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Ontology based intercultural patient practitioner assistive communications from qualitative gap analysis

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Abstract

Purpose – There is an increasing interest in using information and communication technologies to support health services. But the adoption and development of even basic ICT communications services in many health services is limited, leaving enormous gaps in the broad understanding of its role in health care delivery. The purpose of this paper is to address a specific (intercultural) area of healthcare communications consumer disadvantage; and it examines the potential for ICT exploitation through the lens of a conceptual framework. The opportunity to pursue a new solutions pathway has been amplified in recent times through the development of computer-based ontologies and the resultant knowledge from ontologist activity and consequential research publishing.

Design/methodology/approach – A specific intercultural area of patient disadvantage arises from variations in meaning and understanding of patient and clinician words, phrases and non-verbal expression. Collection and localization of data concepts, their attributes and individual instances were gathered from an Aboriginal trainee nurse focus group and from a qualitative gap analysis (QGA) of 130 criteria-selected sources of literature. These concepts, their relationships and semantic interpretations populate the computer ontology. The ontology mapping involves two domains, namely, Aboriginal English (AE) and Type II diabetes care guidelines. This is preparatory to development of the Patient Practitioner Assistive Communications (PPAC) system for Aboriginal rural and remote patient primary care.

Findings – The combined QGA and focus group output reported has served to illustrate the call for three important drivers of change. First, there is no evidence to contradict the hypothesis that patient-practitioner interview encounters for many Australian Aboriginal patients and wellbeing outcomes are unsatisfactory at best. Second, there is a potent need for cultural competence knowledge and practice uptake on the part of health care providers; and third, the key contributory component to determine success or failures within healthcare for ethnic minorities is communication. Communication, however, can only be of value in health care if in practice it supports shared cognition; and mutual cognition is rarely achievable when biopsychosocial and other cultural worldview differences go unchallenged.

Research limitations/implications – There has been no direct engagement with remote Aboriginal communities in this work to date. The authors have initially been able to rely upon a cohort of both Indigenous and non-Indigenous people with relevant cultural expertise and extended family relationships. Among these advisers are health care practitioners, academics, trainers, Aboriginal education researchers and workshop attendees. It must therefore be acknowledged that as is the case with the QGA, the majority of the concept data is from third parties. The authors have also discovered that urban influences and cultural sensitivities tend to reduce the extent of, and opportunity to, witness AE usage, thereby limiting the ability to capture more examples of code-switching. Although the PPAC system concept is qualitatively well developed, pending future work planned for rural and remote community engagement the authors presently regard the work as mostly allied to a hypothesis on ontology-driven communications. The concept data population of the AE home talk/health talk ontology has not yet reached a quantitative critical mass to justify application design model engineering and real-world testing.

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Originality/value – Computer ontologies avail us of the opportunity to use assistive communications technology applications as a dynamic support system to elevate the pragmatic experience of health care consultations for both patients and practitioners. The human-machine interactive development and use of such applications is required just to keep pace with increasing demand for healthcare and the growing health knowledge transfer environment. In an age when the worldwide web, communications devices and social media avail us of opportunities to confront the barriers described the authors have begun the first construction of a merged schema for two domains that already have a seemingly intractable negative connection. Through the ontology discipline of building syntactically and semantically robust and accessible concepts; explicit conceptual relationships; and annotative context-oriented guidance; the authors are working towards addressing health literacy and wellbeing outcome deficiencies of benefit to the broader communities of disadvantage patients.

Keywords Cross-cultural issues, Case study, Computer-mediated communication (CMC), Domain ontology

Paper type Research paper

1. Introduction

There is an increasing interest in using information and communication technologies to support health services. But the adoption and development of even basic ICT communications services in many health services is limited, leaving enormous gaps in our broad understanding of its role in health care delivery. Communication systems for healthcare should accommodate people, messages, mediating technologies and organizational structures; and the relationships between them (Coiera, 2003).

Outside of health service organizations a very modest effort has been invested in ICT systems directly helping the consumer community communicate effectively with health care providers, with some notable exceptions (Bickmore *et al.*, 2007, 2009, 2011; Bickmore, 2010; Bickmore and Giorgino, 2006; Greenberg *et al.*, 2006; Smith and Fellbaum, 2004; Janeice Morgan and Trauth, 2013). Our work addresses a specific (intercultural) area of healthcare communications consumer disadvantage; and it examines the potential for ICT exploitation through the lens of a conceptual framework. The opportunity to pursue a new solutions pathway has been amplified in recent times through the development of computer-based ontologies and the resultant knowledge from ontologist activity and consequential research publishing.

The main contributions of this paper are listed as follows:

- address patient-practitioner interview encounter (PPIE)-related cross-cultural cognition and communications barrier mitigation for Aboriginal patients;
- introduce a qualitative gap analysis (QGA) and utilize it combined with the focus group out for implementation of ontology-based intercultural patient practitioner assistive communications (PPAC);
- investigate the call for three important drivers of change, i.e. PPIE, cultural competence knowledge and practice, and communication; and
- demonstrate the developed PPAC ontology with a depiction of an Aboriginal PPIE case study.

1.1 The problem of Aboriginal patient management in Western Australia

Taylor (2010) addressed on intercultural communication in Central Australian healthcare with a record of two statements from an Aboriginal community member. These succinctly encapsulate the dire state of health care communications affecting rural and remote Aboriginal communities: "Our people are dying […] because they

don't understand what doctors and nurses are saying to them" and "Yuwa (yes) they feel shame and they just walk away and finish up (die)".

The demographic profile, accompanying infrastructure and socio-economic strains impacting health care services covering such a large and diverse geographical region, was readily identified as requiring systems of care that inter alia can overcome distance. The exceptional vulnerability in terms of wellbeing, chronic disease management and incidence of age-related premature mortality affecting the Aboriginal population was identified by Taylor as a stark example of service inadequacies in Central Australia.

It has become apparent that Australia stands to benefit from the communications focus in a hitherto unexpected way. The communications problems, lessons and proposed solutions for Aboriginal healthcare have parallels within, and in turn, opportunities to learn from the experiences of Australia's diverse immigrant population. In basic form, any ICT system that depends upon human-machine interaction for competent and effective healthcare communications must aim to achieve a consistent high level of shared cognition between patients and providers.

When demographics, economic disadvantage and critical state healthcare trends are factored together, WA's remote area Indigenous Type II Diabetes Mellitus (T2DM) patients are disproportionately at risk of developing chronic diseases compared with non-Indigenous people living in or close to urban areas (Endocrine Health Network, Department of Health Western Australia, 2008). Western Australia has the largest land area (2,532,400 sq km) of any Australian State or Territory. Its coastline of 12,500 km amounts to 34 per cent of Australia's total coastline. Over 72 per cent of Western Australia's population is located in Perth, where principal health care support facilities, medical treatment and pathology testing services are located (2009).

Rural and remote communities rely upon thinly spread, mobility-dependent, over-stretched, ill-equipped and sometimes inaccessible, primary care resources; and on a relatively small cohort of Aboriginal Health Workers of Indigenous ethnicity. These adverse factors are compounded by comparably weak communications infrastructure, and sporadic development of telehealth services (Cribbs and Glaister, 2007; Van Ast and Larson, 2007).

In the case of the impact of disadvantage relevant to Aboriginal Type II diabetes treatments and care, the health and mortality risk management goal for the patient is to routinely achieve a consistent and safe level of glycemic or "metabolic" control. The reality for socio-economically and culturally disadvantaged groups, notably rural and remote region living Aboriginal Australians is that lifestyle circumstances are not conducive to achieving a good quality of self-management and wellbeing outcomes.

1.2 Limitations of current healthcare models

Humphreys and Wakerman (2008), noted for their research into Australian rural and remote healthcare services, highlight the inadequacies of a system devised for urban application, stating that among other considerations regional primary care models must be devised and implemented based upon geographical context.

Essential to treatment and care intended to improve upon the best prognosis for the patient, is the application of self-management, i.e. lifestyle disciplines to prevent complications and mitigate the daily detrimental effects of T2DM.

Routine regular actions, strict self-risk management and invariably changed emphasis on dietary and exercise factors can appear to be simple remedies to the uninitiated. The complexities and the spectre of serious life-threatening events arising

from comorbidities combine with the need for modifying relationship habits. Within the ambit of the patient health threat environment are family and other carers; regular social acquaintances and places of resort. 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.

In this research, attention has been paid to the potential value of pre-encounter and post-encounter communications surrounding the PPIE. This is an extremely challenging scenario and poorly managed T2DM consequences are too often witnessed in emergency department and hospital admissions. 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. Figure 1 depicts a common scenario in which the patient is subject to the requirements of the medical culture PPIE system of engagement.

The dashed line connecting the patient with the PPIE denotes the likelihood of a dilution of quality and quantity of information arising through such factors as time constraints cognition/memory issues and other barriers to communications including cultural power distance. Most particularly the information and knowledge transfer is biased towards meeting the practitioner's service constraints and unidirectional processes. Accordingly the patient both before and after the consultation, has limited opportunity to impart potentially valuable healthcare information in detail. This information, for example, elaboration of signs, symptoms and anxieties, exists within the patient domain. The reason(s) for seeking medical advice and the thought processes of the patient before the face-to-face PPIE event merit preservation for detailed explanation to help the practitioner. Similarly retrospective reflection and review by the patient of what has occurred in the PPIE may generate new information. But this information may not be successfully transported and communicated from the pre-encounter and post-encounter stages of the patient thinking process to serve as part of the PPIE engagement. No universally dedicated system exists for extending the scope of the PPIE to capture pre and post-encounter information. In intercultural engagement involving socio-culturally disadvantaged patients the consequential detriment to best health status knowledge is exacerbated.

