A STUDY OF SURGICAL WAITING LISTS AND WAITING TIMES

FOR

SELECTED PROCEDURES IN BRITISH COLUMBIA

By

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ABSTRACT

For some time, the issue of waiting lists and waiting times has played a significant role in the debate about access to health care services in Canada. They are increasingly being blamed for hindering reasonable access to health care services and governments across Canada, both provincial and federal, are continually called on the address the issue of waiting lists and waiting times. A comprehensive understanding of the nature of waiting lists and waiting times is critical to the development of effective policies. The evidence regarding the nature of the waiting lists and waiting times and the factors affecting them remains in the early stages.

The purpose of the study is to contribute to a more comprehensive understanding of the nature of the waiting lists and waiting times. Specifically, the study seeks to: (1) critically review the published and unpublished literature; (2) develop a conceptual framework identifying various patient, physician and hospital factors that may affect waiting lists and waiting times; (3) assess the validity and reliability of the B.C. Surgical Waiting List Data (SWL); and (4) identify patient, physician and hospital factors that significantly affect patient waiting time. The study focuses on four surgical procedures: knee replacement, hip replacement, cardiac and cataract surgery.

Literature Review

A critical review of the existing literature from Canada and abroad revealed several key themes and gaps in our understanding of waiting lists and waiting times. First, the accuracy of waiting list data and the validity and reliability of key measures (i.e. "date-on", "date-off", waiting list size) are often suspect. Second, the evidence regarding factors affecting waiting lists and waiting times remains in the early stages of development and as such, there are significant gaps in the evidence.

Validity/Reliability of the SWL Data

The accuracy of the SWL data were assessed using established data assessment methods for a single and multiple data sets. Additional administrative health care data, hospital separations and physician billing data, were used to assess the validity of the SWL. Overall, the data

appear to be valid and reliable accurately representing those patients placed on the waiting list. Linkages of the SWL data with the hospital separation and physician billing data were highly successful and resulted in high rates of matching for most variables on the SWL. A validity assessment of "date-on" the waiting list revealed that in most cases (50%-60%) patient were placed on the waiting list following their last pre-surgical consultation. A similar assessment for "date-off" revealed that most patients (≥ 90%) were removed from the list on the day of their surgery. The validity of waiting list size, however, revealed that the SWL may under-represent the total population undergoing surgery for the selected procedures.

Factors affecting Waiting Times

Autoregressive models (AR1) were used to identify significant patient, physician and hospital factors affecting individual patient waiting times. The final models explained between 58% (cataract surgery) and 61% (knee and hip replacement) of the variation in patient waiting times. The results of the analyses clearly indicate that patient factors represent most of the explained variation. Specifically, variables representing clinical status (urgent/emergent), placement on the waiting list and movement on the waiting list were significantly associated with patient waiting time. These findings have implications for policy options available to address the issue of waiting lists and waiting times.

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CHAPTER I

INTRODUCTION

In most publicly funded health care systems, waiting lists are widely used as indicators of access to health care services, with implications for individuals, health care professionals, policy-makers, and governments. For some patients, they may simply represent minor inconveniences. For other patients, however, excessive waiting periods may result in considerable anxiety, adverse health effects and lower quality of life. From a health care provider perspective, waiting lists may represent restricted availability of resources they deem necessary for the management of their patients. From a broader health care system organization and funding perspective, waiting lists have been viewed as measures or indicators of general accessibility, equity of access and under-funding. As waiting lists are increasingly blamed for hindering reasonable access to health care services, governments across Canada continue to be called on by health care professionals and patients to address the issue of waiting lists and waiting times.

A comprehensive understanding of the nature, extent, and scope of waiting lists is fundamental to the development of effective policy. The results of various research efforts conducted both within Canada and internationally provide some insight regarding the nature of waiting lists and waiting times and the factors that may affect them. However, currently, much is assumed but little is actually known about the nature of wait lists and wait times. The debate surrounding how best to address them, therefore, has often been driven by assumptions regarding the nature of waiting lists. A more comprehensive understanding of this phenomenon and the factors that

affect both wait list size and wait time is required to better inform policy development in this area.

This study seeks to contribute to a more comprehensive understanding of the nature of waiting lists and waiting times. The objectives of the study are as follows:

- To critically review and synthesize the information identified in the published and unpublished literature regarding the nature of waiting lists and waiting times;
- To develop a conceptual framework that identifies patient, physician and hospital factors hypothesized to affect waiting times and waiting lists;
- To assess the validity and reliability of the B.C. Surgical Waitlist Registry Data (SWL), specifically to assess the construct validity of "date-on" the waiting list; and
- To identify the patient, physician and hospital factors which significantly affect patient waiting time.

The study focuses on waiting lists and waiting times in British Columbia for four procedures: knee replacement, hip replacement, cardiac surgery and cataract surgery. At the start of this project, these four procedures were gaining attention, both within the health car sector and in the media, due to commonly cited problems with both waiting list size and waiting times. As such, they were selected for further investigation in this project.

The study begins with a critical review and synthesis of the information identified in the published and unpublished literature regarding waiting lists and waiting times. Both the national and international literature were canvassed to ensure a comprehensive review. The information has been organized around a set of key themes: conceptualizations of waiting lists; definitions

and measurements of waiting list size and waiting times; characteristics of waiting lists and waiting times; and factors affecting waiting lists and waiting times. A key issue is that waiting lists and waiting times are defined and conceptualized in a variety of ways by various different groups. It is important to understand how individuals conceptualize these phenomena since they often provide insight regarding individuals' understanding of the nature of waiting lists and waiting times and the factors that affect them. There is currently little agreement regarding appropriate methods and indicators that should be used to measure waiting times. The various methods currently used must be explored and the implications of their differences highlighted particularly with waiting lists and waiting times are compared across groups (i.e. physicians, hospitals). Finally, the chapter includes a review of all studies that attempt to identify factors that explain the variation in waiting lists and waiting times. This information serves as the foundation for this study. The Chapter concludes with some key findings and suggestions for future research.

One of the key findings of the literature review was the absence of a conceptual framework that identifies those factors that are believed to affect waiting lists and waiting times. Chapter 3 focuses on the development of such a framework. The work builds on advances made in other areas of health services research namely, access to health care. Waiting lists and waiting times are often defined and described within the broader context of access to health care services. The access to health care literature, therefore, provides key concepts and understandings that can be appropriately applied to the study of waiting lists and waiting times. The framework identifies specific patient, physician and hospital factors and the mechanisms through which they are hypothesized to affect waiting lists and waiting times.

The primary source of data for the empirical portion of this study is the B.C. Surgical Wait List Registry data (SWL). This administrative database is unique in Canada since it represents the waiting list information from most of the major hospitals in a single province. The availability of this data provides an opportunity to address some of the fundamental issues and concerns raised in the literature regarding the quality of waiting list data as well as factors that may affect patient waiting time. Chapter 4 focuses on the assessment of the validity and reliability of the SWL data. Concerns have been raised in the literature regarding the accuracy of administrative health data in general and of waiting list data in particular. This chapter begins with a general discussion regarding the uses of administrative data and the methods proposed to assess the quality of such data. Data assessment methods for a single database and for two or more databases are applied to the SWL data. In the first part of the analysis, descriptive analyses and basic checks are performed to assess the internal validity of the data. The results of this assessment are then used to guide the second stage of the analysis. In the second part, the SWL data are compared to two other administrative databases, hospital separation and physician payment data, to assess the validity and reliability of the patient, physician and hospital information provided in the waiting list data. In addition, the data are used to study the construct validity of two key indicators namely, "date-on" and "date-off" the waiting list and the validity and reliability of waiting list size.

Once the quality of the SWL data has been assessed, the data are used in Chapter 5 to investigate the level of variation in waiting time and to test some of the hypothesized relationships outlined in the conceptual framework. The chapter begins with a descriptive analysis of the intra-procedure variation in patient waiting time occurring across physicians and hospitals. This is followed by the development of several regression models that seek to identify the patient, physician and hospital factors that significantly affect patient waiting time for three procedure

groups. The model is specifically developed to suit the particular characteristics of waiting list data.

The study concludes with a review of the significant findings and their potential implications for policy development and for future research regarding the nature of waiting lists and waiting times.

CHAPTER II

LITERATURE REVIEW

The primary goal of this chapter is to synthesize the information identified in the published and unpublished literature regarding the nature of waiting lists and waiting times. Both the national and international literature have been canvassed for this purpose. The information has been organized around a set of key themes regarding the nature of waiting lists and waiting times. In the following section, the methodology is outlined including both the search and synthesis strategies. Within each thematic area, relevant studies are presented and assessed against a set of pre-determined criteria.

2.1 METHODOLOGY

This chapter contains a critical review and synthesis of the published and unpublished information regarding waiting lists for health care services in Canada and abroad. This section describes the research strategy used to identify the sources of information and the methods used to critically review the studies identified.

2.1.1 Search Strategy

Information on waiting lists was sought in both the published and unpublished literature. Search strategies were developed to suit the particular type of literature.

Published Literature

The primary source of original research regarding the nature of waiting lists and waiting times was published journals and books. Empirical studies were identified using the following medical and social science databases:

MEDLINE: includes all published international literature on medicine and health care-related topics from 1966 to present;

HealthSTAR: includes all published literature in the areas of health administration, planning, facilities and personnel administration from 1975 to present;

CINAHL: a multidisciplinary database including published literature in the area of nursing, allied health, biomedical, and consumer health literature from 1982 to present

SOCIOFILE: includes published journal articles, books, and conference papers in sociology and related social science disciplines

These databases were searched using the following key terms: "waiting lists", "waiting times", in conjunction with "accessibility" and "non-price rationing".

A thorough search of published books was conducted using the online catalogue system at both the University of British Columbia and the University of Ottawa. In addition, book references were sought through the Internet at "www.amazon.com", one of the largest listings of available books.

Unpublished Literature

The identification of unpublished literature presented more of a challenge and therefore required several approaches. First, key Canadian stakeholder groups including health care organizations, research institutes and government ministries were identified through contacts known to the committee members (Barer and Sheps) and the *Directory of Associations in Canada* and the *Canadian Research Centres Directory*. Key international research institutes with an interest in waiting lists were also identified. Second, a preliminary search of the web sites of these key groups was conducted via the Internet to identify sources of information and contacts. Third, contact was made with each group via either e-mail or telephone for a formal request for information. Finally, an additional fugitive literature search was conducted through the library services at the Centre for Health Services and Policy Research, UBC.

2.1.2 Synthesis Strategy

The key objective is to synthesize all relevant published and unpublished sources of information which contribute to a more comprehensive understanding of the nature of waiting lists and waiting times. As such, a broad range of research was identified. The canvassed literature has employed a rich mix of methods to investigate various aspects of waiting lists and waiting times. It is very diverse in both purpose and methods. The information presented in this chapter has been organized around key themes of relevance to waiting lists and waiting times:

- conceptualizations of waiting lists;
- definition and measurement of waiting list size and waiting times (reliability and validity);
- characteristics of waiting lists and waiting times; and
- factors affecting waiting lists and waiting times

In most cases, a particular reference could be categorized under one of these organizing themes, based on the primary purpose of the document. Within each section, relevant studies are described and critically reviewed where appropriate. The latter applies primarily to empirical studies based on primary or secondary data analysis. Each section concludes with a summary of the key findings as well as the identification of gaps in knowledge.

2.2 CONCEPTUALIZATION OF WAITING LISTS

In Canada, as in other countries with publicly funded health care systems, waiting lists are often assumed to mean the same thing to all people at all times. Waiting lists are often viewed as an indicator used to assess the state of the health care system. In the Canadian context, waiting lists are often characterized by the media, and others, as a leading indicator of health-threatening access impediments to publicly funded health care. However, wait lists clearly represent different things for different people and different systems. The conceptualization of wait lists can affect, or restrict, the potential policy options considered; for example, if one views wait lists as an indicator of inadequate resources, the policy solution is obvious. Similarly, if wait lists are viewed as indicators of excess patient demand, this might lead to a policy of increased prices to patients. In the following section, various conceptualizations of waiting lists are outlined as they appear in the published and unpublished literature.

2.2.1 Indicator of Unmet Need/Demand

Perhaps the earliest and most frequently cited definition of wait lists focuses on the notion of unmet patient need and/or demand for health care services. Early references indicate that wait lists were originally taken as a measure of unmet demands for health care services or more specifically as an indicator of the lack of correspondence between, for example, the need for

admissions and availability of health care services (Williams, 1968; Kennedy, 1975; Mason, 1976). The notions of need and demand, and the issue of who defines need, were often blurred or simply not addressed. The notions of patient demand and need for health care services continue to be used in the literature on waiting lists and waiting times, unfortunately often interchangeably. For example, recent references have described wait lists as an indicator of excess demand, that is, the result of a situation in which demand for health care services exceeds supply (Cullis & Jones, 1983; Frankel, 1991; Globerman, 1991(a); Mullen, 1994; Naylor et al., 1994).

Whether "demand" is used in the economic sense of consumers being able and willing to purchase services that are not available, and just why prices do not then simply adjust to "clear the market", are issues generally left unexamined because of the need/demand confusion. In most cases, what is being described are "demands" for care as expressed through clinician/agents, in situations where prices play no allocative role. Such "demand" measures are quite distinct from the economist's notion of consumer "demand", and may also be different from objectively determined needs as defined by 'capacity to benefit given existing clinical knowledge and technology'. Issues of cost-effectiveness of the interventions for which the queues exist are rarely addressed.

2.2.2 Indicator of Inadequate Resources

Another commonly held, but frequently disputed, definition of wait lists is that of an indicator of the inadequacy of resources within the health care system (Sanderson, 1982; Goldacre et al, 1987; Baume, 1995). Acceptance of this view leads inevitably to the suggestion that wait lists for surgical procedures can be eliminated by an increase in funding or other resources (e.g. operating room time and capacity, health care providers). The existence of such a simple

relationship between wait list size and level of resources has been and continues to be disputed in the literature. Yates (1987) addressed this issue in his analysis of the variation in funding and wait list size among health regions in the UK. Variations in funding did in fact exist among regions since some regions offered a broader range of services than others. Some regions also accepted referrals across boundary lines. According to Yates, however, variations in funding did not explain variations in wait lists among the regions and therefore, an increase in resources does not necessarily represent a solution to the wait list problem (Yates, 1987). Similarly, Frankel (1989) argues that wait lists should not be used as a measure of inadequate resources in the health care system but rather as an indicator of the need to better allocate resources.

2.2.3 Indicator of Misallocated Resources

The conceptualization of wait lists as an indicator of misallocation of resources within the health care system is further developed in the notion that wait lists reflect both physician and patient perceptions of disease. According to some, wait lists are not a universal problem but are restricted to a few surgical procedures. Those procedures with long wait lists represent conditions that are not a priority for physicians, not of interest to the general public and/or not requiring urgent care. Wait lists, therefore, can be viewed as a vehicle through which the health profession and the public can both prioritize health care services and in effect, allocate scarce resources to areas offering the perceived greatest potential benefit. Consequently, wait lists will change only when the perceptions of the severity and importance of the disease changes with respect to other conditions among physicians and the public (Frankel, 1989).

2.2.4 Indicator of Access to Health Care

The subject of waiting lists has also been raised in the access to health care literature. In their theoretical framework on access to health care, Aday and Andersen define wait lists and wait

times as characteristics of the health care system which may affect utilization and consumer satisfaction (Aday & Andersen, 1974, 1975). In subsequent work, wait time is categorized as an individual enabling characteristic and determinant of patient satisfaction (Andersen et al, 1983). Wait lists and wait times are also defined as non-economic, aspatial barriers or obstacles between potential and realized access to health care services in the access to health care literature (Aday, 1975; Salkever, 1976; Fielder, 1981; Daniels, 1982; Khan & Bhadwaj, 1994) and in the health care literature (Amoko, 1990; Coyte et al., 1994; Ho et al., 1994).

Recent public opinion polls conducted in Canada regarding access to health care have included waiting lists and waiting times as explicit criteria of access to services. Measures such as waiting times for emergency services, surgery and tests were used in several polls conducted by the Canadian Medical Association and Angus Reid group to assess perceived access to services among the general population (Buske, 1997; CMA, 1999).

2.2.5 Mechanism to Ration Resources

Wait lists can also be viewed as a mechanism to allocate health care services in the absence of price rationing mechanisms (Bloom & Fendrick, 1987; Jacobs & Hart, 1990; Globerman, 1991 (a); Naylor, 1991; Baker, 1994; Light, 1997). Lindsay et al. (1984) argue that waiting lists persist as a rationing tool because there are no direct costs associated with waiting since patients, while on the list, are still free to do as they please (Lindsay et al., 1984). While this may be the case for some patients, those requiring treatment urgently who are forced to wait may incur some type of personal cost (e.g. pain, disability) (Cullis et al., 1986). Opponents of non-price rationing argue that there are serious inefficiencies associated with this approach including obscuring supply and demand conditions, dealing with the social costs of waiting for care and the possible development of illegal black markets for services. Furthermore, in order to avoid long waits,

patients may seek to jump the queue or turn to private markets for care (Globerman, 1991(a)). Advocates of universal, publicly funded health care systems, however, argue that wait lists represent a far more equitable means of allocating scarce resources than that offered through price rationing. Thus steps must be taken to ensure the efficient and effective use of wait lists as a rationing tool (Naylor, 1991; Cox, 1994; Naylor et al., 1995). Extensive rationing by waiting lists may not be necessary if large sources of waste are removed at the organizational and structural levels within publicly funded health care systems (Light, 1997).

2.2.6 Summary

Despite the evident differences in the conceptualizations of waiting lists, the literature clearly indicates some areas of agreement regarding the interpretation and use of wait lists. First, wait lists represent some form of mismatch between the demand for and supply of specific health care services. This situation has been presented from the demand side as either "unmet need" or "excess demand" or from the supply side as "inadequate resources" (Amoko et al.(a), 1992). The choice of presentation often reflects the authors' views regarding possible solutions.

Second, many researchers and policy makers concur that wait lists are an inevitable and unavoidable part of any publicly funded health care system. As such, wait lists are viewed as the "cost" of policies which attempt to remove the financial barriers from access to health care services. Opponents of universal, publicly funded health care systems have argued that this is an inefficient and potentially dangerous solution to a problem better resolved by market forces (Globerman (b), 1991; Sullivan, 1991; Rich, 1992). Supporters of universal systems, however, argue that wait lists are clearly a better alternative than price rationing mechanisms since they represent a fairer approach to the problem of constrained resources which does not discriminate based on income (Katz et al., 1991; Naylor et al., 1993; Ho et al., 1994; Naylor et al., 1995). It is

imperative, however, that wait lists be accurately measured, monitored and managed and that the experience of patients on lists also be actively monitored (Naylor, 1991).

Furthermore, the existence of wait lists per se does not necessarily represent a major fault with a health care system. Some argue that wait lists are essential to ensure the efficient use of constrained resources and to operate a system with no wait lists would require that capital and human resources would remain idle during periods of less demand (Yates, 1987). Excessive wait times for certain surgical procedures, however, clearly indicates a problem that must be addressed at the system level. Consequently, various researchers and policy-makers have concluded over the years that the focus must be placed on patient wait times for surgical procedures in addition to wait list size (Jones & McCarthy, 1978; Cullis & Jones, 1985; Yates, 1987; Frankel, 1989; Naylor, 1991). Wait list size is not an important issue for patients seeking surgical care (Mordue & Kirkup, 1989). Frankel (1989) argues that short wait times are perfectly acceptable since they are required to ensure the most efficient use of resources; long wait times, however, represent possible clinical problems for patients and organizational problems for the system as a whole. As such, the issue should not be why people are waiting but rather why people are waiting so long for certain surgical procedures (Frankel, 1989).

Finally, there appears to be general agreement regarding the need to ensure that policy solutions are based on reliable and valid data and sound empirical evidence regarding the nature of waiting lists and waiting times and the factors that may affect them (Williams, 1968; Jones & McCarthy, 1978; Cottrell, 1980; Weaver, 1981; Davidge et al., 1987; Jennett, 1987; Lee et al, 1987; Yates, 1987; Amoko et al., 1992 (a)(b); Naylor et al., 1994).

2.3 VALIDITY AND RELIABILITY OF WAITING TIME & LIST MEASURES

Since the early 1980's, numerous reports have been produced which provide information regarding waiting lists and waiting times for selected procedures. There have also been numerous studies that focus on the basic characteristics of waiting lists and the factors that affect them. The latter are conducted primarily to gain a more comprehensive understanding of the nature of waiting lists and waiting times. All these reports and studies are based on a range of data sources including survey data, hospital data, central registry data and administrative data.

With this surge in research activities, has come some concern regarding the quality of waiting list data (Deitch, 1981; Davidge, 1987; Yates, 1987; Amoko, 1992). The concerns focus specifically on the validity or meaning of the measures used (e.g. wait list size, waiting times) and the reliability or consistency with which they are used. In this section those studies that focus on assessing the validity and/or reliability of various types of wait list data are reviewed. The review begins with a brief discussion of the basic principles and methods of validity and reliability assessments. This provides some basic criteria with which to critically assess this literature.

2.3.1 Criteria for Review: The Principles of Validity and Reliability

Data quality is often assessed by examining the validity and reliability of the measures used to collect the data. Validity is concerned with the extent to which an indicator measures what it purports to measure, that is, with the meaning or construct of the particular measure. Construct validity, for example, is concerned with the extent to which the indicator reflects the theoretical concepts underpinning the phenomenon. There are various measures used to assess the validity of indicators or measures. The methods include comparing the measure to actual outcomes or to

alternative validated measures; for example, correlation analysis can be used to assess the level of agreement. These methods seek to ensure that the measure or indicator reflects the various dimensions of the concept and conforms to theoretical explanations and expectations (Carmines & Zeller, 1979; Last 1988).

Reliability is concerned with the extent to which any measuring procedure yields the same results on repeated trials and is, therefore, concerned with the degree of consistency and generalizability. While some degree of error is expected due to chance, a reliable variable should demonstrate a high degree of consistency in repeated measures (Carmines and Zellers, 1979). The methods used to assess reliability often depend on the type of data.

With the increasing use of administrative data in health related research, methods have been developed to assess the validity and reliability of such data. These are of particular interest since the majority of validity and reliability studies on waiting lists focus on the use of administrative data sources. The quality of such data may be threatened by coding errors, incompleteness, missing data, and/or duplication of records (Roos et al., 1979). The gold standard in assessing the quality of administrative data is the use of original patient records but this is not always feasible. Perhaps, the most common method of data quality assessment involves comparison of two or more independent sources of computerized data. This method is deemed appropriate for any situation in which two data collection systems relate to the same event such as patient hospitalization, and are independent. Two administrative data bases such as hospital separation claims and physician claims, for example, can be linked to confirm type of procedure, date of procedure and surgeon (Roos et al., 1989 (b); Roos et al., 1993). These computerized methodologies are appropriate for large data bases since they can produce results in a timely and efficient manner.

In what follows, studies that focus on assessing the validity and reliability of two primary measures associated with waiting list data, waiting times and waiting list size, are reviewed.

2.3.2 The Evidence: Waiting Time

Waiting times represent the most important measure associated with waiting lists. In theory, waiting times represent the time between when patients are placed on the waiting list (i.e. "date on") and when they are taken off the list (i.e "date off"). This seems like a reasonable assumption. Any issues regarding the validity of waiting times, therefore, clearly relate to the meaning and use of these key indicators. Date-off appears to be less contentious since it often represents the point at which patients are removed from the list due to receipt of treatment or other reasons (e.g. death, treatment elsewhere) which can often be confirmed by comparisons with other data sources. However, there appears to be less certainty regarding the definition of date-on the waiting list which may have various meanings depending on the nature of the procedure and definition of waiting period.

Over the past several decades, there have been numerous attempts in Canada to compile waiting time and waiting list data for various procedures at the national level (O'Keefe, 1982; Jacobs et al., 1990; Higginson et al., 1992; Higginson et al., 1994). Perhaps the most well-known are the national waiting list data compiled annually by the Fraser Institute for a broad range of specialist services. The data are based on self-reports from a random sample of physicians who were asked to report waiting times for new patients for a range of surgical and diagnostic services. Earlier studies focussed on selected provinces (Globerman & Hoye., 1990; Walker et al., 1992) and since then they have included all 10 provinces (Miyake & Walker, 1993; Ramsay & Walker, 1994; Ramsay & Walker, 1995; Ramsay & Walker, 1996; Ramsay & Walker, 1997; Ramsay & Walker, 1998).

There have been various definitions proposed to identify and distinguish the various types of waiting periods that patients may experience. The broadest definition offered to date is that of Bloom and Fendrick (1987) who in their attempt to measure total waiting time define the point at which a person seeks treatment, which in most cases begins with a visit to the general practitioner, as the appropriate measure of "date-on". Similarly, the British Columbia Medical Association identified four distinct waiting periods: (1) wait for a GP appointment; (2) wait for a specialist appointment; (3) wait for diagnostic tests (if necessary); and (4) wait between booking for a surgical procedure and receipt of care. The Association argues that most accurate representation of the time patients wait is the "total time" comprised of all four waits (BCMA, 1998). Researchers in the UK also acknowledge that patients may experience several distinct periods of waiting prior to surgery. Smith (1994) contends that "total waiting time" is comprised of the following three waiting periods: (1) outpatient wait (GP visit to first outpatient consultation); (2) waiting time to placement on a list (i.e. wait between application for admission and placement on the hospital waiting list); and (3) inpatient waiting time (i.e. placement on hospital waiting list to service or procedure) (Smith, 1994). While all the waiting periods outlined are plausible, the literature to date has focused primarily on the final waiting period: time between placement on a hospital waiting list (or booking) and receipt of service or procedure.

The key issue arises from the apparently wide variation in the meaning and use of "date-on" the waiting list. When do patient waits for a service or procedure actually start? Theoretically, the initiation of waiting time for a specific procedure or service should represent the point when both physician and patient agree that treatment is required. This has been represented in various ways in the literature through the use of specific markers. For example, in their survey of CEOs, Jacobs and Hart (1990) defined waiting times as starting when the application for admission

(i.e.booking) to hospital was made. They simply assumed that all hospitals involved in the survey employed the same working definition.

In the UK, where there is a long history of collecting waiting list at the national level, waiting list statistics have been routinely collected by the Department of Health since the mid 1970s. In 1987, policies were introduced to standardize waiting list data collection across hospitals and health regions and are reported in aggregate format (i.e. < 3 months, 3-6 months etc). Waiting times are defined as the time between the "decide to admit date" and the reporting date. To ensure comparability across hospitals and regions, the Department provides software for data collection purposes (Dept of Health, 1997 a-c). Information regarding the waiting list size and waiting times of specific physicians and hospitals is also provided by the College of Health, a non-profit organization concerned with access to care within the NHS, via a "National Waiting List Helpline". Up-to-date waiting list and waiting time information is provided to patients for 9,000 consultants within 1,000 NHS acute care hospitals. The data are obtained directly from providers (College of Health, 1190, 1995 (a) (b)).

In the absence of specific waiting time data, administrative physician claims and hospital separation data have been used to retrospectively proxy waiting time for a range of procedures. In Nova Scotia, date on the waiting list was defined to be the time of the last surgical consult prior to surgery since this was assumed to be the point when the decision for treatment was made (Nova Scotia, 1996). A similar method was used in Manitoba (DeCóster et al., 1999). This method is problematic when there are multiple contacts with a surgeon prior to surgery. There was no analysis conducted to assess the validity of the measure. Alternatively, if there are several steps in a treatment process, the waiting time for a specific procedure may begin after the

completion of the previous step; for example, Naylor et al. (1994) define the waiting time for CABG as starting at the time of angiography.

Placing patients on a waiting list may in fact be more complex than usually assumed. There are a range of patient and physician factors which may affect when patients are placed on a list. This further complicates the task of determining a useful definition of "date-on". In his discussion of waiting lists, Sanderson (1982) argues that the criteria for placing patients on the waiting list are not constant over time and place. He introduces the notions of admission and waiting list thresholds. The admission threshold is the point at which patients require treatment and in an ideal world, the time they would be admitted. However, patients are not constantly monitored nor are services always available when required. Hence, there is a waiting list threshold, defined as the point at which patients are judged suitable to be placed on the waiting list; that is, the condition has not deteriorated to a point requiring immediate admission to hospital (i.e. surpassing the admission threshold) but is expected to reach this point at some anticipated time in the future, preferably at the same time the patient reaches the top of the waiting list. The waiting list threshold may be different for different conditions and physicians, with low thresholds generally resulting in a long waiting list and vice versa (Sanderson, 1982).

Very few studies have focussed on determining the validity of particular measures of waiting times. As part of a broader study on knee replacement, Ho et al. (1994) investigated the validity of patient-reported waiting times. Retrospective measures of waiting times were obtained from patient surveys. One hundred and eighty-five patients were randomly selected from five hospitals in the Toronto area conducting at least 100 knee replacements during the study period (April 1, 1984- March 31, 1990). The results are based on 127 responses (68%). Patients were asked to report waiting times for surgical consultations as well as for surgery. The starting point

for the latter was defined to be when both patient and surgeon decided that surgery was required. In order to assess the validity of waiting times for surgery, the patient reported times were compared to surgeon recorded waiting times. (The methods used to collect the latter are not reported). It was assumed that the patient-reported estimates of waiting times would be shorter than those recorded by the surgeons but the two measures would be correlated. The mean (median) waiting times were 15.4 (9.5) weeks (patient-reported) and 23.3 (17) weeks (physician-reported). The two measures were significantly correlated (Pearson's r=0.38, p=0.001) (Ho et al., 1994).

In the UK, Smith (1994) investigated the validity of inpatient waiting time as an indicator of the total time patients must wait for surgery. The author compared inpatient waiting time to the "post-referral" waiting time defined as the total time between referral from GP and time of admission. The "post-referral", or total waiting time, was comprised of three distinct waiting periods: (1) time between GP referral and first outpatient consultation (outpatient waiting time); (2) time between application for admission and placement on the inpatient waiting list; and (3) time between placement on the inpatient waiting list and admission (inpatient waiting time). Waiting time information was obtained from three different data sources: (1) outpatient records (outpatient waiting time); (2) inpatient waiting list data (wait time between waiting lists); and (3) inpatient records (inpatient waiting time). All three sources of data were linked at the individual patient level using personal health identifiers. The study included all patients admitted to hospital for an operation in one of six specialties (orthopaedics, urology, gynaecology, ophthalmology, general surgery, otolaryngology) between June and August 1993 in three randomly selected Scottish hospitals (n=3817). The total number of cases for each specialty ranged from 275 for urology to 1454 for general surgery.

The average post-referral waiting time for all specialties was 110 days; on average, 58 days (52.7%) represented inpatient waiting time, 17 days represented the waiting time between waiting lists and 35 days represented outpatient waiting time. All values varied across specialties. The average post-referral waiting times ranged from 82 days for gynaecology to 136 days for urology. The average inpatient waiting times ranged from 42 days for gynaecology to 86 days for otolaryngology. The proportion of total waiting time spent waiting for inpatient hospital care ranged from 40% for orthopaedics to 63.5% for otolaryngology. Additional analyses were conducted for cataract, knee replacement and hip replacement. On average, the inpatient waiting time represented only 53% (76 days) of the total post-referral waiting time for cataract and 48% (95 days) and 45% (74 days) of the total waiting time for knee and hip replacement respectively. The author concluded that inpatient waiting time represents approximately half of the total time patients wait for surgery (Smith, 1994).

While there is very limited information regarding the meaning of wait time, there has been more discussion regarding the range and reliability of the methods used to measure waiting time. A variety of methods are currently being used and proposed in the literature and, not surprisingly, this leads to often disparate results. The following methods are identified in the literature (Cottrell, 1980; Weaver, 1981; Williams et al., 1983; Mordue, 1989):

- Cross-Sectional Method: also referred to as the cut-off method, reflects the waiting times of patients currently on the waiting list and is defined as the time between when patients are placed on the list and some arbitrary cut-off date (e.g. March 31). This method is commonly used with administrative databases to report the waiting times of patients on a list on a particular date.

- Retrospective Method: reflects the total waiting time experience of patients once they have received treatment. This method may provide no information on the waiting times of patients currently awaiting surgery though likely to be reasonably close. Waiting times are commonly measured this way in surveys of patients who have received a particular service or procedure.
- Cohort Method: also referred to as the prospective method involves following patients from the time they are placed on the waiting list until they are removed; the waiting time is a measure of the time between these points. While this may result in the most valid and reliable measure of waiting time, it is considered the most costly and time-consuming method and as such is not frequently used.
- Expected Waiting Time: represents the expected amount of time required to clear the waiting list and thus reflects the expected waiting time of the next patient to be placed on the waiting list. This measure is calculated as: No. of patients on the WL ÷ No. of admissions from WL per unit of time.

The cross-sectional and retrospective measures are perhaps the most commonly used methods. The Expected Time methods are intended to provide information regarding future expected waiting times versus existing waiting times. Expected waiting time measures have not actually been used in the literature to date.

The existence of multiple approaches to measuring average or median waiting times clearly raises the issue of the reliability and consistency of the measures. Don et al. (1987) investigated two different measures of waiting times used in Oxford, England. The first was a census measure provided biannually by the SBH 203 statistical returns that report the total number of patients waiting for surgery by specialty and district. Patients are classified into one of the

following groups: urgent patients waiting one month or less, urgent patients waiting more than one month, non-urgent patients waiting one year or less and non-urgent patients waiting more than one year. Given the nature of census data, such records can easily be dominated by the longer waiting times. The second method was retrospective based on the use of inpatient admissions data provided through the Hospital Activity Analysis (HAA). The HAA provided information regarding the date of admission, source of the admission (i.e. emergency, waiting list) as well as the date when patients were placed on the waiting list; waiting times could be calculated for individual patients.

The study included a range of procedures, ENT, plastic surgery and gynaecology for five regions in the UK. For ENT, the proportion of patients waiting more than 12 months was higher as reported by the cross-sectional method compared with the retrospective method in three of five regions (Region 1: 32.2% vs 12.5%; Region 2: 35.8% vs 7.7%; Region 3: 21.9% vs 9.7%). Similar results were found for gynaecology with the largest discrepancies found in regions 4 (63.3% vs 11.7%) and 3 (42.3% vs 28%). The cross-sectional method is likely to identify a disproportionately high proportion of patients with longer waiting times, relative to the retrospective method (Don et al., 1987).

Despite the limited amount of information, the following general observations about the validity and reliability of waiting times can be made:

- There is very limited information regarding the validity of waiting time as a measure of time spent on the waiting list. This is due in part to the range of meanings ascribed to "date on" (ie. application of admission, last surgical consultation, first contact with GP, date of pre-operative procedure) which marks the beginning of the waiting time.

- Waiting time is not measured consistently across time, specialty, procedure or place. There are a range of methods used (i.e. cross-sectional, retrospective, cohort, expected waiting time, expected waiting time to clear waiting list) which may result in different estimates of waiting time. Evidence suggests that the cross-sectional method, in particular, is likely to over-estimate waiting times compared to the retrospective method.

There are a number of gaps in this literature bearing on the following issues:

- The construct validity of waiting time has not been fully explored. While the literature provides some insight on what waiting time (ie. "date on") means, there may be a range of points in the course of treatment when a patient can be placed on a waiting list. These must be fully identified and explored in order to gain a more comprehensive understanding. In particular, prospective studies that follow patients from GP referral to surgery or involve a review of medical records should be conducted to identify various points of entry to the list.

- Non-clinical factors that may affect when patients are placed on a waiting list have been virtually unexplored. They are likely to vary with the type of condition and anticipated procedure. Anecdotal evidence suggests that provider practices and patient choices may affect when they are placed on waiting lists. This information is essential to test the assumption that patients are placed on the waiting list only when they require an intervention.

2.3.3 The Evidence: Waiting List Size

"Waiting list size" is rarely defined but rather assumed to be the number of patients awaiting treatment at a particular point in time. This measure is often presented as an aggregate value calculated at one of several levels including individual physicians, hospitals or regions. What is often not clear regarding the construct validity of wait list size is precisely who they should represent. Should the measure represent all patients awaiting treatment? Should it include urgent or emergent cases or simply elective patients? Should it include day surgery or just inpatient care? Do measures aggregated at the hospital or regional level include all relevant physicians for the procedure in question?

A single study was identified which focussed on the construct validity of waiting list statistics, and it is again from the UK during the 1980's. Sykes (1986) assessed the effects of the exclusion criteria mandated by the Department of Health and Social Services (DHSS) when collecting waiting list information. The primary source of waiting list information in the UK at this time was the quarterly SBH203 statistical returns which provide aggregated wait list information by length of wait to date and urgency classification (i.e. urgent vs non-urgent), by hospital and region. Those groups excluded from the official statistics include patients who wish to defer their surgery (including patients who have failed to accept an admission), day surgery, and patients who do not require surgery until a later date. Information for 1094 patients awaiting admission was obtained for 10 surgeons in an unnamed hospital.

The results of the analysis of the hospital waiting list data indicated that: 28.7% (n=314) declined an admission for medical or social reasons; 30% (n=325) were identified as possible day cases; and 20% (n=209) were identified as deferred cases. The proportion of cases in these categories varied by specialty. The number of excluded cases was adjusted for those patients who met

more than one exclusion criterion. The official DHSS statistics indicated that only 608 patients were awaiting admission to hospital, thus excluding 486 patients. The number of patients awaiting surgery in the hospital was 79.9% greater than that reported by the official statistics. The author concludes that the DHSS waiting lists statistics are misleading since they do not account for everyone waiting for surgery and they do not allow for proper comparisons across specialties (Sykes, 1986).

The validity of wait list size, as measured by administrative data, was assessed via comparisons with the actual measure, namely the hospital waiting list, a recognized method. The results indicate a significant under-representation of the actual measure; wait list size as reported by the official DHSS statistics did not include all patients waiting for surgery as reported by the hospital. The generalizability of the results is severely limited since the study is restricted to only one hospital. The results, however, were consistent across a range of procedures within the hospital.

In most cases, waiting list size is assumed to accurately represent all patients who need and are prepared to undergo treatment. It is, therefore, often assumed to be a valid measure across physician, hospitals or regions. The majority of studies focus on the accuracy of hospital waiting lists and most originate from the UK where administrative data on waiting lists have been available for some time.

Orthopaedic Care

Donaldson et al. (1984) reviewed waiting lists for orthopaedic in-patient services for eight orthopaedic surgeons in a large district hospital in Leicestershire Health Authority in England. The total list was comprised of 1,595 patients from these eight surgeons. The study was

restricted to a review of patients on the waiting list for more than 1 year (n=950), representing approximately 60% of the total list. A preliminary review of patient records identified 193 patients (20%) who already had surgery but were not removed from the waiting lists. Questionnaires were administered to the remaining patients to determine whether or not they wished to remain on the waiting list and if not, why not. Respondents were asked to select one of the following: still want the operation, no longer wish operation, died, moved away, or already had the operation. Responses were obtained for approximately 88% of patients.

Of those patients remaining on the list (n=757), the majority of patients (48%) indicated that they still wanted to have the surgery; 65 (9%) indicated that they already had the operation; 70 (9%) had moved away from their listed address; and replies from relatives and searches of death records identified 34 (5%) patients who had died. 113 patients indicated that they no longer wanted to have the surgery for a range of reasons including age (i.e. too old) and/or condition improved. The final results indicate that approximately 50% (n=475) of patients on the original wait list were inappropriately classified as waiting. There was a higher proportion of those still wanting the surgery among those under 45 years of age (43%) versus 75 and over (36%). There was a lower proportion of those no longer wanting the surgery among those on the list for 1 to 2 years (9%) versus more than 5 years (25%). There was a higher proportion of those no longer wishing to have surgery among those with minor operations (29%) versus intermediate (21%) or major (12%) operations (Donaldson et al., 1984).

In this study, administrative wait list data were compared to a gold standard, namely patient records. This first step resulted in the identification of 20% of cases that should not have been on the waiting list. The results of the survey may be conservative due to non-respondent bias since the proportion of patients still requiring and/or desiring surgery is expected to be lower

among non-respondents than respondents. The most prominent limitation of the study is the generalizability of the results. Since the study focusses exclusively on orthopaedic in-patient services in one UK district hospital, the results may not be generalizable to other procedures. The intra-procedure generalizability is also limited since the study is restricted to patients waiting for surgery for more than 1 year for one of only eight surgeons.

Hochuli (1988) also investigated the validity of waiting list data for orthopaedic in-patient services in a single regional health authority in the UK. Patient information was obtained from the card index file used to compile names on the waiting list. Letters were sent to all patients appearing on an inpatient waiting list during a two month period (year not specified). Patients were asked whether they still wanted treatment and if not, why. Follow-up letters were sent and GPs were contacted to obtain information for non-respondents. There were 703 patients identified on the inpatient waiting list. The majority of patients (68%) indicated that they still wanted treatment; 17% had decided against any treatment; 5% of patients had already received treatment; and 10% did not respond to the letter. Among the latter group, 5% of patients had moved out of the district, 4% could not be traced and 1% had died. The author concluded that waiting lists do not represent an accurate measure of demand for health care services; they do, however, provide some insight regarding the organization of patient services (Hochuli, 1988).

The methods used by Hochuli do not represent one of the recognized methods noted previously. Instead, the author relied on data from a patient survey. The results of the study, therefore, may be somewhat conservative due to non-response bias. In-patient waiting list information was provided by an out-patient clinic but there was no information provided regarding the number of hospitals or physicians involved in the study. Hence, it is impossible to comment on the intra-procedure generalizability of the results.

West and McKibben (1982) investigated the accuracy of a waiting list for orthopaedic outpatient appointments in three hospitals in the South Glamorgan Area Health Authority in the UK with orthopaedic outpatient clinics. The study included all patients on the waiting list as of March 31, 1978 (n=2256). A questionnaire was administered to all patients on the list to collect information on the current status of the patient as well as to determine if the patient wished to remain on the waiting list. After three mailings, 1702 (75%) patients responded to the survey with 285 patients indicating that they were no longer seeking care. Eighty-eight patients reported by mail, or telephone that they were no longer seeking care and information was obtained from general practitioners for an additional 62 non-respondents indicating the patient was no longer seeking care. Overall, therefore, approximately 20% of patients no longer sought an orthopaedic consultation. A follow-up survey was conducted 18 months later and was completed by 1434 patients (84% of those who completed first questionnaire) and 1049 patients (73%) indicated that they still had the same problem (West & McKibben, 1982). There is no information provided on the remaining respondents.

This assessment is also not based on one of the standard methods described earlier but rather relies on the comparison of administrative data to information from patient surveys. As such, the results of the study may be conservative due to non-respondent bias. Furthermore, the generalizability of the results is limited. As noted in the previous study, the results cannot be generalized to other procedures since the study focuses exclusively on orthopaedic consultations. The intra-procedure generalizability, however, may be somewhat greater since the study is based on the waiting lists of three hospitals. The generalizability of the results beyond the UK is unclear.

A similar study was conducted by Porter (1985) at the Royal Orthopaedic Hospital in Brimingham. Various processes had been introduced to promote the efficient use of hospital resources, including a systematic review of the waiting list via postal questionnaire, an out-patient review clinic and a pre-operative assessment clinic. Questionnaires were mailed to all patients waiting more than 3 years (n=300) to determine whether they wished to remain on the waiting list and if not, why. Overall, 73% of patients (n=220) responded to the survey. Fifty-five patients (18%) wished to remain on the waiting list; 85 patients (28%) requested to be removed; and 80 patients (27%) were removed because they did not respond to the survey. Eighty patients (27%) requested a referral for an outpatient review. Patients waiting 1 to 3 years were immediately referred to the out-patient review clinic (n=135). A total of 215 patients were reviewed (i.e. included 80 patients requesting a referral) and of these, 162 patients (75%) were removed from the list and 53 remained on the waiting list. Patients were removed from the waiting list for various reasons including surgery not required, failure to attend, treated privately and listed on another NHS waiting list. Patients waiting less than one year were immediately sent to a pre-operative assessment clinic. A total of 130 patients attended the pre-operative clinic (i.e. included 55 patients requesting to remain on the waiting list and 53 patients remaining on the waiting list following the out-patient review). Among these, 78 patients (60%) were considered fit for surgery and 52 patients (40%) were removed. In the end, only 57 patients actually had surgery, 13 patients no longer required surgery and 5 had different procedures. The author concluded that postal questionnaires, out-patient review clinic and pre-operative assessment clinic led to the removal of a substantial number of patients on the waiting list (Porter, 1985).

A more recent study conducted by Elwyn et al. (1996) focussed on the accuracy of waiting lists for orthopaedic outpatient care for one urban fund-holding general practice in Cardiff. The study

is based on a systematic review of patient records for patients (n=116) who were awaiting orthopaedic consultations on April 1, 1994. The review was conducted by a general practitioner and a radiologist. Following a preliminary review of the waiting list, approximately 28% (n=32) of patients were removed for various reasons: 14% were no longer registered with the practice, 7% were duplicate entries, 5% had been seen and 2% were excluded for other reasons. The medical records of the remaining patients (n=84) were reviewed to determine clinical priority and the need for further investigation. Among these patients, 14 were classified as high priority and were referred to other hospitals: 5 patients agreed to a referral; 6 patients declined the offer for referral; 2 patients did not show to discuss the issue and remained on the waiting list; and 1 patient underwent further investigation and was reassured and taken off the wait list. An additional 16 patients with low pain and disability scores were classified as low priority and referred to other hospitals. Twenty patients were identified as requiring further radiological investigations, 10 of whom underwent the procedure. Of these, 6 patients were given priority status and remained on the waiting list; 3 were removed from the waiting list; and 1 patient sought private care. Overall, the review resulted in a 50% reduction in the size of the waiting list. The authors conclude that while successful, the process was time consuming with substantial opportunity costs (Elwyn et al., 1996).

Elwyn et al. (1996) conducted their assessment of an orthopaedic waiting list using the "gold standard" (i.e. medical records) as well as expert clinical opinion. The results, therefore, would rank high on any validity rating. The generalizability of the results, however, is limited for several reasons. First, the study sample is small and therefore may not be representative of other patients attending orthopaedic clinics elsewhere in Cardiff or England. Second, the study is based on waiting list information for only one GP fundholding practice and there is no information regarding the representativeness of this practice.

Urology

The validity of waiting lists for urology services was also considered potentially problematic in the UK, prompting various researchers to investigate the issue. Barham et al. (1993) reviewed a waiting list for transurethral prostatectomy in the Department of Urology in the Royal Devon and Exeter Hospital in Exeter England. The majority of patients were placed on the waiting list as a result of symptoms attributed to bladder outflow obstruction and evidence of an enlarged prostate gland. All patients on the waiting list were invited to undergo further evaluation during a 1week period, consisting of the completion of frequency and volume urine chart, interviews, and urine rate flow tests. There were 118 patients on the waiting list and 107 (91%) patients participated in the evaluation clinic. Among the non-participants (n=11), 4 patients had died, 4 patients refused reassessment and 3 patients had received the operation elsewhere. Following initial reassessment, 29 patients (27%) demonstrated evidence of severe obstruction and therefore, remained on the waiting list; 78 patients (73%) were interviewed and underwent further evaluation. Among the latter group, an additional 18 patients remained on the waiting list, 9 patients received out-patient treatment and 51 patients were discharged. Overall, 44% of patients evaluated (n=47) remained on the waiting list while the remaining patients (n=60) were treated in out-patient clinics or discharged. The authors concluded that routine evaluations of patients awaiting transurethral prostatectomy could substantially reduce waiting list size (Barham et al., 1993).

The authors used information from clinical evaluations to assess the validity of a urological waiting list. This method is similar to that using medical records and therefore is expected to produce highly reliable results. The intra-procedure generalizability of the results, however, is limited since the study was based on the experiences of one hospital and a small sample of patients.

Schou et al. (1994) investigated the effectiveness of a standard evaluation programme for patients with benign prostatic hypertrophy (BPH) awaiting transurethral resection of the prostate (TURPS), conducted in part to reduce the length of the waiting list. To determine which patients were in fact candidates for TURPS, patients on the urology waiting list were asked to undergo a clinical evaluation consisting of a physical evaluation, symptom evaluation and routine blood sampling. Between May and June 1991, 132 patients were identified on a waiting list in the Copenhagen catchment area. A total of 117 patients agreed to the evaluation. The remaining 15 patients did not accept the invitation for various reasons; 4 patients had already received TURP at another hospital; 9 patients felt their symptoms had improved and therefore did not require any further investigation; and 2 patients indicated that they did not have the time. Among those agreeing to the evaluation, 26 patients (22%) required no further evaluation and 91 patients (78%) demonstrated symptoms indicating further investigation. Among the latter group, 11 patients were immediately referred for surgery and 80 patients underwent a full urodynamics assessment; the results of which revealed obstructions in 61 patients indicating the need for surgery, and no obstruction for 19 patients. Overall, a total of 72 patients were referred for surgical treatment but 11 patients refused surgery. Hence, 61 patients (52%) underwent surgery, 11 patients (9%) refused surgery and 45 patients (39%) were not deemed appropriate candidates for TURPS. Among the latter group, 17 patients were provided with ongoing care and 28 patients were discharged (Schou et al., 1994).

Once again, clinical evaluations were conducted to assess the accuracy of a urological waiting list. As a result, 39% of patients were deemed inappropriate candidates for surgery and removed from the waiting list. While the methods are expected to produce highly reliable results, the generalizability of the study is again limited due to the fact that it was based on a single hospital and a small sample size.

Various Procedures

A number of studies assessing the validity of waiting list data have focussed on a broader range of surgical services. Lee et al. (1987) focussed on the degree of inflation in waiting lists for selected procedures in the Oxford region. The specialties include general surgery, ophthalmology, trauma and orthopaedic surgery, ENT, gynaecology and plastic surgery collectively representing 90% of patients on the waiting lists. Quarterly reports from the Department of Health SBH 203 and Hospital Activity Analysis (HAA) for the time period between 1974 and 1983 were used. The study is based on the comparison of two sources of administrative data: (1) number of patients on the waiting list at the end of each quarter (SBH 203) and (2) admissions to hospital (HAA). The latter includes information regarding the source of the admission (i.e. waiting list) and therefore it is possible to construct a retrospective measure of waiting list size for those patients already admitted to hospital. This measure would not include those patients still waiting for care.

When compared over time, it is evident that the waiting list size as provided through the SBH 203 was consistently greater than the size calculated using the HAA. There was a positive correlation between the two data sets ($r=0.78$; $p<0.001$). The overall average discrepancy between the two sets of data from 1974 to 1983 was 38.7%. The authors note, however, that adjustments must be made to take into account missing data in the HAA data (10%) which would have resulted in cases that were included in the SBH 203 data but not in the former. The authors conclude, therefore, that approximately 28% of patients on waiting lists (after adjustments) are not eventually admitted to hospitals within the same region. They hypothesized that those patients on the waiting list who did not receive surgery would not have for various reasons including condition improved, treatment received outside the region, treatment received

privately, treatment received on emergency basis, simultaneous listing on multiple waiting lists, patient moved, or patient died (Lee et al, 1987).

In this study, two administrative data sets were used to determine the accuracy of waiting lists. The analysis was conducted at the aggregate level rather than the individual patient level as is recommended. It is not clear whether this method produces results that are as valid as those conducted with linked data sets. The approach may in fact lead to inflated estimates of inaccuracies. For example, the aggregate method does not allow for the identification of patients who were waiting for treatment at a particular hospital but ultimately received care privately or in another region. Such cases would appear in the SHB203 data but not in the HAA data and therefore, would be considered misclassified patients. These cases do not, however, reflect inaccuracies in wait list size since these patients actually did wait for treatment. The generalizability of the results is slightly better than other studies since it includes a range of hospitals and specialties. Results, however, were not presented by procedure; hence it is not evident whether all procedures were affected equally. This method assumes that waiting lists from a range of procedures are homogeneous and behave in a similar manner.

In New Zealand, an audit was conducted in the Dunedin hospital to assess the validity of seven surgical waiting lists. Letters were mailed to all patients on the waiting list (n=2216) to determine whether they wished to remain on the waiting list and if not, why; 92% of patients responded to the survey. The majority of patients (n=1679; 76.6%) wished to remain on the lists; this varied across surgical departments from a high of 92.2% to a low of 60.3%. A total of 339 patients (15.3%) indicated they wished to be removed (Range: 4.7% to 25.5%). Patients requesting removal from this list indicated a range of reasons, including that the surgery was no longer required, or the operation had been performed elsewhere. A total of 34 patients (1.5%)

were removed because they had already had the operation or they represented duplicate names. The remaining patients (n=146; 6.6%) did not reply. This waiting list audit resulted in a decrease in waiting list size of 16%. The audit also revealed substantial variation between surgical departments regarding efficient administration of their respective waiting lists (Fraser, 1991).

The assessment was conducted by comparing hospital waiting list data with patient survey data and therefore, may result in a conservative estimate of inappropriately placed patients. The generalizability of the results is limited due to the use of a single hospital site and although the analysis was presented for seven surgical departments, they were not identified.

The Standards Sub-Committee of the Victorian State Committee of the Royal Australasian College of Surgeons investigated the accuracy of waiting lists for surgery in seven Victorian public hospitals with the largest waiting lists across all surgical disciplines. The study is based on a point prevalence design with a stratified random sample of patients who were actively waiting for surgery in March 1987. A sample of 10% (n=2006) of patients with hospital unit record numbers were selected and stratified by surgical discipline. Only clinical disciplines with more than 10 patients waiting and for which each waiting time period (i.e. <1, 1-3, 3-6, 6-12 and >12 months) was represented by at least two patients, were selected. Hospital records were used to collect information for all patients, including demographic data, insurance status, procedure, and date the patient was placed on the waiting list as well as any failed admission.

The results of the first phase indicated that approximately 20% (n=404) of patients had one or more failed admissions for various reasons, including unavailable hospital beds and patient refusal to attend; 20% of these patients (n=83) were inappropriately included on the waiting list. The second phase of the study involved a telephone interview with approximately 10% (n=206)

of patients to determine if the patients' condition changed while awaiting surgery. Approximately 34% (n=71) of patients reported that the surgery was no longer required for various reasons including patients' condition improved, surgery already performed at another hospital, patient had the surgery at the hospital but was not taken off the waiting list, or the patient died. Among those interviewed, 47% (n=97) of patients considered their condition changed while they were on the waiting list and 56 patients reported that their condition had deteriorated. These clinical changes were verified by physicians in cases (Standards Sub-Committee of the Victorian State Committee, 1991).

Once again, the validity assessment includes the use of medical records, as well as information from patient interviews. The study provides a broader perspective on the accuracy of waiting lists since it includes wait list information from a range of surgical disciplines and hospitals. While in theory this should improve the inter-procedure generalizability of the results, the study design has limitations. First, there is no information regarding the number and type of surgical disciplines included in the study or any information regarding the specific sample size for each specialty. Second, the results of the study are aggregated across the different specialities; this implies again that waiting lists for different specialty groups are homogeneous and behave in a similar manner. Finally, the results of the patient interviews were based on a small sub-sample and the results are expected to be conservative due to non-respondent bias.

The majority of studies clearly focus on the validity of waiting list size with most studies employing administrative data. The methods and results of the studies are summarized in Table 2.1. The following observations reflect the current state of knowledge:

- The evidence suggests that there is a considerable degree of inflation in many waiting list estimates. The majority of studies reviewed, found between 20% and 30% of

patients on waiting lists inappropriately listed. A number of studies conducting full clinical evaluations found as many as 50% of patients on the waiting list were there inappropriately. The generalizability of the results for each study is limited due to limited sample sizes and limited sites. However, the consistency of these estimates is at least suggestive of results that may generalize, at least within the system environment in which they were conducted (i.e. largely the UK).

- List length inflation occurs for various reasons including, patient death, treatment already received or treatment no longer required or desired. Inconsistencies in different estimates of waiting list size can also result if different criteria are used to determine when patients should be placed on the waiting list.

While some progress has been made regarding empirical evidence on the validity of waiting lists, issues still remain:

- The issue of overestimation of waiting list size should be further explored with more rigorous research designs. The studies reviewed are all essentially based on a case series design. While some of the studies conducted to date are based on standard and acceptable assessment methods (i.e. comparison to medical records) many are not (i.e. comparison to patient surveys). This area of inquiry should begin with further exploration of the validity or meaning of "date off".
- The validity of waiting lists may vary across specialties, and procedures. It is important to determine which waiting lists are more or less accurate.
- The very limited number of studies from countries other than the UK is a serious and significant gap in our understanding.

Table 2.1: Review of studies on the validity of waiting list size

Reference	Type of Study	Procedure	Source of Wait List Data	Study Sample			Methods	Results
				Hosp	MDs	Patients		
Donaldson et al (1984)	Cross-Sectional	Orthopaedic in-patient	Physicians	1	8	n=950* (n=757)**	Chart review* Patient Survey**	-193 patients had surgery (20%)* -282 patients no longer sought care (37%)**
Hochuli (1988)	Cross-Sectional	Orthopaedic in-patient	Out-Patient Clinic	n/a	n/a	n=703	Patient Survey	-5% of patients had been treated -17% of patients decided against treatment
West & McKibben (1982)	Cross-Sectional	Orthopaedic out-patient	Hospitals	3	n/a	n=2256	Patient Survey	-435 patients no longer sought care (20%)
Porter (1985)	Cross-Sectional	Orthopaedic	Hospital	1	3	n=300* n=215** n=130***	Patient Survey* Out-patient review** Pre-op Clinic***	-165 patients removed (55%)* -162 patients removed (75%)** -52 patients removed (40%)***
Elwyn et al (1996)	Cross-Sectional	Orthopaedic	Hospital	1	n/a	n=116* (n=84)**	Chart review* Clinical review**	-32 patients removed (28%)* -26 patients referred or removed (31%)**
Barham et al. (1993)	Cross-Sectional	Urology	Hospital	1	n/a	n=107	ClinicalEvaluation Patient Interview	-60 patients removed or treated in out-patient (56%)
Schou et al. (1994)	Cross-Sectional	Urology	Hospital	1	n/a	n=117	ClinicalEvaluation	-45 patients removed (38%) -11 patients refused surgery (9%)
Lee et al (1987)	Retrospective	7 Surgical procedures	Health Region	n/a	n/a	-varied by time	Admin data	-28% inflation
Fraser (1991)	Cross-Sectional	7 Surgical procedures	Hospital	1	n/a	n=2216	Patient Survey	-339 patients requested removal (15.3%) -34 patients removed (1.5%)
Standards Sub-Comm (1991)	Cross-Sectional	All Surgical Specialties	Hospitals	7	n/a	n=2006* (n=206)**	Chart Review* Patient interviews**	-83 patients removed (4%)* -71 patients no longer sought care (34%)**

2.4 CHARACTERISTICS OF WAITING LISTS AND WAITING TIMES

Numerous studies have been conducted since the 1980's to determine the general characteristics of waiting lists and waiting times. These studies were conducted in an effort to gain a more comprehensive understanding of the nature of waiting lists and to address some key questions: who is waiting? for what procedures? is there variation in wait list size and waiting times and if so, at what level? The majority of relevant studies focus on the experiences in the UK and in Canada.

2.4.1 Criteria for Review: Principles of Descriptive Studies

Most of the studies are descriptive in nature and based on cross-sectional or retrospective data. In general, the primary purpose of descriptive studies is to provide basic information regarding the distribution of a phenomenon across various groups and places as well as assess any changes in frequency over time. This information can then be used to generate testable hypotheses using more sophisticated designs and methods. Descriptive studies are most often conducted at the individual level within defined population groups (Henneckens and Buring, 1987). Given this general purpose, descriptive studies should: (1) analyze accurate data, (2) employ appropriate statistical methods, (3) provide sufficient detail of the phenomenon, and (4) achieve a degree of generalizability. These basic criteria are considered in the critical review of the studies whose objectives were to uncover the general characteristics of waiting lists and waiting times.

2.4.2 The Evidence

The primary purpose of the study conducted by Davidge et al. (1987) was to review large waiting lists in order to gain a more comprehensive understanding of their basic characteristics. The authors believed that, at the time, the NHS was being forced to solve the problem without

sufficient knowledge regarding the nature of waiting lists. The study based on a review of 26 of the largest waiting lists in Wales and West Midlands was undertaken in 1986. Collectively, the waiting lists contained 31,224 patients waiting for surgery in one of the following specialties: general surgery, orthopaedics, ENT, gynaecology, and ophthalmology. For each patient, the data obtained from the waiting list cards included demographic information, principal operation, other operations, location of residence, date placed on the waiting list, consultant and hospital. Usable information was obtained for 97% of cases.

The results indicated that 19% of patients waiting for inpatient care were 65 years of age or older; age varied by specialty, ranging from 2% to 58% of patients 65 years and older awaiting ENT and ophthalmology respectively. Within each specialty, a small number of operations comprised a large proportion of the list; approximately 45% of patients were waiting for one of six procedures. These procedures represented the following proportion of cases in their respective specialties: varicose veins 27%, hernias 18%, total hip replacement 13%, arthroscopies 15%, tonsils and adenoids 44%, sterilisation 55% and cataracts 78%. While there was some variation across regions, a common pattern emerged regarding the most frequent procedures. Finally, the results indicated that over 45% of patients had been waiting for more than 1 year, with some patients waiting more than 5 years. This indicated perhaps a lack of routine reviews and the possibility of inflated lists. The study served to dispel some common myths regarding waiting lists, namely, that they are comprised primarily of elderly patients and of patients awaiting difficult and advanced types of surgery (Davidge et al., 1987).

This study provides some basic information regarding the composition of waiting lists and the characteristics of those awaiting treatment. Unfortunately, no information is provided regarding the quality of the data. The results of the analysis clearly demonstrate the presence of variation

in lists across and within procedures. The inter-procedure variation in waiting times indicates that not all specialty waiting lists are the same. Information regarding the intra-procedure variation was limited to the ranges of proportions across the 26 waiting lists; in the case of wide ranges, it is not clear whether this is due to true variation or reflects simply the presence of outliers. Additional information is required to generate some hypotheses regarding the extent and nature of the variation. The study was based on a large sample size, thus contributing to the generalizability of the results. Only the largest waiting lists, however, were selected in a region known for large waiting lists. The generalizability of these results to other hospitals and regions with more moderate waiting lists is not clear.

Bishop (1990) examined waiting lists for urology in the UK based on national statistics provided by the Department of Health and Social Services for September 1987. The data revealed significant regional variation in the number of patients awaiting surgery. Wait list size ranged from just over 500 patients in Oxford to more than 5,550 in North East Thames. Over half of patients in 8 regions had been waiting 2 months; the results varied across regions from 80% in waiting 2 months in Mersey to approximately 56% in NW Thames. Likewise, the proportion of patients waiting 11 months varied from 50% in Mersey to less than 20% in the Northern region. The author contends but does not formally assess that the variation may be due in part to the volume of out-patient treatment, surgeons' experience, adequate staffing in operating theatres and varying periods of post-operative in-patient admissions (Bishop, 1990).

While these data indicate the presence of regional variation in wait list size and waiting times for urological services, there was no adjustment for population, hence, differences in wait list size could be due in part to different underlying populations across regions. The analysis of variation is restricted to the regional level; there is no information provided regarding variation at the

hospital or physician level. Bishop's comments regarding the factors contributing to the variation, however, focus on hospital and physician characteristics. There is no information provided regarding possible regional factors contributing to the variation in waiting list size or waiting times.

Pope et al. (1991) conducted a study of five computerized waiting lists obtained for October 1988 from three general and two orthopaedic surgeons in a district hospital in the outskirts of London. The purpose of the study was to report waiting list size and times as well as to determine the variation in composition and waiting times among surgeons. Collectively, the waiting lists contained 1,283 patients who were actively waiting for care. The information available for each patient included, age and sex, consultant name, date of referral, procedure and urgency rating. The distribution of waiting times was highly skewed, with most patients waiting a few months and some waiting more than 5 years. In general surgery, 60% and 80% of patients waiting more than 1 year and 3 years respectively were waiting for varicose vein surgery or hernia repair. In orthopaedic surgery, 15% of patients waiting more than 1 year were doing so for knee and hip replacements and 22.5% were waiting for surgery on other joints.

The results also indicate a high degree of inter-consultant variation in waiting list size, waiting times and case mix. For example, the waiting list size for the general surgeons A, B, and C were 298 patients, 296 patients and 689 patients respectively and the corresponding average waiting times were 6, 11 and 10 months. Approximately 49% of patients waiting for surgeon B were waiting for hernia and varicose vein surgery compared to 34.2% for surgeon A and 39.7% for surgeon C. Similarly, the waiting list size and mean waiting times for the orthopaedic surgeons A and B were 238 and 265 patients and 15 and 8 months respectively; 31.5% of patients waiting for surgeon A were waiting for knee replacement compared to 1.5% for surgeon B. Finally, a

significant association was found between urgency rating and waiting time using Chi-square analyses. While in general, waiting times were lower among more urgent cases, there were some anomalies; for example, several orthopaedic patients with an urgency score of 3 were less likely to have extended waits compared to patients with urgency scores of 2 representing more urgent cases (Pope et al., 1991).

The study focussed on two important characteristics of waiting lists, namely skewed waiting times and inter-consultant variation. The distribution of waiting times is important since it will affect the appropriateness of different statistical analyses. Despite the presence of skewness in the waiting time data, the authors chose to report means rather than medians, in doing so possibly conveying a misleading picture of wait times. No information is provided regarding data quality. It is possible that the skewness in waiting time may be due in part to inaccuracies within the data (e.g. patients not taken off the list). The authors also investigated the inter-consultant variation through comparisons of mean waiting times, wait list size and case mix. Given the distribution of the wait time data, it is unclear whether the difference in mean waiting time is due in part to the presence of individual outliers or whether it is simply a difference in case mix or differences in access to operating facilities. The generalizability of the study is obviously limited, given the small number of participating consultants.

Bloom and Fendrick (1987) investigated waiting times for medical care in Great Britain based on a variety of data collected between June and September 1984. Waiting time statistics for inpatient services were obtained from the Hospital In-patient Enquiry (HIPE), a 10% sample of inpatient discharges. Telephone interviews were conducted with hospital representatives and physicians to obtain information not included in the HIPE regarding waiting times for primary and specialty care for non-emergency, non-urgent ambulatory visits for new patients, existing

patients and referred patients for specific diagnoses. The surveys were conducted among 43 randomly selected hospitals providing specialty care in the UK. To obtain information regarding waiting times for general practitioners, 33 community based physicians were randomly selected. The surveys also included 10 full-time private practitioners in London, to collect some information on waiting times in the private sector.

The total waiting time was defined as the sum of all waits for non-emergency care for a range of specialties. The authors reported median waiting time for patients awaiting hospitalisation to be 14 weeks, with a sevenfold difference across specialties. The median waiting time ranged from 20 weeks for otolaryngology and orthopaedics to 4 to 5 weeks for general medicine, thoracic surgery and urology. Thirty-six diagnoses were found for which patients had a median wait for admission of 9 weeks or longer. (The total number of diagnoses assessed was not reported). The authors noted regional variations in waiting time but the intra-regional variation was larger than the between region variation. The latter could not be explained by differences in population age and sex. Finally, the reported median waiting time for private care was only 3 days (Bloom & Fendrick, 1987).

Unlike previous studies, this one is based on a range of data sources required to calculate total waiting time from GP referral to treatment rather than simply waiting time for inpatient care. The authors combined two distinct types of data, namely administrative hospital data (HIPE) and survey data. The former represent retrospective measures of waiting times for inpatient care. The waiting times reported by hospitals and physicians in response to the survey reflect current waiting times for patients (i.e. cross-sectional measure). The effect of combining these disparate sources of data is not readily apparent. Perhaps the survey could have included inpatient waiting times which could have been compared to the information obtained from the HIPE to determine

any discrepancies. The researchers did recognize the skewed nature of waiting time data and reported median times. They also reported some degree of inter- and intra regional variation, but did not provide any details regarding the extent or nature of the variation. Finally, the study was based on a random selection of hospitals and physicians and included a broad range of specialties, thus improving the generalizability of the results relative to other studies.

Several Canadian studies have examined the general characteristics of waiting list size and waiting times for a range of procedures. Globerman examined waiting lists and waiting times for selected procedures in British Columbia. Data were collected via a physician survey mailed to 606 randomly selected physicians representing 10 specialties based on mailing lists provided by the British Columbia Medical Association. The response rate was 24% (n=145) and varyied by specialty and region. Physicians were asked to report the total number of patients waiting for selected procedures and the average waiting times; reported average waiting times were weighted to reflect differences in patient volume. The total number of patients reported waiting was 7,840. Average waiting times ranged from 3.1 weeks (internal medicine) to 25.6 weeks (urology). Large standard deviations (not reported) were said to inidicate a high level of variability in both waiting list size and waiting times. The largest single group of patients (n=944) were waiting for cystoscopy and waited an average of 23.6 weeks. The next largest waiting list was for cataract, with 882 patients awaiting surgery with an average waiting time of 18.2 weeks. The author concluded that waiting lists should be monitored since there may be social costs associated with waiting which may vary by procedure (Globerman, 1991(b)).

The study was based on data collected via physician surveys. There was no consideration of the reliability or validity of the data. The response rate is low, thus adversely affecting the generalizability of the results. The results provide some evidence of variability in waiting list

size and waiting time among the various procedures analyzed. The author did comment on the possibility of skewed waiting time data but still chose to report means rather than medians, thus possibly overstating the actual waiting times.

Jacobs and Hart (1990) investigated waiting list times for selected procedures in Canada. The study was based on a survey of teaching hospitals conducted in 1989 to determine average waiting times for three procedures: hip replacement, coronary artery bypass and cholecystectomies. Questionnaires were mailed to the CEO of each teaching hospital (n=57); they were asked to report the average number of days from booking to admission. The response rate was approximately 80%. The distribution of the reported waiting times for all three procedures demonstrated a significant degree of skewness and variability. The standard deviation (SD=104) was greater than the mean (69 days) for cholecystectomies and was also very high for hip replacement (SD=104, mean=136) and heart surgery (SD=84, mean=108). Waiting times ranged from 0 days to 1 year for hip replacement and heart surgery; and from 7 days to 1 year for cholecystectomies. The average waiting times also varied by region, with the West demonstrating consistently higher average waiting times for all three procedures. The authors also noted considerable variation within regions; hip replacement in Quebec, for example, ranged from 30 to 300 days and from 0 to 315 days in Ontario. Respondents were also asked to indicate appropriate waiting times for each procedure and once again, there was variation in reported times. Heart surgery was the only procedure for which the mean reported waiting time (108 days) differed considerably from the mean reported appropriate wait time (54 days) (Jacobs & Hart, 1990).

The study represents one of the earliest attempts to collect waiting time data at the national level in Canada. However, there is no information regarding the quality of waiting time data in each

hospital nor the number of physicians represented. Based on the information presented, the distribution of waiting times as reported by the hospital CEOs is skewed; a more accurate reporting of waiting times, therefore, could have been achieved using medians or time interval frequencies. Furthermore, differences in actual reported waiting times and between actual and appropriate waiting times may be due to the effect of outliers.

Higginson et al. (1992) investigated waiting list size and waiting times for patients undergoing cardiac catheterization, precutaneous transluminal coronary angioplasty (PTCA), and open-heart surgery in Canada between April 1, 1988 and March 31, 1989. The study was based on data collected via a mailed survey to all directors of cardiac catheterization laboratories (n=48) and the chiefs of all adult cardiovascular surgery programs (n=33). The response rate was 100% following two mailings and a telephone follow-up. Total population figures as of June 1, 1988 were used to calculate adjusted rates. Mean waiting times were weighted to reflect the differences in patient volume between centres. The results were presented by province with Nova Scotia, New Brunswick and PEI grouped since most surgeries were performed in Nova Scotia. The number of patients awaiting cardiac catheterization as of January 11 was 5012 (19 per 100,000); waiting list size ranged from 5.1 patients per 100,000 in Newfoundland to 30.9 patients per 100,000 in Quebec. The mean waiting time for Canada was 8.5 weeks ranging from 2.9 weeks in Newfoundland to 10.6 weeks in Nova Scotia. There were 952 patients (3.7 per 100,000) awaiting PTCA as of January 11, 1990. The mean waiting time for PTCA ranged from 2.7 weeks in Saskatchewan to 15.4 weeks in Quebec and the national waiting time was 11.0 weeks. Finally, a total of 4495 (17.3 per 100,000) patients were awaiting elective open-heart surgery with the number varying from 6.7 per 100,000 in Saskatchewan to 25.1 per 100,000 in BC. The mean waiting time was 22.6 weeks, ranging from 7.9 weeks in Saskatchewan to 32.7 weeks in Quebec. The variability in waiting list size and waiting times reflected the differences

in availability of facilities and specialists, attitudes and referral patterns across the provinces. They noted that regular collection of such data would inform resource requirements for cardiac surgery in Canada (Higginson et al., 1992).

This national cardiac study was repeated by Higginson et al. (1994) to determine waiting list size and waiting times for the same procedures in 1991 compared with figures in 1988 (Higginson et al., 1992). The number of patients waiting for cardiac catheterization decreased from 19 per 100,000 in 1988 to 15 per 100,000 in 1991 with no changes in mean waiting time; the rate of surgery increased during this time period from 236 per 100,000 to 256 per 100,000. Waiting lists for PTCA remained the same while waiting times decreased from 11 weeks to 9.2 weeks; the rate of surgery increased nationally from 39 per 100,000 population to 54 per 100,000. The rate of open heart surgery also increased from 63 per 100,000 in 1988 to 76 per 100,000 in 1991. Both waiting list size and waiting times decreased from 17 per 100,00 to 14 per 100,000 and from 22.6 weeks to 21.3 weeks respectively (Higginson et al., 1994).

The authors used the best available data on waiting lists for cardiac surgery. There is no information provided regarding the reliability or validity of the data. Participants were given the opportunity to review responses and make any additional corrections or adjustments. The analysis of variation was limited to the regional level and the data were adjusted for population size. Waiting times were reported as means; given the skewed nature of waiting time data, it is possible that the figures overstated the waiting times.

Naylor et al. (1993) investigated the management of coronary artery bypass surgery cases in Ontario prior to the implementation of formal queue management criteria and expansion of caseload capacity. This retrospective study was based on the chart reviews of 413 patients from

four centres who underwent cardiac catheterization between October 1987 and April 1988. This led to the identification of 193 patients who were eligible for and proceeded to CABS. A 7 point urgency rating scale was applied to all cases, ranging from emergency cases (1) who were expected to be revascularized immediately to marked delay (7) where the expected waiting time was 3-6 months. Waiting times were defined to be the time between date of coronary angiography and surgery.

The mean waiting times varied between hospitals even after adjustments were made for urgency scores ($p<.0001$ with ANOVA). Average waiting times varied from 31.3 (S.E. 5) days at hospital B to 111 days (S.E. 37.7) for patients at hospital D. (Hospital D did not have onsite revascularization but patients were referred to either hospital A,B, or C). Even when the analysis was conducted without hospital D, the results were unchanged. Waiting times also differed between patients catheterized by cardiologists off-site versus those referred to on-site practitioners. A nested analysis of variance revealed that referral from hospital D was associated with longer waiting time ($p<.05$); the results were even more significant when adjustments were made for urgency scores ($p<.0001$). The authors concluded that waiting lists are managed in part by clinical urgency but that explicit queue-forming criteria, audits, and mechanisms to redistribute patients are necessary to optimise the use of waiting lists to allocate resources (Naylor et al., 1993).

This retrospective study was conducted on highly reliable data abstracted from patient records. Waiting times were clearly defined and measured consistently across hospital sites and patients. The distribution of the waiting times appeared to be skewed, making the use of means and parametric tests (i.e. ANOVA) questionable. The study provides considerable detail regarding

variations in waiting times. The generalizability of the results is limited to CABS and additional information is required to determine if the results are generalizable across other centres.

A similar finding was observed in BC for cardiac waiting lists. Katz et al. (1991) reviewed the waiting list situation for coronary artery surgery in BC during the late 1980's. A preliminary review of waiting list data in three BC hospitals revealed marked variation in waiting times across hospitals and physicians. The proportion of patients waiting more than four months ranged from approximately 50% to less than 10%. Waiting list size also varied among the 14 physicians performing the procedure. Approximately two thirds of the waiting list was accounted for by three physicians. Waiting list size ranged from less than 25 patients for one surgeon to over 150 patients for two other surgeons, all of whom were based at the same hospital. In another Vancouver hospital, 7 surgeons had waiting lists ranging from 10 to 50 patients while the eighth surgeon had approximately 125 patients waiting for cardiac care (Katz et al., 1991).

A recent study conducted by Bell et al. (1998) compared the differences in waiting times and out-of-pocket costs for 7 diagnostic procedures in US versus Canadian hospitals. Two hospitals in every major city (>500,000) in the two countries were surveyed to determine the waiting times for each procedure. Overall, 48 US and 18 Canadian hospitals were surveyed between May 1996 and April 1997. Respondents varied in the precision of their estimates of waiting times but none failed to provide an estimate of the expected wait. Waiting time varied across procedures in both countries from a low of 1 day for electrocardiograms and prothrombin time to a high of 165 days for total knee replacement in Canada. Waiting times were generally longer in Canada compared to the US with significant differences for MRI of the head (150 days vs 3 days),

colonoscopy (28 days vs 14 days) and total knee replacement (165 days vs 25 days) (Bell et al., 1998).

Waiting time was one of the key indicators used to compare hospital services in US versus Canadian hospitals. The waiting time data used in the study are highly suspect for several reasons. First, waiting times were not clearly defined; it had to be assumed that researchers were asking respondents to provide waiting times for the next available service. Second, there were no criteria beyond, "individuals in responsible department", used to select respondents providing the waiting time information. Finally, there is no information provided regarding the source of the waiting time data. It is possible that in the absence of valid and reliable waiting time information at the hospital level, these figures may vary depending on the type of respondent. Investigators did appropriately use medians to summarize the waiting time data. The figures suggest a degree of variation in patient waiting time between the two countries and across procedure groups. There is no information regarding the level of variation between hospitals.

Inpatient waiting times for advanced cardiovascular services were compared in various institutions in Toronto, Ontario by Singh et al. (1999). Waiting time was defined as the number of days from referral to the date of transfer to the hospital providing the cardiovascular services. Data were prospectively collected over a 12 month period between May 1997 and April 1998 from 7 area hospitals representing 1202 patients. Nurses and clerks within each institution were responsible for completing a monthly waiting list log with the relevant patient information. Hospitals were grouped into one of three categories: on-site catheterization (Group 1), no catheterization laboratory but cardiologists with off-site privileges (Group 2) and no catheterization and no cardiologists (group3). The average waiting times varied across procedures from a low of 4.2 days for a pacemaker implant to a high of 11.1 days for other advanced cardiovascular procedures. Waiting times also varied by type of hospital. There were

no significant differences in average waiting times between the hospital groups for PTCA and CABG. Group 1 hospitals demonstrated the lowest average waiting time for catheterization (3.1 days) compared to Group2 hospitals (5.4 days) and Groups 3 hospitals (6.5 days). The investigators concluded that waiting times do vary across hospitals, specifically for catheterization in which hospitals with on-site laboratories have significantly shorter waiting periods (Singh et al., 1999).

This study is based on fairly reliable data collected in a standard format with a predetermined definition of waiting times. Waiting times were expressed as averages rather than medians. Standard deviation estimates, however, appear to indicate that the data are fairly normally distributed. The analysis was limited to inter-procedure comparisons in waiting time as well as between the three hospital groups. Intra-procedure comparisons across hospitals would have provided a more comprehensive analysis of the variations in waiting times. The results of the study are likely generalizable only to the Greater Toronto Area.

Median waiting times for a range of surgical procedures were compared in Manitoba by DeCoster et al. (1999) at various levels of aggregation. Eight procedures were included: cholecystectomy, hernia repair, excision of breast lesion, stripping/ligation of varicose veins, carpal tunnel release, transurethral prostatectomy (TURP), tonsillectomy, and carotid endarterectomy. The investigators used hospital and physician administrative data to retrospectively calculate patient waiting times. Waiting time was defined as the number of days between the patient's last preoperative visit and the date of surgery. Median waiting times varied across procedures in 1995/96 from a low of 16 days for excision breast lesion to a high of 57 days for tonsillectomy. Median waiting times were compared by region of residence

(Regional Health Authorities). Southern regions demonstrated consistently shorter waiting times compared to Winnipeg and the West where median waits tended to be longer. Median waiting times for cataract surgery were compared by type of physician. Cataract surgery can be obtained in the province through private clinics. The median waiting time for publicly provided cataract surgery was consistently shorter when provided by physicians working exclusively in the public sector compared to physicians who worked in both the public and private systems. In 1995/96 for example, public sector patients waited on average 7.4 weeks for cataracts provided by exclusively public sector physicians compared to 20.0 weeks for the same procedure provided by physicians working in both the public and private sector (DeCoster, 1999).

The study is based on highly valid and reliable data from the province's Population Health Information System (POPULIS). Waiting times were clearly defined and argued to be appropriate for the selected procedures since they did not involve multiple pre-operative visits. The results of the analysis clearly demonstrate variability in waiting times both across procedures and within procedures at various aggregate levels.

In general, these studies all attempt to identify key characteristics of waiting list size and waiting times. A range of data sources, methods and analyses were used. Hence, it is not possible to compare or aggregate results in any meaningful way. Despite these differences and limitations, however, the studies appear to agree on some general characteristics of waiting lists and waiting times. The majority of studies focus on the latter:

- As expected, the distributions of waiting times for most procedures tend to be skewed. The distributions are most often a positive skew reflecting a small number of

cases with exceedingly long waits. This may occur for a variety of reasons including actual long waits and/or some degree of unreliability in the data (e.g. cases not removed after treatment is received). Thus the first step when presenting and analysing wait time data is to assess the degree of skewness in order to ensure the use of appropriate reporting statistics so that waiting times are not misrepresented. This problem can be addressed in several ways including use of non-parametric statistical analyses, the removal of outliers or transformation of waiting time data; the latter options will result in a more normal distribution. In many cases, waiting times are aggregated categorically (e.g. < 3 months, 3-6 months, 6-12 months, >12 months) in order to address this problem. This often leads, however, to loss of information.

- Evidence suggests that there is often some degree of intra-procedure variation at various levels (i.e. physician, hospitals, regions). This is an important observation for two reasons. First, the presence of variation may render aggregation of waiting time data at the hospital or regional level invalid or at least highly misleading. Second, the presence of variation is an indicator that patient, physician, hospital or regional factors are affecting waiting times. This information may be critical to the development of policies to address situations where wait times may be placing patients' health at risk.
- Evidence suggests that surgical specialty waiting lists are not homogeneous as often assumed. The distribution of waiting times and degree of variation is not consistent across specialties and procedures. Aggregation of waiting list data across specialties and procedures, therefore, may be misleading; the results of such analyses may represent the reality for some waiting lists but not all. Specialty waiting lists need to be analysed individually in order to identify the specific characteristics of each type,

since they may be affected by different determinants amenable to different policy options.

Information gaps regarding the basic characteristics of waiting lists:

- The majority of studies to date focus on selected specialties (e.g. orthopaedics, cardiac care, cataract). This is due in part to waiting list problems initially identified for selected procedures that have then motivated the focus of subsequent research. One almost never finds information regarding waiting lists for a range of other specialties and procedures.

2.5 FACTORS AFFECT WAITING LIST SIZE AND WAITING TIMES

The variation in waiting list size and waiting times has been documented at various levels across regions, hospitals and physicians. The question now is: what are the specific factors that explain the variations in waiting list size and waiting times? There are a number of factors which have been hypothesized to affect waiting list size and waiting times. Returning to a discussion of the conceptualization of these variables, perhaps the most notable is targeted funding. The common belief is that long waiting lists and lengthy waiting times are the result of inadequate funding.

A broad range of other factors, however, have also been implicated. These include patient characteristics (Turner et al.,1991; Alter et al., 1999) non-monetary resource availability (e.g. number of physicians, rate of surgery), and hospital characteristics (e.g. method of funding, admission rates, length of stay, emergency rates, OR capacity) (White, 1980; Buttery & Snaith; 1980, Harley, 1988; Katz et al., 1991; Ellis, 1991; Baker, 1994). While some of these may also represent various types of resources, their relationship to waiting lists and waiting times may be

more complex than originally thought. The identification of these factors and information regarding the nature of their associations would allow for a more in depth understanding of waiting lists and waiting times. It would also provide some direction regarding policy development.

2.5.1 Criteria for Review: Principles of Association and Causation

Those studies that focus on the identification of factors associated with wait list size and waiting times are critically reviewed. An association is defined to exist when "the probability of an occurrence of an event or characteristics, or quantity of a variable, depends upon the occurrence of one or more other events, the presence of one or more other characteristics, or the quantity of one or more other variables" (Last, 1988, pg 7). Several statistical methods are available to assess the significance of an association including correlation measures, tests of central tendencies (e.g. ANOVA, Krustal-Wallis) and regression analyses. A statistical association can be said to exist if chance, bias and confounding are ruled out. The effects of chance are represented in p-values (e.g. $p<.05$) which are affected by sample size; hence, all else being equal, larger sample sizes result in smaller p-values indicating that observed differences are less likely due to chance. Bias is usually introduced by the study design that results in some systematic differences occurring between groups; this could be a result of sample selection bias, data collection bias (interviewer bias, recall bias), etc. In such cases, the differences between groups or levels may be difficult to attribute to the variable of interest. Finally, confounding occurs when the association between two variables occurs as a result of other missing variables. To be considered a confounder, a variable must be related to both the outcome variable (dependent variable) and the variable of interest (independent variable). The effects of confounders can be controlled by including them in the analysis if they can be identified and data are available (Hennekens & Buring, 1987).

Significant associations, however, do not imply causation. Additional criteria must be met in order to conclude that an association is in fact causal. The criteria traditionally used in epidemiological studies that may be applicable to health services research include consistency, strength, temporality, coherence and plausibility (Hennekens & Buring, 1987). The principles of association and causality will be considered when critically reviewing the studies. In addition, given what is currently known about the accuracy of waiting list data and their general characteristics, issues of data quality, appropriate statistical methods and generalizability will also be considered.

2.5.2 The Evidence: Waiting List Size

Many of the earlier studies originate in the UK where waiting lists have been a concern since the inception of the NHS and governments have constantly strived to address the issue.
Goldacre et al. (1987) conducted a study to investigate the relationship between changes in inpatient workload and overall waiting list size. The authors hypothesized that there was an inverse relationship between admissions from the waiting list and waiting list size. The study was based on data from the Hospital Activity Analysis which identifies the source of admissions (e.g. emergency, waiting list) as well as data on the number of patients on waiting lists, reported on a quarterly basis between January 1974 and December 1983. The procedures included in the study were general surgery, trauma, orthopaedic surgery, ENT surgery, gynaecology, ophthalmology and plastic surgery.

Overall, admissions from the waiting list represented approximately 56% of total admissions. Monthly admissions from waiting lists fluctuated widely. The monthly median was reported to be 5012 patients and ranged between 2155 and 6509 patients; the number of admissions from the

waiting list showed a general increase between 1974 and 1979 followed by a slight decline thereafter. Admissions from other sources were fairly constant. Time series analyses were conducted to assess the effect of seasonal variation. Admissions from waiting lists tended to be below average in December and higher than average in November. Admissions from other sources were generally higher in the summer than winter. Over the ten year period, the median wait list size was 25,668 ranging from 20, 388 to 31, 239. There was no significant seasonal variation.

When the two trends were compared, there was a positive correlation between admissions from the waiting list and waiting list size ($r=0.35$, $df=38$, $p<.05$). The authors conducted several additional analyses to investigate the short-term association between admissions and waiting list size and the possibility that an increase in the length of the waiting list in one quarter might lead to an increase in admissions in the next quarter, but no such relationship was found. The authors concluded, therefore, that there was no inverse relationship between admissions from waiting lists and waiting list size as originally hypothesized. The authors offered several explanations for this seemingly counter-intuitive explanation, including inaccurate data, the use of waiting lists as a means to improve the efficiency of scheduling patients for surgery, and the increased likelihood of addressing previously unmet needs when waiting lists are reduced (Goldacre et al., 1987).

This retrospective study was based on 10 years of data and a large sample size, thus ruling out the possible effects of chance. The authors do acknowledge that the association identified could have resulted from inaccurate data, but provide no information regarding possible sources of inaccuracy; hence, bias may be present in the methods of data collection and/or reporting. The authors limited the analysis of additional variables to the effect of seasonal variation and industrial action (results not reported). Thus the possibility of confounding is not eliminated.

Finally, the authors noted fluctuations in admissions from the waiting lists over time but not in waiting list size, thus indicating the possibility of a non-linear relationship. There is no specific information provided regarding the correlation measures used to assess the association.

2.5.3 The Evidence: Waiting Times

Harley (1988) investigated the relationship between waiting times and a range of indicators produced nationally in the NHS, representing regional socio-economic status and resource provision, among others, for all health regions in England. Two measures of waiting times were used: (1) percentage of non-urgent cases waiting over one year, and (2) notional time to clear the waiting list (NWT). The latter is defined as: (Waiting list size x 365)/Discharges and deaths from waiting list per year. The results of the analysis indicated wide variations in NWT and waiting list size between regions, with the NWT ranging from 0 to 812 days and proportion of patients waiting over one year ranging from 0% to 79% across regions. Simple linear correlations were calculated to determine the relationship between the waiting time variables and a range of independent variables measured at the regional level.

The author hypothesized that poorer regions may have less per capita capacity and therefore longer waiting times; however, there was no significant relationship between the dependent measures and socio-economic status of the health regions. The author also hypothesized that the provision of health care resources may affect waiting times (i.e. low levels of resources would be associated with longer waiting times). There was a slightly significant association between proportion of patients waiting more than 1year and unit size (number of beds) ($r=.03$; $p<.05$) and number of out-patient clinics ($r=-.03$; $p<.05$) but neither variable was associated with NWT. There was an inverse association between throughput and NWT ($r=-.06$; $p<.01$) and proportion of patients waiting more than 1 year ($r=-.03$; $p<.01$) indicating that regions with lower through

puts may have longer waiting times as might be expected. The strongest statistical association was found to be between average length of stay and NWT ($r=.07$; $p<.01$) and proportion of patients waiting more than 1 year ($r=.06$; $p<.01$). There was no association between the dependent variable and number of senior doctors per catchment population, discharges and deaths per doctor, nor proportion of day cases. The author recognized that while there are some statistically significant associations, they are relatively small and weak. The analysis was repeated for the 30 districts with the longest waiting lists and the 30 districts with the shortest waiting lists. The author concluded that those with long waiting lists do not demonstrate any consistent characteristics that distinguish them from the others. Additional multiple correlations were examined using both dependent variables and those independent variables showing the highest one-to-one correlation since the effects may be a result of multiple factors; the analyses did not significantly increase the strength of the association (Harley, 1988).

The analysis was based on data for all 14 regions in the UK, resulting in very large sample sizes. Relatively small associations were found to be statistically significant as a result of large sample sizes. The analysis was based on data collected through the HAA and so is reasonably assumed to be consistent across all regions, thus ruling out the effects of bias due to data collection methods. It was based primarily on simple linear correlations which are important to identify significant factors but do not permit the evaluation of possible confounders. The multiple regression analysis was conducted to assess the simultaneous effect of a group of independent variables but information on interactions that may identify possible confounders was not reported. Preliminary descriptive analyses indicated inter-regional variation in both measures of waiting times, suggesting a skewed distribution; the use of parametric tests, therefore, is questionable. Finally, unlike many other studies, the dependent variables were not direct

representations of waiting times as measured in days or weeks; hence, the generalizability of these findings to waiting times more generally is not clear.

Waiting times have been hypothesized to be associated with "demand" for surgery. As is commonly known, demand for health care services is affected by both patient and physician factors. Physician "demand" may be affected by practice style or "signatures" and willingness or unwillingness to operate may be associated with waiting list size and/or waiting times (Cullis and Jones, 1985; Frankel, 1989). Researchers in Finland attempted to address this issue by investigating the association between waiting list size and surgical rates. The authors compared rates of surgery for seven procedures (varicose veins, herniaorrhaphy, cholecystectomy, haemorrhoidectomy, operation on hallux valgus, cataract extraction, and hysterectomy) with data obtained from the 1987 Finnish Hospital Discharge Register. Waiting list size data were obtained from an inquiry made to Finnish hospitals in 1987. The surgery data were obtained for all hospitals while the waiting list data were obtained for most publicly funded hospitals but not all hospitals reported waiting lists for all procedures. The number of surgical procedures and waiting list size were adjusted for population size of the hospital catchment area and were compared using product moment correlations. The results of the analysis indicated a significant positive association for herniorrhaphy ($r=0.31$; $p<.05$; $n=44$), operation on hallux valgus ($r=0.61$; $p<.001$; $n=26$) and hysterectomy ($r=0.42$; $p<,05$; $n=36$). The association was positive but not significant for all other procedures except for cataract, which revealed a non-significant inverse relationship. The remaining procedures did not demonstrate significant associations.

Hospitals were then grouped into low, medium and high rates of surgery. Krustal-Wallis analyses of variance were conducted to determine differences in waiting list size between these groups within each procedure. The only significant association was for operations on hallux

valgus; the waiting list size per 10,000 was 3.3, 7.9 and 10.2 for hospitals with low, medium and high rates of surgery respectively. These stratified analyses clearly indicate that in most cases, the relationship between waiting list size and surgery rate is positive but not linear. In general, most associations were positive, although not all were significant. The authors recognized that this analysis did not demonstrate causality. There may be numerous other factors which affect waiting list size and surgical rates (e.g. population characteristics) that need to be assessed simultaneously (Norberg et al., 1994).

This analysis of the relationship between waiting list size and surgery rates was undertaken for a range of procedures at the hospital level. For only 3 of 7 procedures were the relationships significant, yet all but one demonstrated a positive association. The lack of statistical significance in the other procedures may be due to small sample size. Information regarding waiting list size was obtained from hospitals, but there is no information regarding the method of data collection used at individual hospitals to determine whether there was any systematic bias. The analysis was restricted to surgical rates only; no other variables were included. It is possible that specific policies at the hospital level affected both waiting list size and surgical rates (e.g. caps on procedures) thus confounding the association.

The association between waiting times and a range of patient and institutional factors was examined by Coyte et al. (1994) for knee replacement surgery in the US and Canada. Data for the study were obtained through a stratified random sample of 1486 Medicare recipients in the US and 516 patients in Ontario hospitalised for knee replacement between 1985 and 1989. All those selected were surveyed by mail to determine waiting times for surgical consultations and surgery. The overall response rates were 80%; the rate of response to specific questions was 60% to 65%.

The results of the analysis indicate that the mean (median) waiting time for surgery was 3.2 (2) weeks for the US national sample (n=371) and 5.4 (4) weeks for the Ontario sample (n=325). Multiple regression analyses were conducted to determine the effects of a range of factors on waiting times. Institutional factors including number of knee replacements performed at the hospital, type of hospital and number of beds, were significant determinants of waiting times for surgery in Ontario but not in the US. Mean waiting time for surgery in teaching hospitals in Ontario was 16.3 weeks compared with 10.4 weeks in non-teaching hospitals. Income, education and gender were not significant factors in either country. Race was not a significant determinant in the US. Age was inversely related to waiting times and condition prior to surgery was related to waiting times in the US such that older people and those with worse knee conditions had shorter waiting times. In Ontario, condition of the knee prior to surgery was not related to waiting times. Patient location (urban vs rural) was not associated with waiting times in Ontario but rural patients in the US experienced longer average waits compared to those in urban areas. Collectively, these factors accounted for 20.5% of variation in waiting times for both samples (Coyte et al., 1994).

Like most studies, retrospective data were used but unlike previous studies, the data were collected via patient survey. The results for both groups, therefore, may reflect some recall bias. Multiple regression analyses were conducted to consider the various factors that may affect waiting times but there is no discussion of which factors are indeed hypothesized to directly affect waiting time or how they might be expected to affect waiting times. Finally, variable coefficients are not reported, thus it is difficult to assess the magnitude of the effect of each significant variable on waiting time.

A series of studies have investigated the factors associated with waiting times for specific cardiac procedures. Gaffney et al. (1995) investigated the clinical and non-clinical factors that influence waiting time from initial angiography to angioplasty. The retrospective study was based on a random sample of 106 patients from two Belfast catheterisation laboratories who were undergoing first angiography and proceeding to angioplasty in 1991. Data were obtained regarding patient characteristics (age, gender, location, occupation, marital status), lifestyle habits (smoking, body mass index), history of myocardial infarction, family history, comorbidity, and severity of angina, from medical notes. Logrank tests for univariate analyses were conducted to assess differences in waiting times for defined groups. Significant differences were found by age (Chi-Square: 8.15; $p<.017$) with median waiting times reported to be 7, 28 and 14 days for patients under 45, 45-64 and 65+ respectively. Significant differences were also found with respect to affluence of the patients' area of residence (Chi-square=13.96; $p<.007$) with median waiting times of 7 days for regions with lower deprivation and 69 days for regions with higher levels of deprivation. The results clearly demonstrate the absence of a linear trend. A multivariate analysis was conducted using the Cox proportional hazards model to determine the most significant factors affecting waiting time while adjusting for covariates and confounding. The results of the analysis indicate that presence of severe angina and history of myocardial infarction were significant factors, although limited details were provided regarding the latter analysis (Gaffney et al., 1995).

This study was based on highly reliable data with clearly defined waiting times. The results of the analysis, however, are based on a relatively small sample size that will have an effect on significance values. The researchers did attempt to conduct a multivariate analysis that considered a range of factors and possible interactions but insufficient information regarding the

model renders the interpretation of the results difficult. Medians were used to represent waiting times. Generalizability of the results is limited given sample size and single location.

Similar studies were conducted in Canada by Naylor et al. (1995) for coronary artery bypass. Following the establishment of a central registry for cardiac surgery in Ontario, researchers conducted a study to examine the experiences of 8517 patients leaving the registry between October 1991 and July 1993. The retrospective study was based on patient data routinely collected at each cardiac surgery centre by a nurse co-ordinator and subsequently sent to the central registry office. For each patient, information regarding waiting time (i.e. time from registration to surgery) and acuity score (i.e. defined by clinical characteristics) was available. The analysis was based on 8213 patients who underwent surgery. The distribution of waiting times was skewed, with a median waiting time of 17 days (IQR: (4-51). Once controlled for clinical factors, waiting times varied by hospital ($p<.001$) from 8 to 48 days. A multivariate analysis was conducted to determine the most significant factors contributing to waiting times. The factors considered included age, gender, symptom status, recent MI, anatomy (condition of vessels) and risk from non-invasive test results. The most significant factors associated with waiting times were symptom status ($p<.001$) and anatomy ($p<.001$) (Specific coefficient values were not provided). Patients with class IVC angina underwent surgery 3-4 days faster than patients with IVB; patients with IVA received treatment 10 days faster than patients with class I-III angina combined (Naylor et al., 1995).

This retrospective study was based on the data obtained from a single registry where waiting times are clearly defined and data were assumed to be collected in a consistent and reliable fashion reducing the chance of bias. Likewise, the sample is large, thus ruling out chance as a possible explanation for associations found. Efforts were made to consider a range of factors

simultaneously hypothesized to affect waiting times. Limited information is provided regarding the magnitude and direction of the association of these factors with waiting times.

An earlier study conducted by Naylor et al. (1993) considered the association of patient preference for surgeons and waiting times. The study sample included all patients (n=571) referred to a central referral office in Toronto by cardiologists from hospitals without on-site revascularization, between Jan 3, 1989 and June 30, 1991. 496 patients were accepted for the study. Relevant demographic and clinical information was provided to the referral centre by the cardiologist. In 20% of the cases, a specific surgeon or interventional cardiologist was specified; the mean waiting time for patients who did not specify a preference was 22.73 days compared to 35.31 among patients who did specify a preference (p=.002 after adjustments made for acuity scores). The authors concluded that a request for a specific physician caused significant delays (Naylor et al., 1993).

A recent study conducted by Clover et al. (1998) investigated patient factors associated with waiting times for surgery in three public hospitals in New South Wales, Australia. The study was based on data obtained from the Area Health Service's booking system as well as information from patient surveys. The study included all patients entered into the booking system between November 16 and 22, 1994 and then again between January 16 and February 12, 1995 (n=691). Consenting patients were interviewed via telephone to obtain demographic information, health status (SF-36) and satisfaction levels; subsequent follow-ups were conducted after three months and six months. The SF-36 was conducted on average one month following booking on consenting Category 2 patients (i.e. no desirable time for surgery) still awaiting surgery (n=436). Waiting times were explicitly defined as the time between patient booking and the date of surgery. Survival analyses were conducted to identify significant factors with (Model

1) and without (Model 2) information from the SF-36. The results of Model 1 revealed that waiting times differed significantly across specialty groups; waiting times for ENT (Hazard ratio (HR)=0.32), orthopaedics (HR=0.43) and urology (HR=0.566) were significantly longer compared to general surgery (i.e. Reference Group). Category 1 patients with urgent conditions (HR=3.48), employed patients (HR=1.45) and those with private health insurance (HR=1.69) had shorter waiting times. The remaining patient factors (i.e. age, gender, aboriginality, country of birth, education, and marital status) were not significant. When the urgency rating was replaced by the SF-36 scores in Model 2, the results were unchanged. None of the SF-36 scores were significantly associated with patient waiting time. The authors concluded that waiting times for surgery were not simply determined by patient status (i.e. urgency) but were also influenced by other factors, thus raising the question of equity within the system (Clover et al., 1998).

This study was conducted prospectively on a fairly large sample size. The data used in the study were collected through standard methods, thus improving the quality and accuracy of the data. While a Hazards model can be appropriately used to assess the association of various factors on the probability of a particular outcome, there is no preliminary assessment of the potential level of autocorrelation within the data and the possible effects on the model. There was no discussion regarding possible interactions between the independent variables. Finally, the study is restricted to one Area Health Service region in Australia and patients were only included over specific times thus reducing the generalizability of the results.

Alter et al. (1999) recently investigated clinical and non-clinical factors associated with waiting times for coronary angiography among patients in a single hospital in Toronto, Ontario (Sunnybrook Health Science Centre). This prospective study followed 357 patients from triage

to surgery during an 8 week period in 1997. Among those awaiting surgery, 22 patients experienced adverse events while in the queue leaving 335 patients in need of surgery. Upon initial assessment, patients were categorized into one of the three groups (urgent, semi-urgent, or elective) based on the recommendations of the referring physician and the triage officer. Patients were also grouped into one of the following categories based on the affiliation of the referring physician to the hospital: (1) Sunnybrook physician; (2) itinerant physician (i.e. practices elsewhere but performs angiography at Sunnybrook; and (3) other. For each patient, an actual waiting time (AWT) was provided as well as a retrospective estimate of the recommended maximum waiting time (RMWT). Approximately 60% of patients received angiography within the RMWT. ANOVA results indicate that there were significant differences in the AWT by physician affiliation. For inpatient referrals, patients of Sunnybrook physicians waited a significantly shorter time (1 day) compared to both the itinerant group (5.7 days) and the other group (8 days). For outpatient referrals, patients of the itinerant group waiting significantly shorter time (28.6 days) compared to the Sunnybrook group (58.5 days) and the other group (85.2 days). There were no significant differences in the RMWT between the groups for both inpatient and outpatient referrals. When both clinical and non-clinical factors were considered in a multivariate regression model, the clinical factors accounted for 45.6% of the variation in AWT; physician affiliation accounted for 9.3% of the variation. Age and sex were not significant factors. The investigators concluded that the effect of non-clinical factors on waiting times suggests possible inequities in access to services and the need for queue-management systems to ensure timely and equitable provision of services (Atler et al., 1999).

This prospective study is based on reliable data collected through a single source. The sample size appears to be adequate given the number of independent variables used in the model. The effects of various clinical and non-clinical factors on waiting times were assessed through

various statistical methods. There was little information provided regarding the regression model used to assess the combined effects of patient demographic and clinical factors and physician affiliation. Final regression coefficients were not provided so it is not possible to appropriately assess variable specific effect size. Furthermore, there is no mention of potential interactions between the various independent variables used in the model. Finally, the generelizability of the results is limited due to the use of a single hospital site.

The perceptions and experiences of providers regarding preferential access to cardiovascular care in Ontario were investigated by Atler et al. (1998). The study is based solely on data generated from the provider surveys and does not actually involve any waiting time data. The results, however, warrant a mention in this review. Surveys were sent to 1105 physicians including cardiac surgeons, hospital chief executives, internists and family physicians and 71.3% responded (n=788). Respondents were asked a series of questions focussing on pressure for preferential treatment, beliefs about factors that cause preferential access, types of patients benefiting from preferential access and personal involvement in preferential access. The majority of respondents indicated that pressure from referring/consulting physicians (91.3%) or patients or relatives (83.5%) were involved in cases of preferential access. Over 70% of respondents indicated that the following factors could be associated with preferential access: a patient's personal connections to the treating physician(s); patient's community standing is such that it would be disadvantageous if they were unhappy with the services provided by the hospital; and patient's community standing is such that it would be advantageous if the patient were satisfied with the services. Approximately 63% of respondents indicated that litigious factors could be involved. The types of individuals most likely to receive preferential treatment included physicians or their families, public figures, politicians or hospital board members. The

majority of cardiologists (95.3%), cardiac surgeons (90.0%), internists (80.7%) and family physicians (59.8%) indicated that they had been personally involved in providing preferential access. This exploratory study provides preliminary evidence that non-clinical factors are involved in providing preferential access to cardiac services (Atler, 1998).

A number of studies have assessed the effects of various factors on waiting list size and waiting times (Table 2.2). The studies are based on differing methods and conducted at various levels (e.g. patient, hospital, region) and are primarily concerned with determination of association rather than causation. The diversity in the methods makes it difficult to consolidate results in any meaningful way. Nevertheless, the following observations are possible:

- Patient Factors:

  Various studies have considered a variety of patient characteristics (e.g. clinical status, age, gender, education, location, patient preferences) to determine whether they explain any variation in waiting times. The intent of such analyses has been to determine whether access was influenced by clinical need rather than patient characteristics such as socio-economic status. Patient clinical status has been shown to affect waiting time among patients undergoing cardiac surgery; this is expected since waiting lists for such procedures are more likely to be actively managed. The evidence on clinical factors for elective procedures is less clear. There is also limited evidence that suggests that non-clinical factors may be involved in determining patient waiting times for surgical procedures.

- Physician Factors:

  Recent studies have focussed on the role of physician characteristics in determining patient waiting times. While the evidence remains scanty, there are some indications that factors such as access to hospital services and non-clinical

decisions may affect waiting times.

- Hospital Factors:

  A common assumption is that hospital factors such as available resources and throughput will affect waiting list size and waiting times such that more resources and greater throughput are associated with shorter waiting lists and shorter waiting times. Selected indicators such as throughput, length of stay, type of hospital and volume of surgery have been found to affect waiting time in a limited number of studies. There is very little information regarding the direction and magnitude of these associations. There is certainly no empirical base from which we could currently draw conclusions about relationships between capacity or throughput and waiting list size and waiting times. There are also many other hospital factors such as OR capacity and management, availability of technicians, for example, that may affect waiting lists and times but to date have not been tested.

The literature is clearly at a preliminary stage with respect to the identification of factors affecting waiting list size and waiting times. There are significant gaps in the literature:

- There is currently no general theoretical framework that outlines a comprehensive range of factors that may affect waiting list size and waiting times. The development of a framework would serve both to identify the likely contributing factors as well as to provide some information regarding the pathways through which they affect waiting list size and waiting times. The studies to date have been limited in scope due to the absence of such a framework and limited availability of data.

- As is evident in Table 2.2, there are gaps in information regarding a whole range of patient, physician, hospital and regional factors that may affect waiting times. Some of these factors have been identified in various discussions and editorials on waiting lists and waiting times. For example, patient choice regarding physician and time of surgery has long been hypothesized to adversely affect waiting time. Patient waits may be lengthened if treatment is postponed due to work, family commitments, holidays or specialist preference; conversely, waiting time may be shortened if patient cancellations and non-attendances are reduced (Fishbacher et al., 1986; Houghton et al., 1989; Koppada et al., 1991; Wildner et al., 1991). Waiting times may also be adversely affected if treatment is cancelled or limited due to various physician and hospital factors (Keene, 1989; Baker, 1994; Hamilton, 1997). Conversely, patient waiting times may be reduced with changes in models of care (e.g. day surgery) (Miles, 1988). The prevalence of these events and their effect on waiting times are important and not well understood. Prospective studies could be conducted to track patient activities and events while waiting for surgery.

- While traditional epidemiological methods tend to focus on the effects of a single factor, there is clearly a need to promote studies that focus on a broader range of factors simultaneously in multivariate analyses. Waiting lists and waiting times exist in a complex environment affected by various forces at the patient, physician and hospital level. As such, complex models are required to consider these effects simultaneously, as well as assess possible interactions. For example, the introduction of hospital global budgets has been hypothesized to adversely affect waiting lists and waiting times, in part due to the need to limit the number of specific procedures;

Table 2.2: Review of studies investigating factors affecting waiting list size and waiting times (* Significant Association)

Reference	Procedure	Unit of Analysis	Data	Methods	Dependent Variable	Independent Variables				
						Patient	Physician	Hospital	Regional	Other
Goldacre (1987)	Various	Health Regions	Hospital Activity Analysis	Time Series	Wait list size	-none used	-none used	-none used	-none used	-adm from WL*
Norberg (1994)	Various	Hospitals	-Discharge Registry -WL data	Correlations	Wait list size	-none used	-none used	-surgical rates* (for selected procs)	-none used	-none used
Harley (1988)	Various	Health Regions	n/a	Correlations	-% cases waiting>1 year -NWT	-none used	-discharge and death per MD	-through-put* -LOS*	-SES -# of beds* -# out-pat clinics* -# of MDs	-none used
Coyte et al (1994) Canadian	Knee Replace-ment	Patients (n=516)	Patient Survey	Multiple Regression	Waiting time	-age,gender, -income, education -location -type of arthritis -condition prior to KR	-none used	-type of hospital* -# of beds* -volume of KR*	-none used	-none used
Gaffney (1995)	Angioplasty	Patients (n=106)	Medical Records	Univariate (Log Rank test) Multi-variable analyses (Cox Prop Hazard)	Waiting time	-age*, gender -location, occupation -marital status, lifestyle -history* -co-morbidity -severity of angina*	-none used	-none used	-SES*	-none used
Naylor et al (1993)	CABG	Patients (n=496)	Cardiac Registry	Univariate	Waiting time	-patient preference for MD*	-none used	-none used	-none used	-none used
Naylor et al. (1995)	CABG	Patients (n=8213)	Cardiac Registry	Multivariate Regression	Waiting time	-age, gender -symptom status* -recent MI, anatomy* -risk of invasivetests	-none used	-none used	-none used	-none used
Clover et al. (1998)	Various	Patients (n=691)	-Area Health Service's booking system -Patient Survey	Survival Analysis	Waiting time	-age,gender -aboriginality, birth -education, married employment status* -health insurance* -health care card -urgency*,SF-36 scores	-none used	-hospital location	-none used	-type of surgery * (i.e. specialt y area)
Alter et al. (1999)	Coronary Angio	Patients (n=357)	Referral and Triage Data	-Multivariate Regression -ANOVA	Waiting Time	-age, sex -clinical status*	-status of referring MD*	-none used	-none used	-none used

this practice could affect physician practice by limiting the number of procedures s/he can perform. An analysis that simply considers physician practice volume would not accurately reflect this reality.

Studies need to be conducted with a focus on specific specialty waiting lists. There is some evidence to suggest that waiting lists are not homogeneous and different specialties or procedures may respond to different factors differently. Study designs should be developed to ensure greater levels of generalizability.

2.6 FUTURE RESEARCH

A review of the existing published and gray literature provides some insights regarding our collective understanding of waiting lists and waiting times to date. It also provides some insights regarding current gaps in our understanding and knowledge of these phenomena which serve to guide future research efforts in general as well the work of this particular project. The review points to the need for research in two primary areas: (1) data validity and reliability and (2) factors affecting waiting lists and waiting times. The evidence also points to a need to focus on waiting time versus waiting list size. The methodologies used in either area of research should take into consideration the basic nature and characteristics of waiting lists and waiting times as they are known to date.

These findings were used to guide the analysis of the BC SWL data. Regardless of the type of investigation conducted, the review clearly indicates the need to ensure that any study, including this one, is based on accurate data with valid and reliable measures of waiting time and wait list size. The first step, therefore, must be to conduct a thorough analysis of the BC SWL data

focussing specifically on the validity and reliability of waiting time (i.e. date-on and date-off the waiting list) and waiting list size. This analysis is presented in detail in Chapter 4 .

Second, the availability of the SWL data provides a unique opportunity to further the research and knowledge regarding those factors that affect waiting lists and waiting times. The literature review, however, points to several key issues regarding such investigations. First, given the lack of a conceptual framework, this work should begin with the development of a comprehensive framework that builds on our current understanding of what does or might affect waiting lists and waiting times as well as identify factors not yet considered. These factors should be placed within a theoretical framework that illustrates likely pathways. In the following chapter, such a model is proposed. Since evidentiary developments on waiting lists and waiting times remain in their infant stages, prior conceptual work in another area of health services research, namely access to health care services, will be incorporated to develop a more in depth model. Elements of the model will be tested in Chapter 5.

CHAPTER III

A CONCEPTUAL FRAMEWORK for WAITING LISTS AND WAITING TIMES

The findings of the literature review clearly indicate the need to investigate the factors affecting both the variations in waiting times and waiting lists size. The results of such investigations would serve to provide a more comprehensive understanding of this phenomenon. However, an analysis of the gaps in our understanding of waiting lists and waiting times points to the need for a conceptual framework to guide the course of inquiry. The creation of such a framework is aided by developments in other sectors of health care research, specifically, access to health care services. In the previous chapter, access to services was identified as one of the key frameworks used by various groups to facilitate their understanding of waiting lists and waiting times. The access to health care literature provides some key concepts and understandings that are applicable to the study of waiting lists and waiting times. Indeed, wait lists and wait times represent potentially important indicators of access to health care; therefore, any conceptualizations of wait lists and times should be embedded, or embeddable, within a broader access to care framework or model.

3.1 ACCESS TO HEALTH CARE SERVICES

The following section provides a brief review of the literature focussing on access to health care services including various definitions, research findings and conceptual frameworks for the study of access related issues.

3.1.1 Definitions of Access

Access to health care services is often described as a vague and confusing concept due in part to the various problems associated with its definition, the most prominent being the existence of multiple meanings (Aday & Andersen, 1974; Frenk, 1985; Penchansky et al, 1981; Birch & Abelson, 1993; Khan et al, 1994).

Access is often described as synonymous with concepts such as utilization and availability of health care services. One of the earliest definitions is provided by Donabedian who defines access as the "use of services not simply the presence of a facility" (Donabedian, 1972, pg1111). Aday & Andersen, foremost researchers on access to health care, define the concept as whether or not those who need care get into the system (Aday & Andersen, 1974; Aday, 1975; Aday & Andersen, 1981). Similarly, the Institute of Medicine in the US defines access as "the timely use of personal health services to achieve the best possible health outcomes" (Millman, 1993). In several studies, access to health care services is defined or described in terms of equitable utilization of health care services across different socio-economic groups (Aday et al., 1980; Manga, 1981; Aday, 1990; Badgley, 1991).

The notion of availability of services is often linked to the concept of access. Most researchers agree that access is not synonymous with the mere availability of resources (Donabedian, 1973; Vladeck, 1981; Mhatre & Deber, 1992). Indeed, Penchansky et al defined availability of services as only one of five dimensions of accessibility to health care services (Penchansky & Thomas, 1981). Others describe the availability of health care resources as the prerequisite for accessibility since without available resources, the issue of access to health care is meaningless (Frenk, 1985; Joseph & Phillips, 1984).

Perhaps the most popular definition is one that describes access as a dynamic process between the health care system and potential patient (Donabedian, 1973; Aday & Andersen, 1974, 1975; Fielder, 1981; Penchansky & Thomas, 1981; Vladeck, 1981). This definition was first presented by Donabedian in his *Aspects of Medical Care Administration* in which he defines access as a set of factors "that intervene between the capacity to produce services and the actual production or consumption of services" (Donabedian, 1973, pg419). As such, accessibility is viewed as an interaction or degree of adjustment between characteristics of the health care system and characteristics of the population. Penchansky and Thomas define access as the degree of fit between the health care system and clients within the following five domains of access, namely, availability, accessibility, accommodation, affordability, and acceptability (Penchansky & Thomas, 1981). In their landmark theoretical work on access, Aday and Andersen define access as the interrelation of a range of factors that define characteristics of the health care system and characteristics of the population affecting potential access (Aday & Andersen, 1974). This particular conceptualization of access will be further elaborated later in the chapter.

In early works, access is defined in terms of the absence of barriers to obtaining health care services. Many of these studies focus on economic barriers to access. In a Canadian study conducted before and after the introduction of Medicare, McDonald et al., defined barriers to access to health care services in terms of the existence of economic barriers. The authors hypothesized that the introduction of a publicly sponsored health care system would remove the economic barrier and thus improve access to care (McDonald et al., 1973). Various other studies followed that also examined the effects of socio-economic status or income on access to health care services (Beck, 1973; Manga, 1981). In a US study conducted by Salkever, access was defined as a multi-dimensional concept focussing on a range of barriers to access, including

economic status and availability of resources (Salkever, 1976). In his work on regionalization and access to health care services, Lewis argues that the most effective way to define the concept is in terms of the need to overcome the barriers associated with both the production and consumption of health care services (Lewis, 1977). Finally, Fielder also defines access in terms of barriers to care and the existence of barriers to care (Fielder, 1981).

3.1.2 Types of Access

Various typologies of access have been presented in the literature in an attempt to simplify and more precisely define the notion of access to health care services. Access is described in terms of potential versus realized access, a distinction first introduced by Aday & Andersen and subsequently discussed and used in various other works (Aday & Andersen, 1974, 1981; Fielder, 1981; Andersen et al., 1983; Aday et al., 1984; Daniels, 1984; Khan et al., 1994). Potential access is defined as the process that leads up to, but does not include, actual use of services and is often viewed as the existence or availability of services to meet patient needs. Potential access can be assessed through the use of various structure and process indicators describing the characteristics of the health care system and the population. Realized access is defined as the actual use of services, often referred to as the proof of service use which can be investigated through the use of various outcome indicators[1]. Perhaps the most notable indicator is the utilization of specific health care services such as physician visits, hospitalization rates, and ambulatory care use (Aday & Andersen, 1974; Andersen & Aday, 1978; Aday & Andersen, 1980; Aday et al., 1984; Freeman et al., 1987; Berk et al., 1995; Black et al., 1995; Cohen & MacWilliam 1995; Cykert et al., 1995; Tataryn et al., 1995; Brownell et al., 1999)

[1] "Outcome indicators" reflect the outcomes of the process of accessing care (i.e. confirmation that potential access has been realized) versus the more traditional understanding of "outcomes" of care.

as well as other needs based utilization measures that describe use relative to need (Aday 1975, 1976; Taylor 1975; Hulka & Wheat, 1985).

Another common classification is based on the distinction between socio-organizational accessibility and geographic accessibility. According to Donabedian, the former encompasses all characteristics of the health care resources, other than spatial, that facilitate or hinder the consumption of resources including such factors as the specific characteristics of the health care provider (e.g. gender, age, specialty) or the cost of the health care services. The latter category is related to all spatial characteristics related to health care service such as the location of services and the travel time and distance required to reach care (Donabedian, 1973). A similar distinction was made by Khan and Bhardwaj in their definition of aspatial and spatial access respectively (Khan, 1992; Khan & Bhardwaj, 1994). Aday & Andersen added a third dimension to this typology namely, patient willingness to seek and receive care (Aday & Andersen, 1974).

Figure 3.1: A Typology of Access (Khan and Bhardwaj, 1994)

Access	**Spatial (Geographic)**	**Aspatial (Social)**
Potential	I. Potential Spatial/ Geographic Access	II. Potential Aspatial/ Social Access
Realized	III. Realized Spatial/ Geographic Access	IV. Realized Aspatial/ Social Access

Khan and Bhardwaj have combined these classifications in a two by two matrix (see Fig 3.1). According to the authors, the matrix serves several purposes. First, it can be used to focus on a precise aspect of the access to health care problem thus leading to the identification of more precise outcome indicators. Second, the matrix allows policy makers and researchers to put the concept of access to health care services in perspective when addressing this issues at various regional and national levels. The ideal process, of course, would involve the simultaneous analysis of all four quadrants, an approach that is not always feasible (Khan & Bhardwaj, 1994).

3.1.3 Conceptual Frameworks

Several conceptual frameworks of access have been developed since the early 1970s. The frameworks presented by Aday and Andersen (1974, 1975) and Khan and Bhardwaj (1994) both focus on the relevant process and outcome indicators potentially involved in access to health care services. They are described in detail in the following discussion.

3.1.3.1 Aday and Andersen Framework (1974, 1975)

Perhaps the most comprehensive and influential work in this area of study is the conceptual framework presented by Aday and Andersen incorporating a broad range of indicators to operationalize the concept of access to health care services. The framework was introduced in the mid 1970s during a time following the introduction of various programs in the US to improve access to health care services, notably Medicare and Medicaid, and was developed to better understand the concept of access and transform it from a mere political idea to an operational idea to evaluate the newly introduced programs. Over the years, this landmark work has been used by various other researchers interested in the study, measurement and evaluation of access to health care services (Joseph & Phillips, 1984; Hulka et al., 1985; Khan & Bhardwaj, 1994).

A social indicator approach was used in the development of the access framework. Social indicators are used to gauge the quality of life in various countries, similar to the use of economic indicators to gauge the economic well-being of a country. According to Aday and Andersen, access to medical care can be considered a type of social indicator of the processes and outcomes associated with an individual's entry into the health care system (Aday & Andersen, 1975). The model is comprised of a number of process and outcome indicators identified in part through an extensive review of the access literature and the use of previous theoretical work conducted on the structure of the health care system and the individual

determinants of health care utilization. The 1970 Centre for Health Administration Studies survey was used to assess the validity and reliability of selected measures.

The framework begins with a reference to health policy since access to health care services occurs within a political context. According to Aday and Andersen, health policy marks "the starting point for the consideration of the access concept" (Aday & Andersen, 1974). This is due primarily to the fact that in the US, as in other countries, health policy planners and governments have introduced various programs and polices altering the financing and organization of health care services in an effort to improve patient access to services.

The second part of the model is comprised of process indicators. These indicators, also referred to as input indicators, are comprised of various characteristics of the health care system and the population at risk. They are the independent variables, representing potential availability and access believed to affect entry to the health care system and ultimately patient satisfaction. According to Aday and Andersen, it is imperative that process indicators also be classified according to their degree of mutability by health policy. Indicators that can be affected by health policy, such as distribution of resources or insurance status, are defined as mutable and subject to change to improve access to services. Indicators that cannot be changed by policy, such as patient age and sex, are considered immutable and serve to identify groups at risk to whom health policy initiatives should be directed (Aday & Andersen, 1974, 1975).

The selection of indicators representing the characteristics of the delivery system is based on previous work conducted on the structure of the health care system. There are two main categories of indicators: resources and organization. The former refers to the total resources devoted to the health care system, including labour and capital, and the distribution in a specified

area. Organization refers to the manner in which the resources are co-ordinated to provide services, specifically ways in which entry into the system and patient care throughout the system may be affected. The specific process indices assessed by Aday and Andersen include regular source of care, travel time, appointment or walk in visit, appointment time and office wait time (Aday & Andersen, 1975).

The selection of indicators representing the characteristics of the population at risk is based on previous work conducted in the early 1970's on the individual determinants of the use of health care services (Andersen, 1973; Andersen & Newman, 1973). They are categorised as predisposing, enabling and need indicators. Predisposing characteristics are those existing prior to the onset of illness and represent the propensity of individuals to seek care (e.g. sex, race, age, values). The enabling characteristics represent the, individual and family, means available to a patient to seek and utilize health care services (e.g. income, insurance status, rural/urban location of residence). Finally, need refers to the actual and perceived level of illness requiring health care services (Aday and Andersen, 1974, 1975).

The final component of the model is comprised of outcome indicators. Health care utilization and consumer satisfaction represent the two main outputs of access to care. Together, they are considered to be the dependent variables and as such represent, or are based, on actual or realized access to health care services. The utilization of services is described according to type (e.g. physician, dentist), site (e.g. physician office, emergency department), purpose of visit (e.g. preventive, illness related) and time interval (e.g. continuity of care). Utilization measures range from conventional measures, such as mean physician visits and percent (not) seeing physician, to more needs based measures such as the use-disability ratio and symptom response ratio. With respect to consumer satisfaction, the authors identify the satisfaction domains which are pertinent

to access including convenience, costs, coordination, courtesy, information, and perceived quality (Aday & Andersen, 1974, 1975).

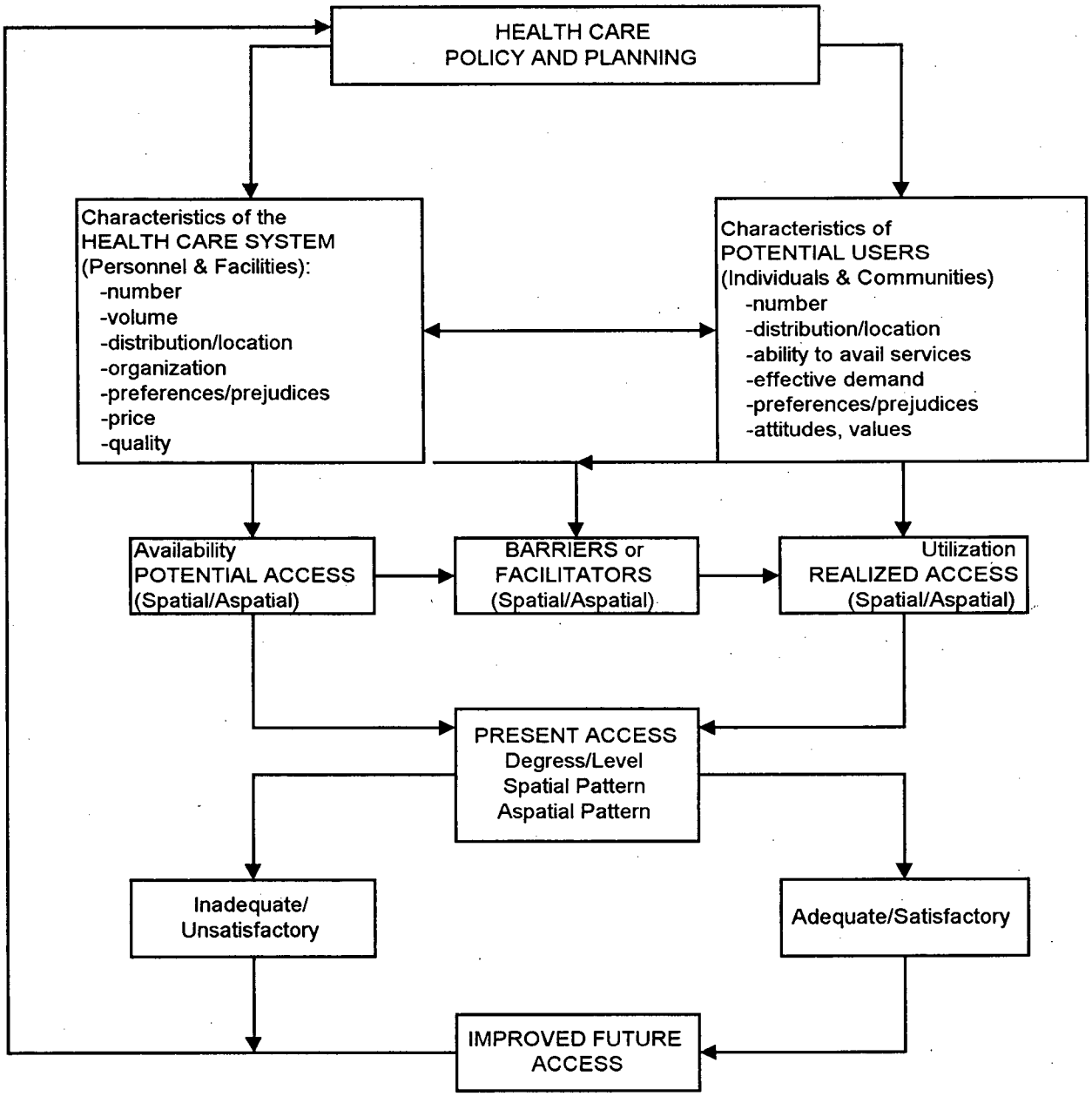
3.1.3.2 Khan and Bhardwaj Framework (1994)

Khan and Bhardwaj (1994) have adapted the basic framework developed by Aday and Andersen placing greater emphasis on the dynamic nature of access to health care services. Specifically, the authors highlight the role of barriers and facilitators in the transformation of potential access to realized access (Figure 3.2).

The first two parts of the framework are similar to those presented by Aday and Andersen. First, the authors begin with the role of health care policy and planning since the processes of access to health care services are ultimately mediated by the efforts and changes made in this area. Unlike the previous framework, however, there is a feedback mechanism that allows for changes in policy and planning based on new information learned about the access process. Second, the authors also introduce the primary process indicators of access associated with characteristics of the health care delivery system and characteristics of the population at risk. The interaction of these indicators results in the creation of potential access; elements of the health services delivery system adjust in response to the characteristics and needs of the population at risk and make health services available thus resulting in potential access offered to potential patients. Potential access, therefore, reflects availability of services but does not guarantee entry to or actual use of services (Khan & Bhardwaj, 1994).

Actual use of service, or realized access, depends on the interplay between barriers and facilitators characterized in the third part of the framework. Barriers and facilitators to access

Figure 3.2: A schematic model of access to health care (Khan & Bhardwaj, 1994)



reflect different dimensions of the characteristics of both the system and the population at risk which may hinder or help facilitate the actual use of services. If the barriers exert greater force than the facilitators, the population at risk will not be able to gain entry to the system and consume services. If, however, the facilitators overwhelm the barriers to access, actual entry to

the system is gained and in theory, services are used; in other words, potential access is transformed into realized access to health care services.

The final part of the framework focuses on an evaluation of the state of access the results of which can be used to improve the processes, specifically the degree or level of access achieved and the spatial and aspatial patterns. The present state of access can be categorized as inadequate or adequate depending on whether realized access has been achieved. Information regarding the current state of access is then generated back to the health policy and planning level. Minor adjustments are most likely required if the current state of access is deemed satisfactory. If, however, access problems exist in the system, information regarding the nature of these problems can be fed back to those responsible for health policy and planning so that the appropriate responses and changes may be made to rectify the situation (Khan & Bhardwaj, 1994).

A review of the current understanding and conceptualizations of access to health care services serves to clarify some of the key characteristics of this often confusing phenomenon. Access to health care services is fundamentally a process through which potential access is translated into realized access resulting in various outcomes including use of services, patient satisfaction, patient outcomes etc. The conceptual frameworks serve to identify the specific indicators that may be involved in this process. The frameworks recognize the need to study access to health care services within the broader political context of the health policy arena in which decisions are made that may ultimately affect the access of individual patients. They also identify characteristics of both the health care system and population at risk that determine the level of potential access and availability of services. The volume of resources, number of hospitals, physicians and clinics, are important but incomplete indicators of availability, without

consideration of how these resources are organized and used within the system (e.g. type of admissions).

While both frameworks presented touch on these issues, the work presented by Aday and Andersen has been criticised for placing too much emphasis on final outcomes. Daniels argues that, from an equity perspective, it is just as important to study variation in process indicators since they reflect problems in access which may not ultimately affect utilization rates, and therefore, would be ignored by focussing exclusively on outcomes (Daniels, 1982). The contribution of Khan and Bhardwaj is primarily the recognition of the importance of process variables, namely barriers and facilitators to care. The transformation of potential access to realized access depends in part on the presence of barriers or facilitators that may hinder or promote the actual use of services. These key concepts may be applicable to the study of waiting lists and waiting times.

3.2 AN ACCESS APPROACH TO THE STUDY OF WAITING LISTS and TIMES

Having explored the concept of access to health care services, it is important to establish their relevance to waiting lists and waiting times. Based on a review of the access literature, it is evident that wait lists and wait times are associated broadly with concerns about access to health care services. Hence, it is with some confidence that we can conclude that these concepts can be applied to a study of waiting lists and/or waiting times. The literature review presented in Chapter 2 also points to the fact that there can be many different types of waits experienced by patients in their attempts to access care. In order to focus the development of a conceptual framework, therefore, the first step must be to identify precisely the waiting lists and times of

interest. This is followed by the development of a framework that incorporates key elements and concepts of access to health care services.

3.2.1 Types of Waits

Based on our current understanding of waiting lists and waiting times, it is clear that they occur at various points during a patient's journey to care. Building on the information provided in the literature review (Smith, 1994; BCMA, 1998), Figure 3.3 identifies the possible waiting periods during a patient's course of care:

- Wait #1: GP Visit

  Waiting time to get an appointment with the general practitioner.

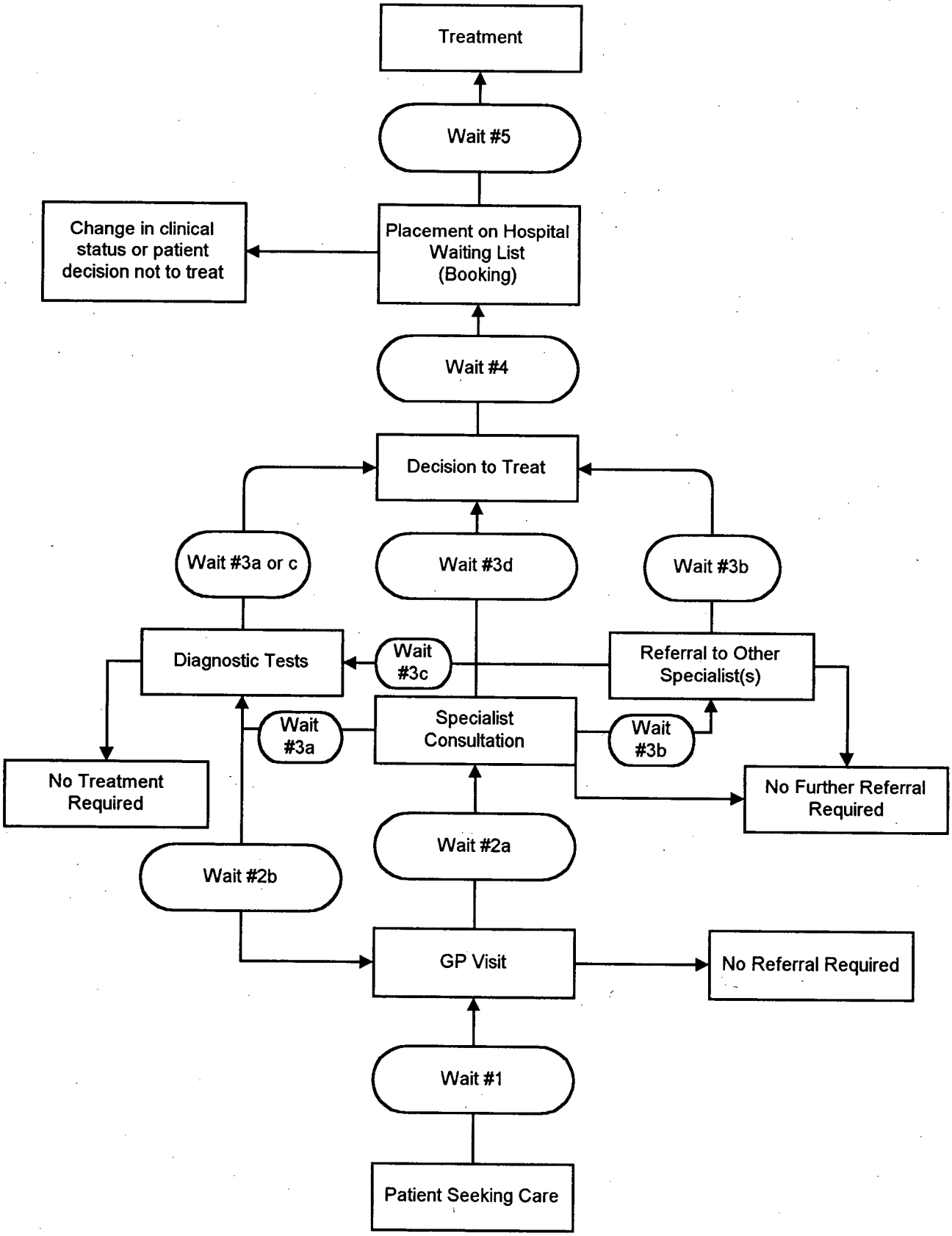
- Wait #2: Specialist Consultation

  Following a visit to the GP, patients may require a specialist consultation. A period of waiting may occur between the date of referral and the date of consultation (Wait 2a). Patients may also require diagnostic tests prior to a specialist consultation (Wait 2b).

- Wait #3: Decision to Treat

Following an initial visit to the specialist, patients may proceed on different paths to a decision to treat depending on the nature of the problem and level of need. Patients may require specific diagnostic tests (Wait 3a), an additional consultation with another specialist (Wait 3b) or both (Wait 3c) before a treatment decision can be made. Alternatively, the decision to treat may be made immediately following the first specialist consultation (Wait 3d). (The waits are not assumed to occur in the order they are presented). Some patients may not require any further treatment or can be

Figure 3.3: Patient Waiting Times



treated through the use of pharmaceuticals, thus requiring no further referrals. This decision can also be made following a second referral.

- Wait #4: Placement on Hospital Waiting List (Booking)

  Once the decision regarding treatment has been made, the specialist must request a booking date from the hospital. This often results in the placement of the patient on the hospital waiting list. Physicians may choose, for example, to request a booking for surgery immediately following the decision for surgery or may wait until they have confirmed access to operating time. Evidence from the literature (Chapter 2) suggests that waiting list audits at this point in the process may result in patient removal from the list due to changes in clinical status or other factors (e.g. patient moved, patient died, patient decides not to undergo treatment).

- Wait #5: Treatment

  Placement on the hospital waiting list marks the beginning of the hospital waiting time during which patients are waiting for treatment on an inpatient or day surgical basis.

It is clear that patients may be waiting for health care services at several points in their trajectory of care. The length of their waits at each point will vary depending on, for example, the clinical status of the patient and availability of services. Each waiting period represents the existence of a different waiting list. Based on the literature review, it is evident that most of the attention to date has focussed on waits for hospital based services (Wait #5), particularly for surgical services. Given the specific nature of this study and availability of data, a similar focus will be placed on this final waiting period. The development of a conceptual framework, therefore, will focus on those factors affecting waiting lists and waiting times for hospital based services.

3.2.2 A Conceptual Framework: Waiting Lists and Waiting Times for Hospital Services

The access to health care literature offers relevant concepts and constructs that are applicable to the study of waiting lists and waiting times for hospital based services. To ensure the appropriate application of these concepts, it is imperative to consider key features of waiting lists and waiting times as they are known to date.

First, waiting lists and waiting times are often involved in the process through which patients gain access to hospital services. From an access perspective, they can be described as process indicators involved in the transformation of potential access to realized access (Aday, 1975; Salkever, 1976; Fielder, 1981; Daniels, 1982; Frenk, 1985). Within the specific framework presented by Khan and Bhadwaj, waiting lists and times can be described as aspatial barriers hindering realized access to health care services (Khan & Bhadwaj, 1994).

Second, the identification of waiting lists and waiting times as process indicators demands a process based approach. