient may walk into a clinic once he/she notices their vision is blurred. Typically, the patient will say they have "bad eyes"

when seeing the doctor or they might choose to say “Gooras Winyarn”, which is Aboriginal English for blurred vision. If the condition is serious, the patient would use the Aboriginal English word as it not only provides a description of the problem but also the severity of it, which is not captured in Standard Australian English.

Knowledge captured in the T2DMPPAC ontology as shown in Figure 3 illustrates that the Nyungar Aboriginal words of gooras winyarn can be taken to mean blurred vision or altered vision. Literal translation between traditional or original Aboriginal words that now have a place within Aboriginal English pragmatics is limited and not always sufficiently explicit as to carry a specific meaning. Such words appear in phrases and accord with circumstance; and will therefore vary in context. It is not appropriate for instance, to assign a distinct Australian English oriented meaning to ‘gooras winyarn’ unless the context is completely clear. In the situation where a patient is anxious and/or has limited English proficiency, such words become key triggers to justify ontological system queries. The practitioner will know from the annotation that together these words come close to meaning ‘eyes bad’, thereby informing the practitioner that an eye problem is suspected and will require investigation. The investigation may then include comparison with a prior PPIE record in addition to physical examination that will then better determine whether the condition is altered or blurred vision, or possibly both.

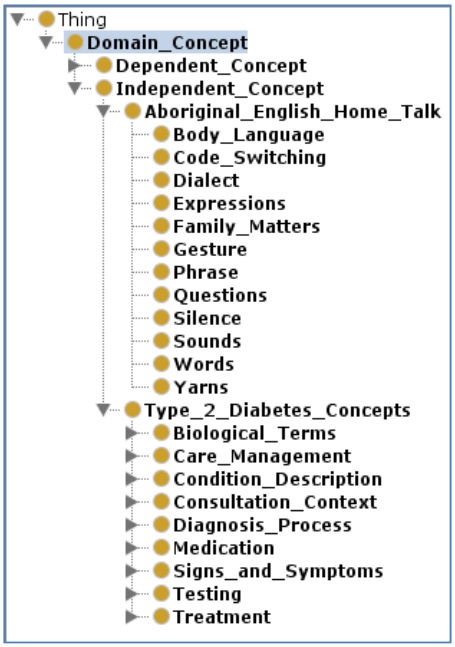

Fig. 2. Class Independent_Concept and its sub classes.

As can be seen in Figure 3, gooras_winyarn is an instance of class Words which is sub class of class Aboriginal_English_Home_Talk. Instance Altered_Vision which is same instance as Blurred_Vision is instance of class Vision i.e. sub class of class Signs_and_Symptoms i.e. sub class of class Type_2_Diabetes_Concepts. The instances are mapped through object properties inAboriginalEnglishHomeTalk and inType2DiabetesConcept.

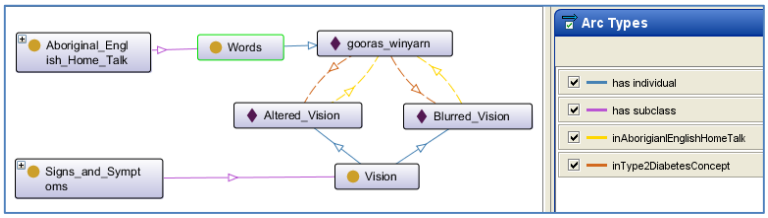

Fig. 3. Object properties inAboriginalEnglishHomeTalk and inType2DiabetesConcept mapped classes Aboriginal_English_Home_Talk and Signs_and_Symptoms

4.2 Refining the T2DMPPAC Ontology

There are refining concepts which will add meaning to other concepts. We form these into class Dependent_Concept as shown in Figure 4.

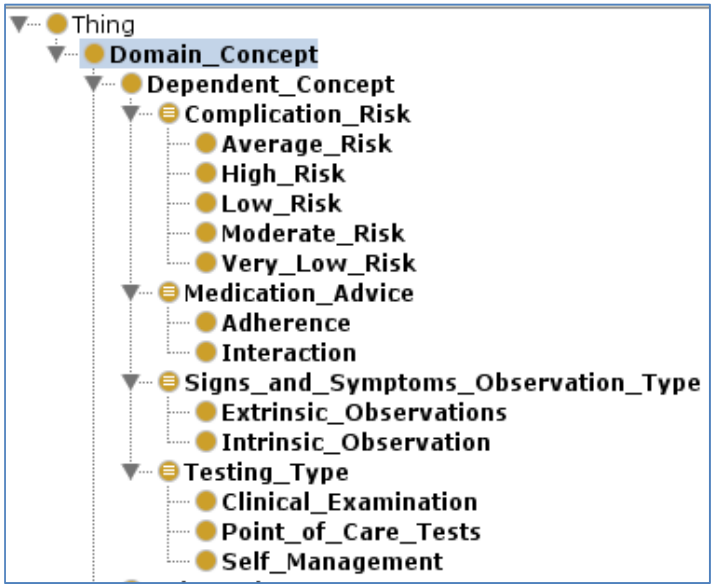

Fig. 4. Class Dependent_Concept and its sub classes

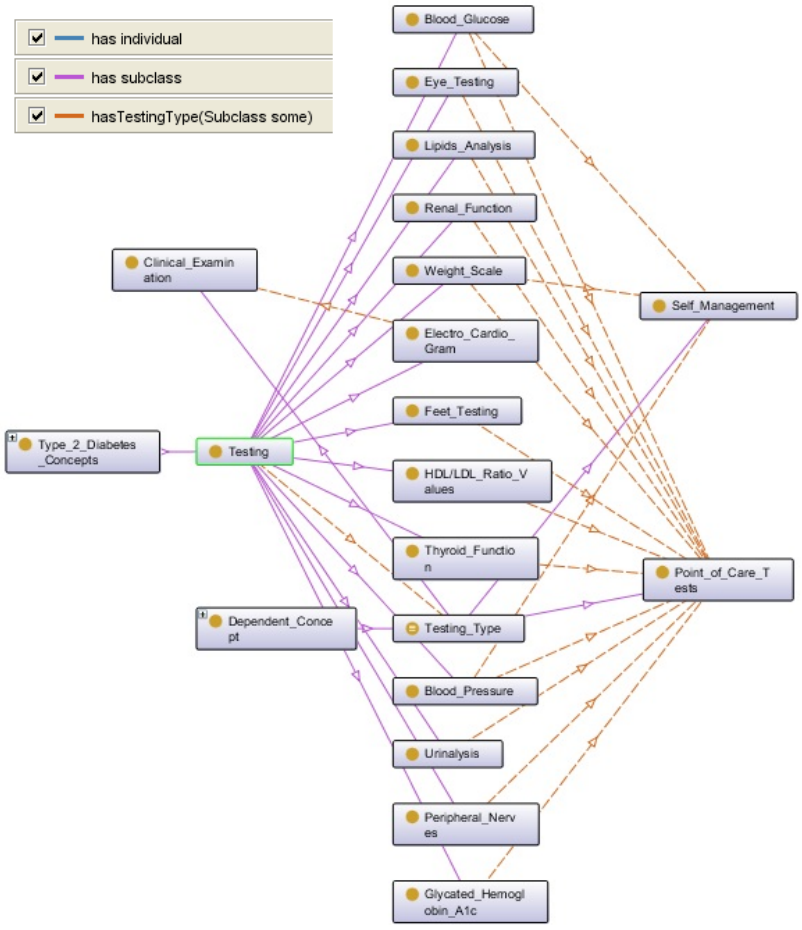

Fig. 5. Class Testing relates to class Testing_Type through object property hasTestingType

Class Complication_Risk adds risk value to any sub class of class Type_2_Diabetes_Concepts through relation hasComplicationRisk. It can be restricted to particular risk of average risk, high risk, low risk, moderate risk, or very low risk. Class Medication_Advice adds value in term of medication advice of adherence and/or interaction to any classes under classes Care_Management, Treatment, and Medication through relation hasMedicationAdvice. Observation of particular sign and symptom of patient can be specific to extrinsic or intrinsic observation of the patient. This can be specified through relation hasObservationType. Figure 5 shows class Testing_Type adding value to class

Testing through relation hasTestingType in term of types of testing i.e. clinical examination, point of care tests and self-management.

5 Conclusion

This paper introduces a novel approach to using ICT in the patient-practitioner interview encounter (PPIE). We developed a framework that links medical information with different language and cultural information to provide ease of understanding and communication between the patient from a minority group with a healthcare practitioner from a different cultural group. The key component of this framework is the Type-2 Diabetes Management Patient-Practitioner Assistive Communication Ontology. We showed how this ontology was created and the links between different classes and components in the ontology. We also presented a case study on how this ontology can be used by the Aboriginal patient to the practitioner.

For future work, we intend to populate the Aboriginal English ontology with as many medical words and phrases used within the Aboriginal community. We will then validate this ontology by the results it provides in a selection of typical PPIE situations faced by Aboriginal patients consulting non-Aboriginal practitioners.

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