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# A framework for an intelligent decision support system: A case in pathology test ordering

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ABSTRACT

Decision context, knowledge management, decision makers, and decision strategy are fundamental components for understanding decision support systems (DSSs). This paper describes the specific case of designing a framework for an intelligent DSS in the *context* of pathology test ordering by general practitioners (GPs). In doing so it illustrates the processes of discovering practical and relevant *knowledge* from pathology request data generated and stored in a professional pathology company, investigates and understands the *decision makers* (GPs) through a survey about their current practices in test ordering and their requirements for decision support, and finally proposes an intelligent decision support framework as the decision *strategy* to support GPs in ordering pathology tests more effectively and appropriately. The process and framework developed through this case contributes effective guidance for practitioners and theoretical understanding concerning intelligent decision support in a complex environment.



## 1. Introduction

Ordering of pathology tests by general practitioners (GPs) contributes significantly to the rising costs of health care [48]. Over the past decade Australia has witnessed a considerable rise in the number of and expenditure on pathology requests by GPs. This increase is the consequence of: improved communication between patients and GPs; government incentives for longer consultations; the shift of health services to a community environment; increased concern about medical litigation; and/or increased patient expectations [11,29,48]. Other external factors include the introduction of new Medicare Benefits Schedule (MBS) items and increased computerization [12]. Globally there is a perception that pathology tests are not used appropriately [49,65,67,75,76,80], although there are concerns with the rigor in some studies and associated weak supporting evidence [45,64,74].

Evidence-based medicine indicates that tools like computerized clinical decision support systems (DSS) can improve the quality and effectiveness of clinicians' decisions [16,18,28,34]. For Australian GPs, although government promotion and incentives have resulted in increased use of "medical desktop" software as the referral point for primary care during patient consultations, particularly for prescribing medications (98%), checking for drug–drug interactions (88%), ordering laboratory tests (85%), running recall systems (78%) and recording progress notes (64%), the current application of computerized clinical DSSs is limited [33,47,78]. For example, with respect to *pathology requests*, the most common practices involve ordering laboratory tests (85%), receiving or storing pathology test results (79%) and running the recall system for routine tests (78%) rather than investigating the suitability of available options.

Evidence from some studies show that a high percentage of real-time clinical decision support suggestions are being over-ridden or ignored due to disruptions to workflow, time restraints and a perceived lack of relevant suggestions [52,69,77]. Hence, in designing a pertinent DSS, it is crucial to take account of contextual factors.

The aim of this paper is to develop a framework for a DSS that can assist GPs in ordering pathology tests more effectively and appropriately. In so doing we establish the merit of an integrated approach that combines knowledge discovery and case-based reasoning (CBR) mechanisms to capture the contextual requirements for an *evidence-based*, *situationally relevant*, *flexible* and *interactive* DSS, which we call an *intelligent* DSS.

The contributions of this study are three-fold. Firstly, by discovering and extracting practical and relevant knowledge from past pathology request data, we provide fresh understanding about the use of pathology tests from both patient-centric and clinical situation-centric perspectives. Secondly, results from our online survey provide comprehensive understanding about the appropriateness of GPs' ordering behavior as well as their needs of and requirements for intelligent decision support. Finally, this study shows how an integrated approach can be used to create an *evidence-based*, *situationally relevant*, *flexible* and *interactive* DSS that suits complex environments.

The remainder of the paper is structured as follows. Section 2 discusses the limitations of existing support for GPs in ordering pathology tests, while the components involved in decision making in the context

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of pathology ordering are outlined in Section 3. Section 4 describes the processes deployed to discover and extract useful knowledge/evidence from past ordering behavior that can be used to inform the decision making process, while Section 5 reviews the decision makers' (i.e. GPs') needs of and requirements for support in ordering pathology tests. These ideas are synthesized in Section 6 where the research proposes and reviews a framework for an intelligent DSS as a strategy to support GPs in ordering pathology tests more effectively and appropriately. In Section 7 we highlight implications for future research and present our conclusions.

## 2. Background

In prescribing drugs, guidelines are generally presented to GPs as a series of brief prompts targeted at managing individual patients [2]. In contrast, decision guidelines for pathology ordering are primarily disease-focused and contain low levels of evidence. Even when a high degree of evidence is available in a disease setting, information about the application of laboratory investigations in specific patient situations is often limited [66]. At present, when GPs order pathology tests, the clinical guidelines are commonly presented as text, in paper or static electronic form. While this extends GPs' own knowledge and experience, given that most clinical guidelines have not been developed in a format that allows easy incorporation into computerized clinical DSSs, flexible and interactive guidelines are yet to become reality [37].

General feedback provided by pathology companies to a GP on pathology ordering typically contains general and brief information on the overall volume of tests ordered by that GP during a given period of time, without detailed and specific information like the tests ordered for a particular group of patients with a particular kind of disease. As this omits patient characteristics, there is no patient-specific or situationally relevant evidence to assist GPs. Thus, it is unsurprising that studies have shown that GPs' everyday behavior can be based on less than effective clinical memory [20].

General practice centers on the individual patient–doctor relationship [73]. Given that in the decision making context of pathology ordering, the current decision support provided to GPs has very limited interactivity, flexibility, situational relevance, and evidence base, we propose to address these deficiencies through development of a framework for an intelligent DSS. This enables more situationally effective ordering of pathology. Before detailing the framework we introduce the theoretical foundations of the study.

## 3. Theoretical foundation: decision making in the context of pathology ordering

Using the context of GPs' ordering pathology tests, we now discuss the theoretical underpinnings of the framework for the aforementioned intelligent DSS. Herein, decision support activities can be broadly defined as the set of activities within unstructured or semi-structured decision contexts that aim to support rather than replace the decision maker, facilitate learning on the decision maker's behalf, and use underlying data and models to focus on the effectiveness of the decision making process [46]. Given a DSS, in the context of decision making, is a tool, key components requiring appreciation include:

- the decision context (see Section 3.1);
- how knowledge is used (see Section 3.2);
- the decision makers (see Section 3.3); and
- the typical decision strategies (see Section 3.4) [36].

These components are outlined below.

### 3.1. Decision context

Decisions are not produced in a vacuum. They are made within a specific environmental *context*, with the broader context in which decisions are made needing to be adequately considered [26]. As summarized in Fig. 1 (see below), decision making is a multi-step process comprising problem recognition, information search, problem analysis, alternative evaluation and choice [22].

Based on appreciation of specific patient characteristics like demographics, past clinical history (including past pathology tests) and existing symptoms or diseases, the decision making process begins with *problem recognition* related to a need to order certain tests for a particular patient. To support decision making, in the *information search* process, standardized guidelines or protocols are consulted and combined with subjective personal knowledge or experience. Through this *problem analysis* GPs derive a meaningful list of plausible tests to be ordered. These alternative tests are then evaluated (*alternative evaluation*) before a choice is made regarding the particular types of tests to be ordered. This *choice* can be influenced by internal factors (such as a clinical need for screening, diagnosis, disease monitoring or prognosis) and external factors (such as patient pressure, defensive behavior, clinical guidelines and government economic and cost considerations) [43,44,79].

### 3.2. Knowledge

According to Burstein and Carlsson [14, p. 104], *knowledge* management is the "continuous process of acquiring and deploying knowledge to improve decision making". Knowledge overflow contributes to the decision makers' need for relevant and reliable knowledge to make 'the right decision' [36].

Presently, sources of knowledge to support GPs in ordering pathology tests include clinical guidelines (e.g. the *Manual of Use and Interpretation of Pathology Tests*) and educational material (e.g. the *Common Sense Pathology* series) [56,57]. However, their impact is limited [56] because the information is often regarded as too diverse, inaccessible, overwhelming and/or difficult to contextualize [32,36,61,70]. The question that arises is how can knowledge be identified and structured so that GPs can access the "right" information in the "right" format at the "right" time i.e. providing information that works at an individual patient level, rather than as general guidelines.

In the course of modern pathology, massive amounts of pathology ordering data are generated and stored by professional pathology companies. This means that the data required to build such a knowledge base already exists, which creates the potential to extract the

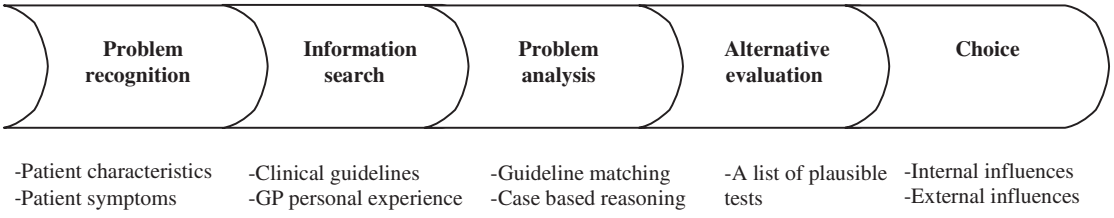


**Fig. 1.** The decision context.
Framework adapted from [22,84].