2. Literature review

Computer-based ontologies are relatively new phenomena. In the latter part of the twentieth century, artificial intelligence researchers became active in a debate about computational modelling of ontologies that would deliver automated reasoning

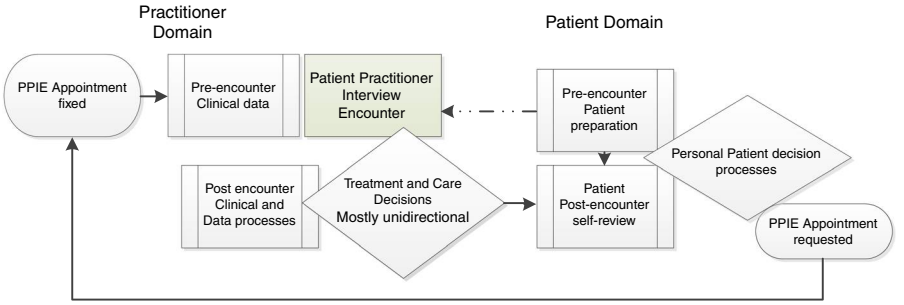

Figure 1. Current general practice PPIE engagement flow in primary care

capabilities. The fruits of work in 1992 and 1993, notably the ontology conceptualization explications from Tom Gruber, subsequently generated expansive interest across the computer science community; and the development of new software tools to facilitate ontology construction. Ontology building is therefore an 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 (Wikipedia, n.d.). In artificial intelligence, ontology is an explicit specification of a conceptualization (Gruber, 1995). For our research purposes ontology is a domain knowledge representation formed upon a controlled, standardised vocabulary for describing classes and the semantic relationships between them.

Our close interest in ontology research contributions is in major part a discovery process to determine best features of concepts and process that will serve our purpose which is the formulation of a conceptual framework. This will eventually lead to an assistive communications technology (ACT) application model to support equitable cognitive consonance in the PPIE. More specifically it aims to enable Australia's Aboriginal English (AE) speaking community and primary care providers to share common, acculturated pragmatics and wellbeing benefits when consultation, treatment and care of T2DM are augmented through the syntax, semantic and reasoning power of computers. Earlier work (Forbes *et al.*, in press) has provided examples of this conceptual development using a case study projection.

Information technology is increasingly used to improve the management of chronic disease (Storni, 2014; Waycott *et al.*, 2014; Maria Piras and Zanutto, 2014), and to help underserved patient communities (Coiera, 2003; Celler, 2009; Gibbons, 2011; Smith, 2007). The emphasis on ICT/ACT opportunities is strengthened by the ability to conduct health care communications over long distances. Williams *et al.* (2002) review the literature on remote health information for the consumers. Phillips (2009) discussing health status differentials research across rural and remote Australia describes mortality and disease patterns across five broad remoteness categories of Australia, concluding that health and its outcomes become worse as remoteness increases. Travers *et al.* (2007) report progress with innovative multimedia in the services of behavioural health change in remote Indigenous settings bringing together challenges of remoteness, availability of technology and readiness of patients including Aboriginal communities to embrace technological innovation in treatment and care. It is acknowledged that major goals are to offer new generation systems such as telehealth innovations (Cho *et al.*, 2009) and to further explore the role of social networking platforms and mobile communications systems and applications to deliver healthcare to remote and other underserved patient groupings (Ackerman *et al.*, 2010).

The gap of health disparities for minority groups is significantly represented by a gap in semantics. Culturally influenced conversational pragmatics is not accommodating variations in meaning from patient and clinician words, phrases and non-verbal expression. This semantic minefield surfaces not only in human to human conversational encounters. It is a major risk challenge in the use of remote service technological healthcare applications and the computer-driven communications systems within and supporting these applications. Vallet *et al.* (2007) propose a personalized content retrieval system aimed at improving the process by accommodating the actual interests of individual users; while recognizing that user preferences are not relevant in all circumstances. The authors emphasize that human preferences "are complex, multiple, heterogeneous, changing, even contradictory, and should be understood in context".

Relevance sits at the core of information retrieval; the authors remind us that it is strongly dependent on context. Analysing explicit semantic relations can allow a set of concepts to be properly attributed. For the purposes of our research, analysis is convoluted because intercultural discourse will include implicit or vague context markers of varying value, sometimes presenting a communications barrier due to the cognitive distance between high- and low-context language cultures (Arwood, 2011).

Rector (2008) makes two strong points on expectations from ICT: for communication between machines and people and information display, understandability and reproducibility are critical. For automated support, unambiguous and repeatable information capture is critical. The author also agrees that "Web based initiatives and social computing will become increasingly important". Writing in a European healthcare context Rector adds that multilingual and multicultural systems are of particular importance. Reassuring for our work is the finding of Brady *et al.* (2008) that Indigenous people around the world are becoming more and more interested in ICT.

2.1 Intercultural communications problems in healthcare

Communications between Australia's healthcare practitioners and their patients, patient families, carers and communities include the need to engage with diverse cultural groups. Many members of these groups are disadvantaged through socio-economic, education, health literacy and limited English proficiency (LEP) circumstances among a host of barriers that threaten best outcomes from primary care consultations. The Australian community is made up of people from more than 200 countries; more than 300 languages are spoken in Australian homes; and more than 60 Indigenous languages are spoken, together with a range of dialects (Australian Bureau of Statistics, 2012). One such dialect distinctive from mainstream use of Standard Australian English, is AE. As a community dialect this is also referred to in the research literature as "home talk". Our work forges a conceptual model to overcome barriers through ACT systems that will facilitate a higher quality of equitable engagement in healthcare for these communities; specifically for speakers of AE.

Anthropological perspectives of the relationship between culture and health are offered by Kagawa-Singer and Kassim-Lakha (2003) who stress that most clinicians lack understanding of the influence of culture on PPIEs. The authors observe that "Eurocentric" adoption and implementation of cultural competency policy and practice still retains the unidirectional philosophy of providers dictating the PPIE processes while lacking adequate respect for personal beliefs of patients. Their proposed solutions, however, retain much of the flawed assumptions and expectations that are criticized as inefficient communication. These ignore the fact that many ethnic cultures do not customarily anticipate, expect to be asked, or comfortably entertain, many of the more personal and probing questions. As is the case with Australian Aboriginals it is not unusual to encounter a patient who does not know his or her date or even year of birth. This is not necessarily due to ignorance or lack of education but may be a characteristic of cultural beliefs and practices (Fryer-Smith, 2008; Lowell, 1998).

2.2 The dyadic conversation

The ubiquitous feature of the great majority of primary care consultations is the conversation between two people, the provider and the patient. We distinguish consultation occurrences as PPIEs because "consultation" may conjure up an inadequate misleading or ambiguous connotation.

Interview generally refers to a face to face meeting, with conversation, formal questions and answers. In the context of healthcare that general term "consultation" does not convey the qualitative nature of an interaction between two people. Encounter is sometimes described as "to come upon or a meet someone unexpectedly" or it may also imply conflict between two parties; but it also means engagement. The PPIE label therefore takes the consultation context into the realm of engagement between provider and recipient of healthcare service. Most importantly for the purpose of the research delineated here, it creates compatibility with aspirations for more equitable relationships between the Western style clinician culture and the culturally and/or socio-economically disadvantaged patient communities. There are two leading reasons for seeking to introduce ACT to this service environment. The first is that these disadvantaged patient communities and specifically the Aboriginal population, are exceptionally vulnerable to and record a high incidence of adverse health experiences. Of equal importance is that it is widely recognized that primary care interventions offer the greatest promise of success through prevention and management, including self-management, of chronic disease (Beck *et al.*, 2002; Heritage *et al.*, 2006; Greenberg *et al.*, 2011).

A clear account of miscommunication in the Australian Aboriginal healthcare context is confirmed by Cass *et al.* (2002). Five clinical encounters over a period of five months, in Darwin, NT, providing diagnosis and chronic disease management of Aboriginal patients were videotaped. Each PPIE was followed by in-depth interviews, of individual patients and the involved health workers. It was concluded that miscommunication is pervasive; trained interpreters provide only a partial solution; and a shared understanding of key concepts "was rarely achieved" while "miscommunication often went unrecognised".

The Cass study gave light to the phenomena of "gratuitous concurrence", i.e. the patient giving a yes/no type answer to a health worker question in either an unconvincing or a convincing and less questionable manner. Offering a response that the patient thinks the health worker prefers to hear, this tendency became apparent through the videotaped method of qualitative study; but may not have been known or recognized without the benefit of retrospective review of the PPIEs. The Cass paper clarifies this quite simply: one nurse remarked "I never even considered that they might be saying 'yo' (yes) when they are really saying 'no'. I never even thought of it" (Cass *et al.*, 2002).

2.3 Cross-cultural communications complexity

Communications in the sense of pragmatic human to human contextualized knowledge transfer and two-way cross-cultural cognition is currently too unpredictable and too complex to simulate via the use of artificial machine readable agents and media. Notwithstanding this challenge to computer capabilities the potential for high-value interaction between a human and a machine continues to be an attractive proposition. In circumstances of health care service access and delivery where patient concordance with professional advice is the goal, the cross-cultural dimension is multi-faceted. The provider is invariably an educated qualified professional and consequently a member of a sector of society which has its own cultural distinctions. These manifest in a number of ways, including the manner and content of conversational interactions with those inside and those outside (extra-domain), of the work-culture group. The introduction of ethnically different, diverse and/or disadvantaged patients into the PPIE brings additional layers of complication density. This produces barriers to ease of understanding between participants. When the ever-increasing volume and

comprehensive intricacy of medical knowledge is considered, both patients and practitioners benefit from computer generated data systems, with access magnified by the semantic web. Heathfield *et al.* (1999) examine the problems of a multi-disciplinary team working together to understand and evaluate healthcare information systems. The issues are important and often difficult which arise through the interaction between information technology and people.

In cross-cultural healthcare discussion and research, the literature variously cites cultural awareness, cultural safety and cultural competence, in some instances attributing definitions to semantically distinguish each label. In educational domain ontology building, Thakker *et al.* (2012) describe a work in progress, referring to cultural awareness as a key skill required in many settings. Using their semantic data browser in their existing technical infrastructure named I-CAW the authors have introduced a cultural prompt mechanism to raise cultural awareness. The eventual application will create an informal exploratory learning environment.

The inclination from this research is to favour the term "cultural competence" which properly denotes the effort towards meaningful engagement, as Betancourt *et al.* (2005) states: "Culturally competent health care – broadly defined as services that are respectful of and responsive to the cultural and linguistic needs of patients". Incisive scrutiny suggests that optimal cultural competence must capture both cultural awareness and cultural safety, the latter largely aimed at invoking provider consciousness and training to improve responsiveness to "the experience of the recipient of care" (Nguyen, 2008).

In an exemplar on culturally safe nursing practice, Blackman (2009) illustrates the superimposition of numerous social issues on routine clinical expectations, for Aboriginal patients. She lists isolation, homelessness, racism, language barriers, cultural obligation, unfamiliar and non-committed health professionals, under resourced Aboriginal health services and lack of Aboriginal Health Workers as a confusing medical and social welfare picture.

Winguard and Lester (2001) are two Australian Aboriginal authors who in their book carefully and succinctly illuminate the different approaches of Indigenous and non-Indigenous people towards health and healthcare. Their description of the necessary philosophy to be adopted by mainstream services for consultation is explained thus:

> There is much room for error when dealing with Aboriginal people, whose beliefs, understandings and perceptions are so different from non-Aboriginals. Our body movement, eye contact […] is very different. Aboriginal people say that non-Aboriginals talk, but don't communicate (Winguard and Lester, 2001).

Li-Chuen Wong (2011) speaks of Aboriginal relationships with and concepts of the land, time, language, kinship obligations, spiritual beliefs, death and ceremony. An experienced dermatologist working with Indigenous community in Wadeye/Port Keats she concludes that the most important lesson from her work is to realize that interactions are based on trusted relationships built over time. She compares this with the conflicting experience of westernized acceptance of efficient, detached and depersonalized ways of dealing with patients. Her 2011 article describes how she searched the Centrelink website without success for information provided in any of the estimated 250 Aboriginal dialects of Australia. Centrelink is a government run department providing a number of human services including help with the cost of prescription medicine Australian Government funded medical services, and access to state, territory and local government health care service concessions.

Saras Henderson (2004) has written of the community nurse relationship with AE, emphasizing the critical importance of good communication in community assessments. AE and SAE speech and cultural differences confront the community nurse with communication difficulties. Henderson references the case of an Aboriginal man complaining of headache as an example. He was administered Panadol the painkiller analgesic but continued with his complaint. It transpired with the help of an interpreter that the patient had family problems that were figuratively and mentally, not physically, giving him a "pain in the head". As with other authors (Malcolm *et al.*, 1999; Eades, 1991; Trudgen, 2000) Henderson refers to periods of silence by Aboriginal patients as part of the cultural norm for communication but which are commonly not understood or respected by westernized practitioners.

2.4 ICT and ontology-based solutions

Cimiano *et al.* (2010) propose a new definition of ontology localization, which had generally referred to the adaptation of ontology to a particular language and culture. The authors' re-definition reads "ontology localization is the process of adapting a given ontology to the needs of a certain community, which can be characterized by a common language, a common culture or a certain geopolitical environment". The paper advocates identification of two ontology layers. The Lexical layer is described as comprising labels of concepts, properties and individuals as defined in the ontology; definitions of the entities in natural language; and also the ontology documentation describing its function and scope. A Conceptualization layer accommodates ontology adaptation to map two different ontologies. In the case of our T2DM and AE domains, the initial need is to move the more formalized structured source of T2DM guidelines towards synergy with the cultural reality of a largely undocumented and elusively structured dialectal sphere.

Other researchers and authors offer insight to ontology support for communications. Burger and Simperl (2008) in the effort to prepare the way for ontology development opportunities introduced a method for measuring the benefits of ontologies based on a multiple gap model for user information satisfaction analysis. Farrar and Langendoen (2003) are working towards the creation of a linguistic community of practice by beginning work on a General Ontology for Linguistic Description (GOLD). This is part of a larger effort "to create domain-specific ontologies connected to an upper ontology known as SUMO" (see, http://ontology.teknowledge.com). Claiming GOLD as the first ontology being designed specifically for linguistic description on the semantic web the authors are organizing linguistically related concepts into four major domains: expressions, grammar, data constructs and metaconcepts. Bilidas *et al.* (2007) have introduced ELEON, an editor allowing enrichment of Ontology Web Language (OWL) ontologies with linguistic and user-related annotations. Enriched ontologies are used by natural language generation (NLG) engines to generate textual descriptions of objects represented in the ontologies in the selected language for the user's model. ELEON provides a well-defined interface for use by different NLG engines.

In the healthcare arena ontology papers reporting stages of development are increasing in number. Buchanan *et al.* (1995) introduces an intelligent interactive system for delivering individualized information to patients; B. Celler (2009) writes of emerging technologies in health – telehealth services for the management of chronic disease at home and in the community; Chalortham *et al.* (2009) offer a paper describing ontology development for a T2DM clinical support system; and Ganendran *et al.* (2002) have published a proposed ontology-driven multi-agent approach for healthcare.

In work on cross-cultural domains Bilidas *et al.* (2007) assist the ontology building process with advice on enriching OWL ontologies with linguistic and user-related annotations. Carstens (2006) identifies unresolved problems concerning the extent to which culture influences ICT usability, asserting the need to develop a model of cultural barriers to human-computer interaction (HCI). She declares that today's technology and the different cultures that interact with ICT, a model of ICT and the HCI barriers produced by it should be identified "to better help designers of ICT avoid technology pitfalls".

Ontologies focused on health care are prolific in number and scope, yet are relatively limited in their impact on such a large multifaceted domain. Computer ontologies have been developed and some adopted by medical professionals, with a notable bias in the published research towards provider-centric systems needs (Amoussou, 2011; Beveridge and Fox, 2006; Cenan *et al.*, 2008; Chalortham *et al.*, 2009; Ganendran *et al.*, 2002; Kim and Song, 2007; Kumar and Smith, 2003; Kumar *et al.*, 2004a; Lin and Sakamoto, 2009; Mabotuwana and Warren, 2009; Noy *et al.*, 2009; Bickmore *et al.*, 2011; Rector, 2008; Shahar *et al.*, 2004; Smith *et al.*, 2007) compared with the patient-practitioner relationship environment (Ahmed, 2011; Bailin and Lehmann, 2003; Barrett, 2006; Verma *et al.*, 2009).

Context-based task ontologies (CTOs) have been created by Kumar *et al.* to form a core component of a Computer Interpretable Guideline Model intended to automate representation and execution of clinical practice guidelines (CPGs) (Kumar *et al.*, 2004b). Their specific task orientation follows the WHO guidelines for hypertension management. Whereas the work of these authors is concerned with clinical practice and not directly with patient or cultural interests or engagement, the development of CTOs for CPGs is of consequence to assistive communications ontologies. The authors point out that an internal medicine team would need to supplement CPGs with implementation task ontologies aligned with workflow practices in the specific healthcare environment. Medical history taking is an example of this. In the clinical and professional applications workflow arena ontology construction relates to formal terminology sources, in the instance cited, the Unified Medical Language System semantic networks.

As CTOs involve multiple ontologies and multiple context-interpretations of guidelines it seems logical to argue that as communications and semantic sophistication advance, a gateway linking patient-practitioner healthcare ontologies will open up relationships with the technical and clinical medicine domains, for example in diagnostic procedures and outcomes. Kumar *et al.* mention merging various task ontologies from different guidelines as one of the advantages of their system. The ontology literature is revisited later in this review section in order to consider and pinpoint the role of ontologies in intercultural assistive communications particularly in the Aboriginal health care informatics and pragmatics environment.

Health care focused ontologies range in objectives and ultimate purpose, e.g. ontology planning and potential for health and healthcare improvement and education, medical information management, clinical guidelines, patient web-enablement, health care interpreter support and chronic disease management, etc. (Kamel Boulos *et al.*, 2006; Kim and Song, 2007; Kumar *et al.*, 2004a, b; Lemaire, 2000; Masland *et al.*, 2010; Mynatt *et al.*, 2010). Based upon our search process we find that little attention is devoted to communications ontologies serving the needs of disadvantaged healthcare communities enduring healthcare and health disparities. We have found none that address PPIE-related cross-cultural cognition and communications barrier mitigation for Aboriginal patients.

3. Methodology: QGA

From focus group experience with members of a Nyungar trainee nurse community in South-West Australia we have learned of the innumerable difficulties in building a dialectal lexicon, given the fact that no AE dictionary exists, and least of all is there any published document containing AE linguistic or paralinguistic healthcare data. Such references as anatomical descriptions and self-descriptive biophysical characteristics, signs, symptoms and conditions generally appear in hardcopy or DVD media published by health care provider organizations, and then only in basic Standard English, along with graphical representations that attempt to convey a cultural connection with Aboriginal art. These media are constrained by knowledge of and respect for cultural taboos. For example gender sensitivities referred to by Aboriginals as "men's business" and "women's business" make it prudent to avoid publishing material that may offend the practice of separation of intimate sexual discussion; a factor also pertinent within other minority communities.

Accordingly we turned to the literature to apply in search mode what we learned from the focus group and from other informal encounters (which Aboriginal people prefer vs formalised ethics-bound approaches). In the analysis process search for and identification of PPIE barrier contextual pragmatics 146 keyword-selected literature sources were reviewed. In total, 16 of these were rejected after review, as having insufficient relevance or applicable detail to offer meaningful data formalisms. The remainder were divided into general (non-intercultural) discussion of patient-practitioner interactions; and cultural (intercultural) commentary on the same. The benefit of the general category is that it takes account of behavioural and institutional influences that may present barriers in PPIEs without a cross-cultural dimension affecting the interactions. As the concept framework aims to capture a bi-directional PPAC system, an equitable treatment of participatory sources is important, i.e. we aim to recognize and resolve miscommunication that can occur due to westernized health care provider causal factors, as opposed to the more obvious characteristics of intercultural PPIEs:

- in total, 130 literature sources were reviewed;
- in total, 96 (or 73.8 per cent) of the literature sources were peer-reviewed, consisting of 91 journal articles; four books and one doctoral thesis;
- the remaining "General" sources were made up of professional web articles and expert-source healthcare and cultural communications advisories and submissions;
- in total, 58 sources reviewed were in the general category; and
- in total, 72 were cultural; and of these, 32 related specifically to Aboriginal PPIEs.

Data were identified under the following three column headings:

(1) source reference;

(2) setting and participants; and

(3) communications barrier (Gap) characteristics.

In the communications barrier (Gap) characteristics column the data identified as pertinent for populating the ontology are determined using the criteria of those cultural and contextual pragmatics documented in the several AE literature educational literature sources, applying such measures as (for example) time and space dimensions;

asking questions; stories and yarns, etc. Effectively this qualitative evaluation also provides a quantitative indication of the need to overcome PPIE communications barriers, e.g. the repeated reference by different authors and researchers to consultation time constraints as a barrier.

The contextual schema search process criteria (for the purpose of the conceptual framework ontology) comprised 42 AE pragmatics domain words and descriptions which explicitly or implicitly identify barrier characteristics. The voluminous output included considerable detail to facilitate further analysis. This produced an original working table exceeding 100 pages and 30,000 words. Borgatti (1999) avers a rule of thumb for distinguishing cultural domains, stating that they are about perceptions rather than preferences. His techniques include eliciting attributes and relations that structure the domain. Much of his work relies upon human "respondents". In this instance, we treat specific subject matter literature and findings as similar to a form of response. Subsequent analysis, in part drawing upon Borgatti's free-list and pile-sort techniques for eliciting items in a cultural domain first reduced the table to 16 pages and 5,200 words. The next stage in this process narrowed the field of barrier characterization to 17 sub-groups. The final stage consolidated these into seven main attributes that are identified as overarching terms describing PPIE cross-cultural barrier communications, thereby providing semantic and syntax priorities for building the PPAC ontology.

Barrier characteristics found in the literature were either specific or semantically inferred and confirmable through contextualization. Sufficient role descriptions of participants, as active, passive or unsuspecting contributors to communications barriers, justified labelling where specific terms were absent. For example, "cultural competence" was a very clear attribute though these words were not used, in articles describing PPIE type occurrences where health care providers were either ignorant of or indifferent to cross-cultural engagement for the wellbeing of an Aboriginal patient. If "cultural awareness" or "cultural safety" appeared in any QGA literature source, sufficiency of detail and context determined whether or not "cultural competence" would be added to the classification.

There is a tendency in the literature to assign barrier causative factors in PPIE performance and outcomes to the practitioner/provider population (ACSQHC, 2010; Bauman *et al.*, 2003; Charles *et al.*, 2006; Engel, 1978; de Ridder *et al.*, 2007; Jacobs, 2001; Towle *et al.*, 2006). This posture acknowledges the widely perceived authoritative power-based medical culture and relative educational distance with patient communities, most especially those disadvantaged by socio-economic and ethnic status. The relationship between practitioner as the medical "expert" and the lay patient is not equitable for good as well as negative reasons. The difficulty presented for this research is that there is little Aboriginal patient-culture-generated research on the contributory value specifics to be nurtured and utilized from the patient source (Lowell, 1998).

The final working table is too long to include here. Examples illustrating the mid-process table content for each of the categories, "General"; "Non-Aboriginal-cultural" and "Aboriginal-cultural" are as follows.

General:

Source: D. Angus *et al.*

Setting: analysis of conversational behaviour in consultations, using an automated computer visualization measurement technique.

Communications Barrier (Gap) Characteristics:

Too much practitioner time "off-topic" with rapport but at expense of developing health narrative, may represent poor task focus. Over-use of check-lists can hinder health narrative development. Best conversations characterized by appropriate accommodation in approximation, interpretability and discourse management. Patterns of interaction uncovered may explain why patients feel constrained by time or that doctors did not understand their needs.

Non-Aboriginal-cultural:

Source: Australian Human Rights Commission.

Setting: highlights of consultations interviews and public submissions with African-Australian community and stakeholders.

Communications Barrier (Gap) Characteristics:

Culture shock. Breakdown of family ties. Language barriers. Health problems from food and diet changes. Lack of access to culturally appropriate health services. Inter-generational conflicts. Breakdown of traditional cultural lifestyle and values. Discrimination and racism. Children language brokers. Lack of knowledge: hygiene practices; sexual health; nutrition; importance of exercise. Practice of politely agreeing they understand doctors when they do not (gratuitous concurrence). Discrimination and stereotyped responses; lack of interpreter; reliance on family members resulting in wrong diagnosis; lack of awareness of health professionals; inadequate cultural skills; problems with translation and miscommunication.

Aboriginal-cultural:

Source: J. Kelly *et al.* (Kelly *et al.*, 2011).

Setting: this study uses a framework derived from analysis of staff and patient interviews. It identifies five underlying factors that affect the needs and experiences of Aboriginal patients from "the country" (remoter parts) who come to Adelaide for care It is the interaction of all these underlying factors – being a country person in a city setting, experiencing a high burden of illness (and needing care across the hospital/non-hospital divide), perhaps not having English as a first language, perhaps being poor, and being Aboriginal in a mainstream system – that makes city hospital care for country Aboriginal patients a unique challenge for them and their carers and staff. Note that not all Aboriginal country patients experience all of these factors equally or uniformly.

Communications Barrier (Gap) Characteristics:

The Australian Indigenous Doctors' Association has developed a comprehensive model of health in five dimensions, for the purposes of assessing positive and negative health impacts building on existing definitions of Aboriginal and Torres Strait Islander health:

- physical or biological – morbidity, mortality, chronic conditions, self-reported health;
- psychological or emotional – levels of stress, trans-generational and cumulative trauma, freedom from shame, discrimination, racism;
- social wellbeing – family and kinship systems, community cohesion; access to quality housing, education, employment, living conditions, support services; self-determination, participation, trust, social inclusion;
- spiritual – recognition and respect for Aboriginal people, worldviews, knowledge, values and aspirations (enacted in policy and programs); hope and despair; and
- cultural integrity – levels of community control of health, education, land rights, police and fire protection.

Table I displays the consolidated data from the penultimate and final QGA stages. It focuses on ontology design needs for PPIE involving AE speaking T2DM patients.

4. PPAC ontology for the chronic disease T2DM management in Aboriginal patients

In our development of the PPAC ontology we have focused on helping with management of the chronic disease T2DM in Aboriginal patients. To accomplish our goals we have used sources of knowledge about the common use of the AE dialectal form sometimes referred to as "home talk" (Forbes *et al.*, in press). The absence of available lexical data representing pragmatic AE health care interactions in primary care has meant that we have had to rely upon focus group work, personalized informal advice offered by AE speakers and a strong corpus of educational literature on AE, and

Overarching term for PPAC ontologies priority	Subgroups identified from qualitative gap analysis (QGA)	Ontology contextualization Communications barrier mitigation factoring
Cultural competence (51)	Cultural competence (39) Cultural awareness (6) Cultural safety (6)	Navigation and negotiation design for two-way cross-cultural cognitive consonance
Biopsychosocial (44)	Biopsychosocial (16) Emotion (11) Empathy (10) Practitioner dominance (7)	Emphasis of PPIE subclasses attributes/ properties prompting inclusion of psychological and sociological as well as biomedical issues in the PPIE
Language (42)	Language/linguistics (21) Interpreters (11) Terminology/jargon (6) Storytelling (4)	System recognition of role of language barriers. PPIE syntax simplification; Aboriginal English dialectal accommodation; interpreter engagement advice
Beliefs (40)	Beliefs (17) Lifeworld/worldview (10) Concepts/taboos (9) Spirituality (4)	Extension of Cultural Competence. System recognition of role of Aboriginal holistic health including healthcare and death perceptions
Education (28)	Education (19) Training/retraining (9)	Extension of cultural competence, query and response FAQ type system knowledge transfer prompts Practitioners: professional cross-cultural educational content AboriginalPatient/carer: using Aboriginal English pragmatic syntax and semantics to informalize and overcome T2DM and PPIE cognitive dissonance
Family (25)	Family (15) Community (10)	Annotative inclusion of extended family and community terms and their relationship with individual member health/healthcare occurrences. Aboriginal family structures, names and contra-Western cultural constructs
Time (23)	Time-cultural/temporal interpretation (6) PPIE Time Constraints (17)	Quantification and measurement guidance to engage/comprehend Aboriginal concept of time and timing of health "events". Annotative advice on psychosocial impact of PPIE time limits affecting cross-cultural patients

Table I.
Qualitative gap analysis (QGA)

consultations with the principal contributing researchers in this field within Western Australia. The traditional owners and inhabitants of the South-West of Australia are the Nyungar people and the AE captured in our research is primarily from that community. The nature of the Western Australia led work is concerned with teaching and learning in secondary education. It examines and demonstrates barriers to communication and the conflict between Standard Australian English and AE. With the concentration on grammatical constructs, cultural pragmatics for the classroom and the overall effort to educate the teaching profession about engagement with Aboriginal speakers; no provision for healthcare dialogue appears in this work.

In 2010, the first dictionary of anatomy in a native Australian Aboriginal language was published in the Northern Territory (ARDS Inc., 2010). We have not found an AE version of anatomical or health care expressions, health synonyms or terminology; and the focus group experience has increased the need to extend the scope of enquiry. Consequently our work must rely heavily upon the education sources mentioned. Much work remains to elicit reliable health care interpretive Aboriginal health care data and pragmatic guidance and a substantial reliance will be placed upon ontology annotations, some of which will be represented through tagging of data links, for example, graphical illustrations and phonology sampling of voices of AE speakers. In the health care PPIE context, most assets of this kind have yet to be created. In order to compensate for the absence of documented AE health care "home talk" the conceptual framework favours support for cultivating practitioner cultural competence in a general worldview acculturation context.

The use of the PPAC ontology is mainly focused on the representation and reorganization of Type II diabetes terminologies together with AE home talk. The objective is to help GPs and Aboriginal patients storing and communicating general Type II diabetes knowledge and patient-related information efficiently. The PPAC ontology supports the need of Aboriginal Type II diabetes healthcare process to transmit, reuse and share patient data.

The practitioner objective is:

- to identify T2DM standard concept equivalents of patient AE words, phrases or expressions;
- to identify AE words, phrases or expressions suited to the consultation context; and
- to semantically identify relevant AE properties.

The patient-oriented objective is:

- to guide the practitioner towards cultural competence;
- to find AE concept equivalents of T2DM words, phrases or expressions;
- to guide the practitioner towards links with relevant AE PPAC concepts;

4.1 Cultural aspects of the PPAC ontology

The eventual PPAC system is initially intended to educate and equip health care professionals in their PPIE communications with Aboriginal speakers who are socio-culturally disadvantaged and vulnerable to complications arising from their Type II diabetes chronic disease history. Although the system will also serve the dual purpose of assisting AE speaking patients to understand and more successfully

communicate with their health care providers, the latter have the comparative advantage of greater health literacy, proportional access to ICT and to assistive communications initiatives. This advantage can be used to best effect as a medium for helping to introduce the technology and the PPAC concept to the patient communities. The process as anticipated in this paper will effectively act in an educational capacity. The PPAC concept will require training of healthcare professionals to encourage sharing of the system usage and output with Aboriginal patients.

In our previous papers (Forbes *et al.*, 2012, in press), the PPAC ontology has been developed for Type II Diabetes in which a standardised vocabulary drawn from Type II diabetes management guidelines is captured along with AE home talk. The two domain ontologies are captured, i.e. Type II diabetes concepts which classify all concepts related to Type II diabetes and AE home talk concepts which classify all concepts used in Aboriginal communications. These two domain ontologies are linked together through ontology relations and constraints. In this paper, the PPAC ontology development will be updated and extended to include cultural aspects. Hence in this paper the AE home talk related concepts will be focused. We picture the update and our focus through scenarios. Note that the Ontology has been developed in Protégé 4.2 with Pellet reasoner for reasoning, DL Query and SPARQL Query for querying, and OntoGraf for graphical presenting. Figures shown in this paper are then captured from Protégé with capability of reasoning, querying and graphical presentation to ease understanding on the update and focus. At the time of writing this paper, PPAC ontology contains 774 logical axioms, 213 classes, 22 object properties, seven data properties and 129 instances.

Ensuring an ontology is consistent is an important part of ontology development and testing. It is especially important when a shared ontology is necessary for meaningful communication. If a shared ontology is inconsistent, no reliable conclusion may be deduced. Consistency validation through reasoner for PPAC ontology includes consistency checking, concept satisfiability, classification and realization. These services are all the standard inference services traditionally provided by a reasoned, e.g. Pellet, Racerpro, etc. The PPAC ontology does not contain any contradictory facts in which logical consistency of the ontology is checked through Pellet and Racerpro. The PPAC ontology has also concept satisfiability, i.e. a class in PPAC ontology can have instances. If a class is unsatisfiable, then defining an instance of that class will cause the whole ontology to be inconsistent. The PPAC ontology has a complete class hierarchy (classification service). The class hierarchy can be used to answer queries which we cover in the next section, usability validation. The most specific class, that an instance belongs to, can be found in the PPAC ontology (realization service). From our experiment the PPAC ontology is consistent and ready for consumption.

4.2 Challenges in communication and cultural behaviour

Based upon research findings we can determine how existing PPIE practices can be modified to better effect for the participants, applying the PPAC concept. This can be illustrated conceptually by bringing together the known components of current practice with the future capabilities offered by assistive technologies, supported by the AE and T2DM ontologies. The scenario for this projection is a fairly common setting in rural health; the provision of primary health care service for regional AE speaking patients through country location general practice clinic appointments. In context it must be remembered that many parts of regional Australia, and in particular for this purpose, Western Australia, have very few primary health care sites. Each site has

variable resource capabilities and serves a widely scattered population in a physical ecosystem with a relatively weak and environmentally vulnerable infrastructure. As a consequence the relevant health care knowledge gap between patient and practitioner is greater than that applicable to patient-practitioner relationships in metro/urban locations. Further complexity can arise in rural and remote areas from inadequate continuity in the patient-practitioner relationship, for an assortment of reasons including among many the mobility of patients who habitually traverse the Australian bush; attrition rates of health care provider staff and the presence of international medical graduates. In most instances, ICT access and usage by patients embedded in these lifestyle circumstances will be significantly less than health care providers and urban patient counterparts. The concept, however, envisages gradual change in this disparity, in part because patients suffering complications of T2DM receiving essential treatment and care in metropolitan and urban hospitals are becoming more exposed to ICT and specifically to the active use of mobile phones across extended Aboriginal family communities. A summary of challenges is not exhaustive, as these carry an element of unpredictability and are also implicit if not explicit within sub-domain attributes and specific individual instances. The phenomena known as "code-switching" practised by Aboriginal patients is a particular challenge for practitioners and is explained later.

4.3 Case study

Based upon input from an ethics-approved focus group exercise involving Aboriginal trainee nurses, we have assembled a depiction of an Aboriginal PPIE case study into two scenarios as follows.

4.3.1 Scenario No. 1. A 28 year old Nyungar male "Vincent" is in the care of a 58 year old close community friend "Ted" who while not blood related he refers to as "uncle". Both have been living for an unknown period of time in bushland in and around the South-West of Australia. Together they attend a country health clinic by appointment, and initially the older man enters the doctor's office alone. He is surprised to discover that the GP, Dr Rose, is a white European-born female. He tells her that he wants a male doctor to examine his "huncle" but that the patient is refusing to come in from the waiting area due to embarrassment. The only person in the waiting room at that time she notes is Vincent who is visibly unwell and suffering dizziness but could not possibly be (in her view) Ted's uncle. The doctor is somewhat confused but realises there is a communications barrier. Her training should enable her to consider how to resolve this quandary. The option of querying an ontology supported PPAC system would help her to navigate through a search of consultation context subclasses and attributes to learn more specifically how she might handle this situation.

Extended family. From the above scenario Dr Rose could query search for a word of "huncle" to find its possible meaning. Figure 2 shows query used for finding the possible meanings of word huncle and result provided from DL Query. Figure 3 shows the result in details in which it shows that word "huncle" in AE can be taken to mean "uncle" and also to mean "nephew" in standard English. Figure 3 shows that "uncle" can be taken to mean "nephew" as well. This refers to bi-directionality in the uncle and nephew relationship.

As can be seen in Figure 3 it is an individual of classes Blood-related_Family, Community, Kinship_System, Marriage and Mutual_Respect. Figure 4 shows subclasses of class Extended_Family. From this reference it shows that the notions

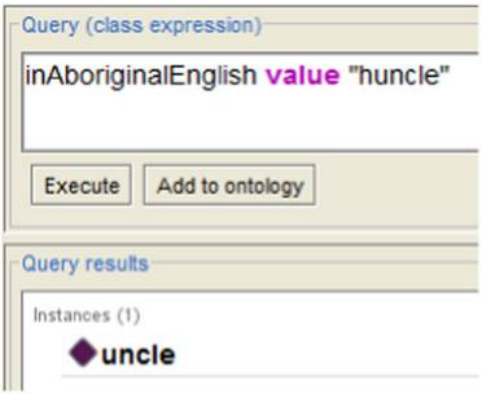

Figure 2.
Query to find possible meanings of word huncle

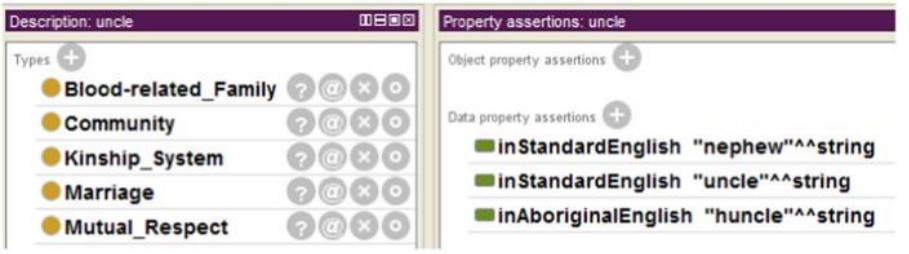

Figure 3.
Query result in detail for individual uncle

of extended family and community as family in Aboriginal communities encompass the idea that children are not just the concern of the biological parents, but of the entire community. The raising, care, education and discipline of children are the responsibility of everyone – male, female, young and old. Also shown in Figure 4, "elder", "friend" and "neighbour" are instances of class Non-related_Family. This reflects community as family.

Dr Rose can also navigate through the concepts. Looking into class Consultation_Context which has class Accompanied_Patient as subclass, there is relation called hasExtendedFamily which links to class Extended_Family (yellow dot line in Figure 4). With all these references, it then makes sense to apprehend that Vincent accompanied by Ted who being called his uncle whom may not be his blood related uncle. Hence from these references, Dr Rose will be able to assume that the Aboriginal patient and his carer are part of a community that would treat each as "uncle" of the other.

Another term that can cause confusion like uncle is the term "grannies" which is commonly used to refer to Aboriginal "grandchildren". Figure 5 shows a query and its result from the word "grannies". Figure 6 shows the result in detail in which it presents that grannies in AE can be taken to mean grandchildren in SE and it is an individual of class Blood-related_Family.

Men's business gender sensitive. In this scenario, it is apparently a "men's business" gender sensitive and possible a "shame" situation. It would be able to confirm by looking at concept of Consultation_Context in PPAC ontology. Figure 7 shows class Consultation_Context and its subclasses and its relations.

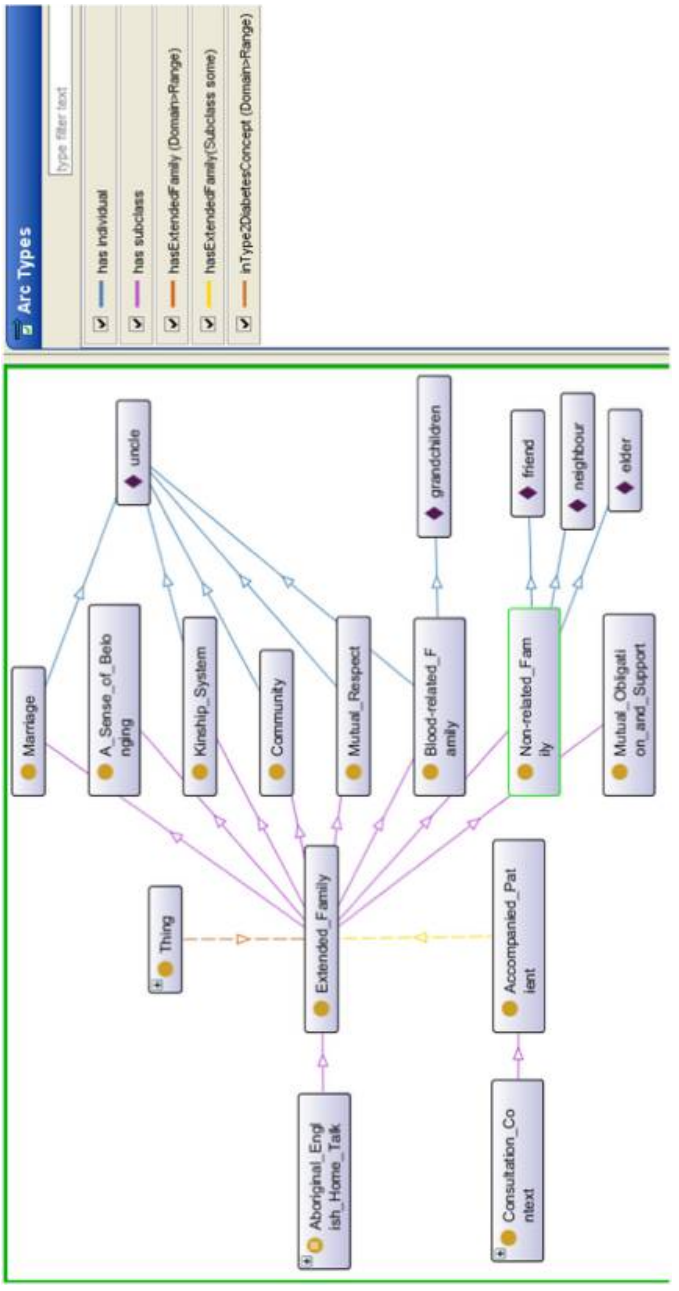

Figure 4.
Ontology graphic representation of the notions of extended family and community as family

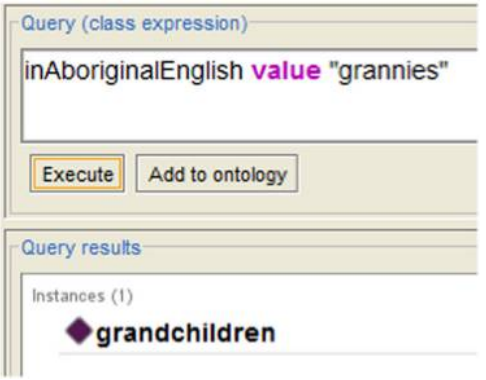

Figure 5.
Query to find possible meanings of word grannies

Figure 6.
Query result in detail for individual grandchildren

Among other subclasses of class Consultation_Context, Class Bio_Phycho_Social_Sensitive has classes Mens_Business and Womens_Business as subclasses. Class Bio_Phycho_Social_Sensitive relates to class Feeling_Shame with relation hasExpressivity. Instance of class Feeling_Shame show its detail in Figure 8. Class Feeling_Shame is subclass of classes Body_Language, Silence and Expressions. These refer that feeling shame is a kind of body language, expressions, and silence having signs of bowed head and turning away and having precaution of early unannounced departing from the meeting. Feeling shame can be shown or expressed in any consultation context. Men's business is bio psycho social sensitive in consultation context.

From these references shown in the PPAC ontology, this would tend to confirm that Dr Rose should call upon a male doctor colleague to conduct the PPIE. In the limited resource circumstance of most country clinics, general practitioners are not locally resident but conduct such clinic work on fly in fly out or drive in drive out visiting schedules. It would be more likely in the circumstances described to rely upon a locally based male Aboriginal health worker or nurse to overcome this barrier. For illustration purposes we assume here the availability of a male doctor we call "Dr Brown" and we account for this by recognizing that the Dr Rose is a new arrival in training as a locum to cover for Dr Brown while he is absent from the area.

AE mode of measurement. Projecting further that Dr Brown is treating another patient in a nearby home and will be back in 30 minutes, it is advisable for Dr Rose to reassure the two men so that they do not prematurely leave the clinic and fail to complete a PPIE with Dr Brown. In the PPAC ontology, different forms of media, i.e. audio, video and graphics are captured along with some concepts. There are in form of relations hasAudio, hasVideo, and hasPicture which links to location where media

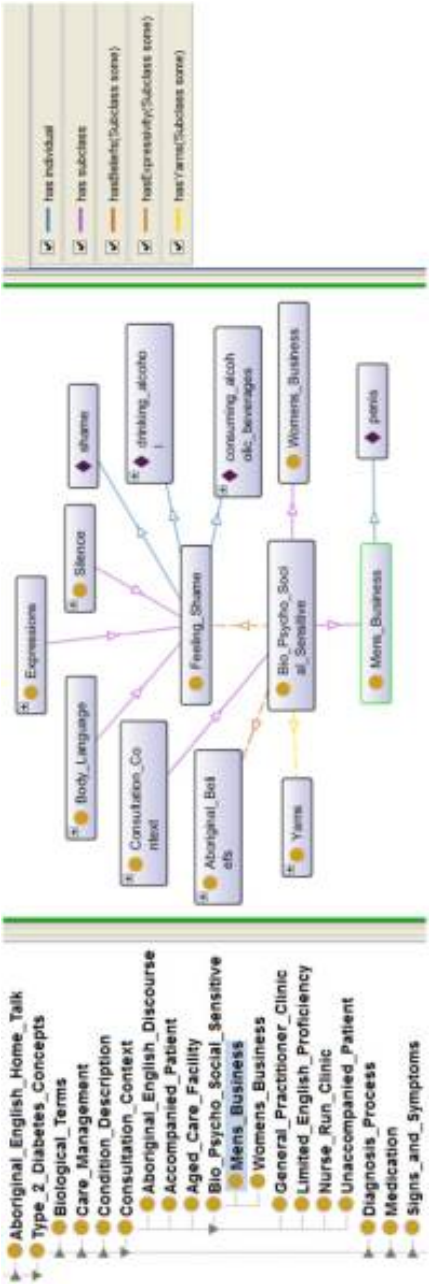

Figure 7.
Class relations to show related concept of men's business gender sensitive

files are kept. In the scenario, if Dr Rose navigates through AE concepts, quantifiable specification is captured to describe how the Aboriginal world view quantifies and qualifies things as temporal which references time and measurement which also express distance, dimensions and size in relational terms. Figure 9 shows class Quantifiable_Specification and its subclasses and instances.

In the scenario, Dr Rose finds instance "soon" and the recording of an AE voice can be heard to say "soon" in elongated version to represent AE mode of measurement emphasis. Instance "soon" has relation hasAudio with a string which is showed where its audio locates. It is to notice that elongated version of "soon" represent a short time, however, elongated version of "big" represent a large size which is opposite in distance of measurement. Figure 10 shows annotations for relationship hasAudio.

Note that this concept development is conceptual and although existing technologies can be used to deliver interactive speech systems suited to PPAC, this is a matter for future work.

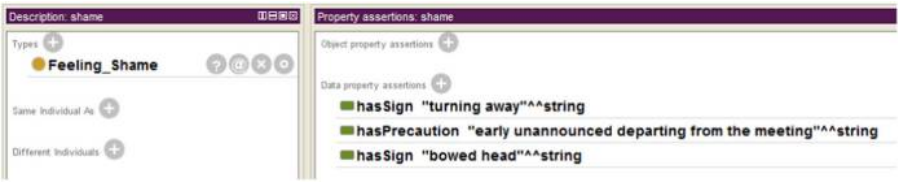

Figure 8.
Detail of individual shame of class feeling_shame

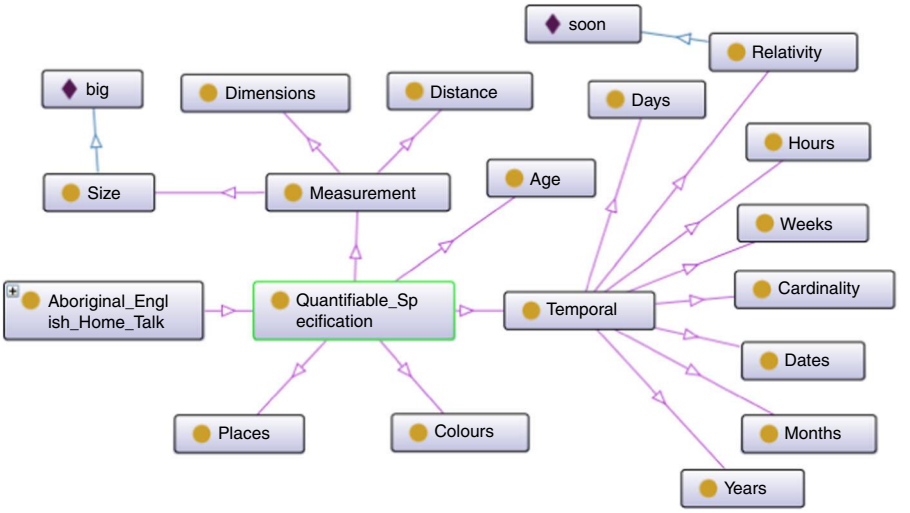

Figure 9.
Class quantifiable_specification and its subclasses and instances

Figure 10.
Relationship has Audio annotation

4.3.2 Scenario No. 2. Dr Brown, after being briefed by his female colleague, and with the advantage of access to a record of Vincent's prior medical history would be positioned to conclude, in advance of the PPIE with Vincent, that:

- The patient is a diagnosed Type II diabetic.
- Vincent has probably neglected his personal wellbeing as he appears to be in some distress; has not attended this clinic for a long time; and it is well established among medical professionals that T2DM, also known colloquially as "the lifestyle disease", demands constant attention with daily care to ensure patient wellbeing.
- From the information provided by Ted on Vincent's behalf, his condition will possibly include some form of personally intimate information and may necessitate examination of male genitals, hence the "men's business" references expressed by Ted.
- Ted represents a member of Vincent's extended family and subject to the doctor's professional judgement with the help of PPAC advice will be regarded in the PPIE as acting in the role of "carer". Carers of AE speakers living in rural and remote areas fulfil multiple roles including moral support during interactions with health care practitioners […].

Dr Brown's assessment as just described denotes recognition of challenges to cultural competence and safety in securing the continued cooperation of the patient. Dr Brown would have the opportunity to observe the two Aboriginal men in the waiting room. If we assume that he has not met Ted previously and has a vague recollection of Vincent as a patient from 18 months before, confirmed by his computer records, we can assess how the PPAC model will help to fill gaps in interpretation of Vincent's demeanour. A doctor with experience of consulting with Aboriginal patients in rural and remote areas may recognize the risk that the PPIE will end prematurely; behavioural signs may be witnessed but reasons and therefore prevention tactics may not be instantly evident. The men, for example, may be talking in a fairly agitated fashion but it is not possible to decipher exactly what is being said, the dialogue being rich with AE home talk, accents and dialectal phonology (pronunciation, sounds).

Self-populating. Dr Brown could, via this integrated ontology model concept, search for clues and cues. One challenge in this process is that conversations taking place between Ted, Vincent and the doctor will involve what is known as "code-switching". In "Ways of Being" and in the AE context Ian Malcom describes code-switching as follows:

> The speaker of Aboriginal English will often use Standard Australian English at work and when interacting within the broader community and Aboriginal English as soon as he/she is at home or within an Aboriginal community. This is called code switching. But for the speaker of Aboriginal English, this requires not just the changing of one's speech (pronunciation and grammar) but also requires reference to a completely different set of meaning systems for each dialect situation (Malcolm *et al.*, 1999).

Dr Brown at times will be an observer trying to make sense of what is said between the two Aboriginal men. From his observation, Dr Brown could populate new instances into his own knowledge base which may be useful and can be reused by other GPs. In this particular scenario it is possible that Ted is a community elder and is more self-confident than Vincent. Dr Brown would be able to learn from Ted any new words that might arise, with their meanings and populate into his ontology-driven system as new instances of dialect, words, phrase and expressions. Figure 11 shows class

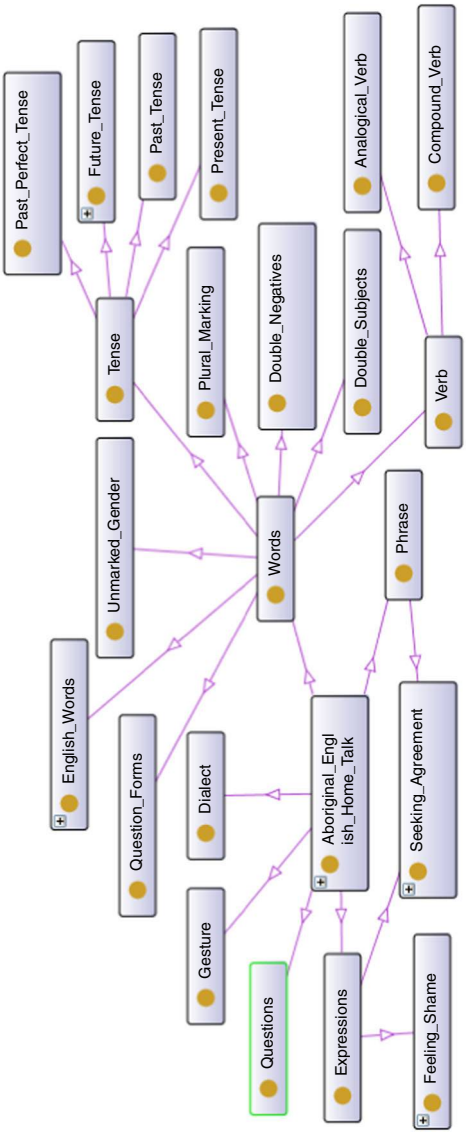

Figure 11.
Class Aboriginal_ English_home_talk and its subclasses

Aboriginal_English_Home_Talk and some of its subclasses in which could populate their instances while the ontology is in use.

Interrogating the system to determine whether dialectal differences might affect the PPIE communication is justified as a precaution. If it appeared that Ted is from the north of Western Australia, whereas Vincent is from the South-West, this may suggest a slowing of the PPIE conversations to limit miscommunication and misunderstanding. Dialectal advice options in the initial ontology constructions are, however, mostly limited to known Nyungar AE names and expressions.

Patient and health professional interaction. During the subsequent PPIE Dr Brown may adopt a physical posture that he has learned from the PPAC ontology to offset cultural barriers that present difficulties for his patient and carer. The idea promoted here is that habitual routine PPIE is an unreliable mode for communication when there is reason to believe in advance that the patient may intrinsically endure a persona or perception of significant cultural disadvantage. In many Australian country care circumstances, the Aboriginal patient is pragmatically disposed towards the provider sitting alongside the patient as opposed to a face to face positioning. Moreover this helps to reduce another risk that of offending the patient by using direct eye contact. The doctor would after consulting or confirming system advice choose to sit next to both men in the interview/examination room. Figure 12 shows advice on interaction captured in the ontology.

From Figure 12, the ontology-driven system would trigger the system to prompt practitioners of the importance of personal distance position, of listening and of empathy. In particular on personal distance position, the system would be able to further advise on appropriate seating positions with (for example) the suggestion of a short arc of three people alongside each other.

Asking questions. In the course of the PPIE Dr Brown will want to elicit some symptoms from Vincent, in part with the encouragement from Ted, who while not specifically acting as an interpreter, as a trusted member of Vincent's community can be regarded as Vincent's carer. One prevalent problem in the Aboriginal T2DM management domain is the consumption of alcohol. It is a subject matter replete with AE euphemisms and metaphors with a fairly high risk of being missed by unfamiliar general practitioners. Patients generally as well as Aboriginal patients can be defensive when asked questions on this topic. Figure 13 shows this is annotated as precaution in asking such questions.

The design thinking for this is that although there is no intention or attempt to implicitly or explicitly interfere with the work of the qualified medical professional, the overall aim of the model is to help participants move towards a shared compact for

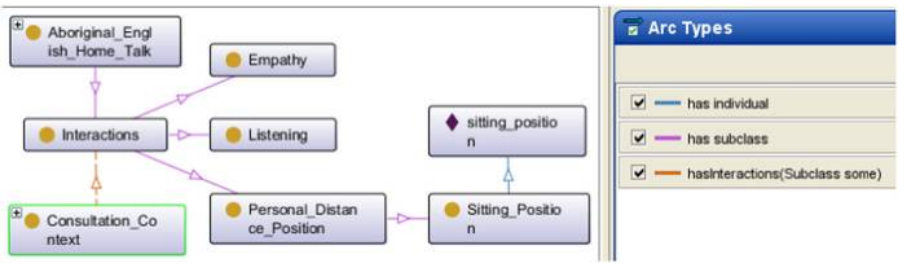

Figure 12.
Capture of advice on interaction

improved patient wellbeing outcomes. To that end the ontologies cross-map AE and T2DM guidelines to highlight differences in world views and thereby head off break downs in cognitively consonant communication.

From commonly used AE expressions we can also identify that when the patient closes a statement with "unna" this means "isn't it so?" or "isn't that right?". "Unna" is therefore a single word that may be found by querying shown in Figure 14. Figure 15 show query result in detail in which it shows that it is individual of class seeking agreement.

Building trust. Doctors can carefully seek further information based on professional knowledge and the T2DM guidelines ontology mapped to AE. Already having reason to investigate "men's business", Dr Brown can use both observational and system generated indicators of the likely gender sensitive issue. It may be prudent to avoid launching too quickly into the removal of clothing for a physical examination as the patient's reaction is unpredictable without the benefit of further engagement and trust building. Our approach is to use ontology annotation tags that will include clinical

Figure 13. Data property has precaution for instance asking_questions

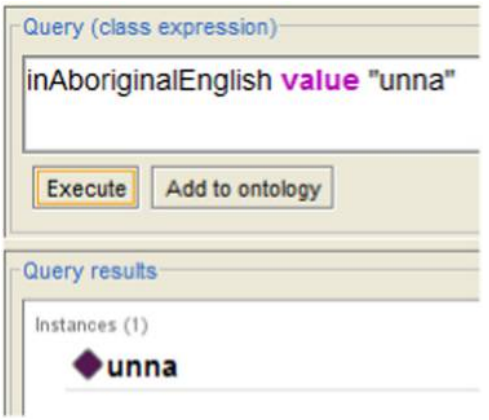

Figure 14. Query to find possible meanings of word unna

Figure 15. Query result for possible meanings of work unna

graphic depictions of a range of known conditions that can become evident as biological signs and symptoms. Many GPs have such visual media on their own system and/or fast access to accredited Web based health files serving the same illustrative purpose. This is a process mentioned by way of ontology annotation advice on AE emotion in the context that making the patient feel that his condition is not unusual but important to treat, will help remove a barrier to physical examination. It will be necessary to include colloquial AE descriptions for genitalia in the ontology, e.g. "Ma ole fella" is one Nyungar expression that refers to male genitals, and there are others more commonly found in the more earthy English slang. It is not likely for instance that formal anatomical words such as "penis" or "testicles" or "vagina" will be used in AE discourse; but it will be necessary over time to build the ontology so that T2DM maps with many AEHT alternatives. Figure 16 shows query to find an AE word for penis in SE. Figure 17 shows query result in detail.

4.4 Summary of AE conceptualization

During any discussion about personal health regardless of cultural considerations the conversational flow does not exclusively contain or dwell upon clinical healthcare terminology. Even when a PPIE is dominated by a practitioner who is not skilled in or who does not discernibly practice social engagement, the many natural words that help us to make sense of utterances are essential to establish the opportunity for patient history taking, including most importantly, recent symptoms and health related events. In the QGA, biopsychosocial barriers include weaknesses and failures in equitable

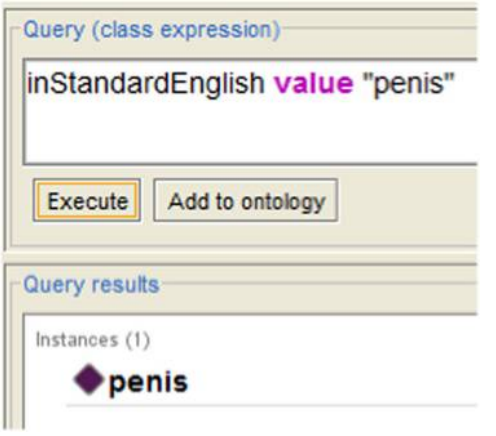

Figure 16.
Query to find an AE word for penis in SE

Figure 17.
Query result for an AE word for penis in SE

social engagement. This is a direct conflict with the cultural worldview priorities of Aboriginal patients, whose mode of achieving trusted engagement is to first exchange information on a social level, sometimes using stories known as yarns, while effectively seeking to open up a dialogue based upon mutual knowledge, one of the other.

Western logic does not match the Aboriginal worldview. This is amply illustrated by the findings of the QGA. This means that relationships between concepts in the ontology are influenced by variable patterns in which semantics and syntax are heavily dependent on surrounding context, as determined from the broader conversational content. These do not reliably accord with and can defy the norms of English grammar. In the ultimate design process for the PPAC, a preparatory tutorial in the form of a system walk through Wizard, must set the scene, differently for the two cultures, i.e. Aboriginal patient and health care practitioner. This will elaborate on the QGA barriers and how these can be overcome. Included in the ontology is a concept class Aboriginal_English_Grammar and sub-class concepts that allow for gradual population of AE every day home talk words. We have begun this process with AE educational literature sources and our focus group output; but it is acknowledged that a considerable effort is required in future work to discover and document more AE home talk words, phrases and other forms of expression as part of a general vocabulary. Figure 18 shows AE classes and subclasses.

A depiction of an Aboriginal PPIE case study in various scenarios can be found in (Forbes *et al.*, in press). Due to space limitation, we cannot show all ontology population of AE in context of healthcare. When we view this through the biopsychosocial lens, however, it is possible to learn how words can help to create context. For example, a practitioner treating a diabetic patient is interested to know about dietary practices of the patient. Speaking about food, the patient will use the word "feed" as a noun, not necessarily as a verb. When speaking about a diet that includes sources such as flora

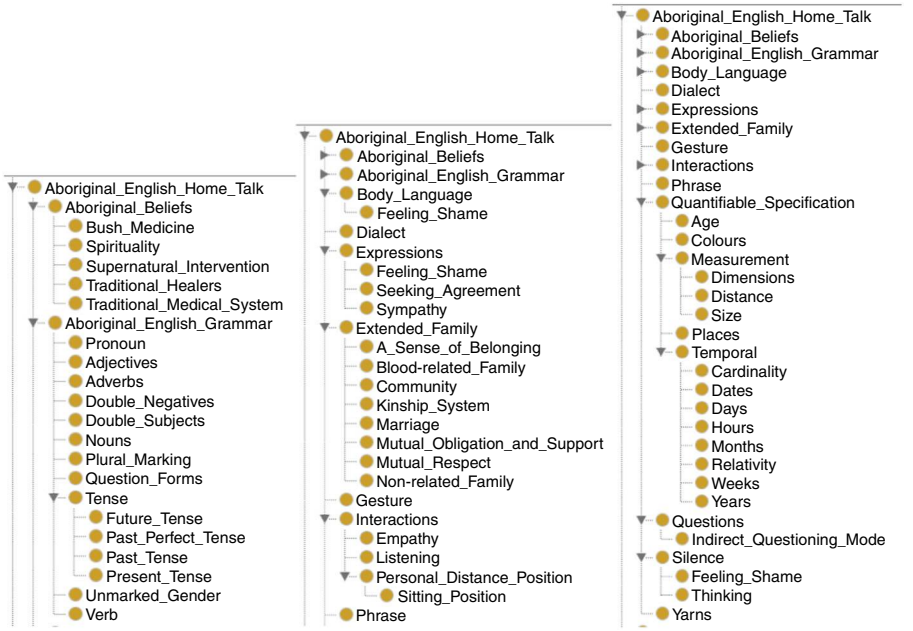

Figure 18.
Aboriginal English classes and subclasses

and fauna, such as wild berries and kangaroo meat, the patient may refer to bush tucker. The complete description comprises these two words, and separately the words "bush" and "tucker" may not truly reflect what is being described. Moreover the phrase "deadly tucker" does not mean poisonous food, but effectively the opposite, i.e. really good, enjoyable food for the Aboriginal person. We have listed these terms in the health care focus group output table as diet is so significant in T2DM care.

Perhaps one of the most delicate and challenging areas of PPIE discourse with the Aboriginal patient is the presence in the patient's mind and worldview, of beliefs unfamiliar to the practitioner. This features strongly in the QGA and includes spirituality factors. It is always possible that the patient has been following traditional remedies and community consultations with respected elders who have a holistic approach to treatment and care, including what is sometimes referred to as "bush medicine". A patient mentioning a song and "debil debil" would be revealing a spiritual belief in a supernatural message and an evil spirit. Cultural competence, at the top of QGA findings list, is therefore a major objective in the development of the ontology, of enrichment of property annotations and investment in user tutorial design.

Spirituality factors cannot be safely ignored or even covertly denigrated in the PPIE while patient wellbeing remains the priority. Utterances or other forms of expression during the PPIE may appear mysterious to the practitioner but because these have a significant psychological role in the life of the patient, knowledge of the principal beliefs through ontology inclusion is necessary. This initially takes the form of textual annotation; future work will present graphic representations where culturally appropriate. Due to space limitation we cannot show ontology population of Aboriginal beliefs.

Our observations of PPIE communications issues include work with an Aboriginal focus group, interactions with members of the Aboriginal health care community, and critical review of a substantial literature of comprehensively constructed educational studies into AE (O'Brien and Plooij, 1973; Malcolm *et al.*, 1995, 1999; Cahill and Collard, 2003; Eades *et al.*, 2000; Eades, 1991, 1993/2000; Sharifian *et al.*, 2004, 2012).

5. Limitations of this research

There has been no direct engagement with remote Aboriginal communities in this work to date. We have initially been able to rely upon a cohort of both Indigenous and non-Indigenous people with relevant cultural expertise and extended family relationships. Among these advisers are health care practitioners, academics, trainers, Aboriginal education researchers and workshop attendees. It must therefore be acknowledged that as is the case with the QGA, the majority of the concept data is from third parties. We have also discovered that urban influences and cultural sensitivities tend to reduce the extent of, and opportunity to, witness AE usage, thereby limiting our ability to capture more examples of code-switching. Although the PPAC system concept is qualitatively well developed, pending future work planned for rural and remote community engagement we presently regard our work as mostly allied to a hypothesis on ontology-driven communications. The concept data population of the AE home talk/health talk ontology has not yet reached a quantitative critical mass to justify application design model engineering and real-world testing.

Australia's ethnic diversity is considerable, with multiple languages spoken in the home (Commonwealth of Australia House of Representatives Standing Committee on Aboriginal and Torres Strait Islander Affairs, 2012; Australian Bureau of Statistics, 2012). Taking into account the continuing dominance of English in public and private health care and in Australian life generally the prospect of building an intercultural

communications bridge based upon simplified English holds out greater hope for progress than other "purist" translation options. Attempting to construct a large and diverse multilingual, multidialectal and very complex assistive communications tool presents formidable obstacles not only in the effort required but in the essential of achieving user receptivity.

6. Conclusion

The combined QGA and focus group output reported here has served to illustrate the call for three important drivers of change, i.e.: first, PPIE for Aboriginal patients and wellbeing outcomes are unsatisfactory; second, there is a need for cultural competence knowledge and practice uptake on the part of health care providers; and finally, communication is the key component within healthcare for ethnic minorities. Communication, however, can only be of value in health care if in practice it supports shared cognition; and mutual cognition is rarely achievable when biopsychosocial and other cultural worldview differences go unchallenged.

Computer ontologies avail us of the opportunity to use ACT applications as a dynamic support system to elevate the pragmatic experience of health care consultations for both patients and practitioners. We have begun the first construction of a merged schema for two domains that already have a seemingly intractable negative connection. Through the ontology discipline of building syntactically and semantically robust and accessible concepts; explicit conceptual relationships; and annotative context-oriented guidance; we are working towards addressing health literacy and wellbeing outcome deficiencies of benefit to the broader communities of disadvantage patients. The continuing challenge is to enrich the information source schema and semantic quality of the data to populate and map the merged ontology systems so that the eventual applications model will be attractive to and its use ubiquitous among the major stakeholders in health care PPIEs.

6.1 Comparison with the related work

Nešic *et al.* (2010) propose an ontology-driven approach to semantic annotations, initially by lexical expansion of ontological concept descriptions to "enhance syntactic matching". Che-Yu Yang and Hua-Yi Lin (2011) are working towards ontology and Resource Description Framework-based automated approach to semantic annotation for the web of data; arguing that if text data is linked to vocabulary, the data can be understood by machine while reasoning can be accomplished through the defined inter-vocabulary relationships. A number of resource acquisitions and developments are required for this to be achieved and in common with other emergent ICT and semantic web activity is not yet mature enough to accommodate PPIE healthcare type applications.

The prospect of machine-conversational simulation is attractive but too complex in the contemporary environment, i.e. not achievable in the near term to satisfy the equally challenging and complex nature of PPIEs. In this research, however, it is important to identify the path and purpose of other work, as already inferred in the hope to steer opportunity for future technology convergence.

Attention has been paid to the work of Bickmore, who with alternate others is widely published for his work on reusable automated health counselling dialogue systems; and on the Boston University work on relational agents as "computational artefacts designed to build long-term socio-economic relationships with users" (Bickmore *et al.*, 2007, 2011). This particularly references disparities in diabetes and

treatment, the serious social threat from T2DM with the health literacy context as a backdrop factor.

Viewing relational agent web-based demonstrations of this development it is, however, apparent that the educated level, phonology, and overall presentation of the simulated human articulations in the interactive model are close in conversational style to that of the real-life dominant clinician culture. In this form it does not accommodate people with LEP. Whereas the relational agent work offers great promise and along with other Bickmore related research findings is synergic with objectives of this research work, it is one more factor influencing choice of formulation for using ontologies in the conceptual construction of Aboriginal and ethnic minority ACT. The contemporary status of such work is that it is intended to promulgate support for the push and pull of purposeful knowledge flow through the knowledge supply chain, for widely shared user applications from evolving next generation networks.

6.2 Future work

The intention is to use the work reported here as a design base to offer a computerized communications application that can be employed via convenient and ubiquitous devices to assist PPIE that are otherwise disadvantaged by cultural differences and consequential communications. Contemplating the contemporary status of health literacy and its role in communications efficacy, future work must examine societal trends in seeking and attempting to understand health and healthcare information, extending ACT system capabilities to the general mainstream user population.

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About the authors

David Forbes has enjoyed decades of successful experience in industrial and government management roles. Raised and educated in England, trained as a Senior Detective at New Scotland Yard, he holds a PhD in Information Systems from the Curtin University, Western Australia, a Master's Degree in Security Management from the Loughborough University UK, and a Graduate Certificate in Research Commercialization also from the Curtin University. His PhD thesis was initially dedicated to the advanced development of communications that will facilitate remote healthcare service delivery to Australia's patient communities disadvantaged by distance, socio-economic and socio-cultural circumstances. In further development, this research will lead to assistive communications technology applications that will serve broader mainstream populations as well as ethnic minorities; the latter including refugee groups. David is a former Global Head of Security for a major international express logistics organization, Creator and Leader of the first global security management in the Express Logistics sector. His handpicked regional team covered 140 countries. He later became the CEO/President of risk management and systems design businesses in the USA, and a recognized expert in aviation safety and security management frequently appearing as a guest on American Radio and TV broadcasts including ABC, CBS, CNN, NBC, Fox News and many other national and regional stations. In his volunteer capacity he was at one time the President of the Rocky Mountain British American Chamber of Commerce based in Denver, Colorado. David's "risk management by environmental design" skill set has long embraced an ability to configure leading edge technologies that consequently optimize productivity within a variety of organizations. Much of this work has been conducted as a team member and project manager involving highly skilled architectural engineering and design team contracts. Clientele consist of large and small public organizations and private sector businesses; services to government agencies with highly sensitive requirements include (inter alia) emergency response and military operations sites. David's continuing professional focus is the enhancement of multicultural human and human-machine communications, specifically though not exclusively in the context of health care consumer populations. David's coaching mentoring and presentation capabilities have consistently delivered productive outcomes for a range of community engagement beneficiaries, from students to seniors. His risk management and logistics expertise is today reflected in and directed toward his passion for overcoming barriers to service delivery. In healthcare and in other high demand sectors these challenges are met by creative application and integration of established and emerging technologies.

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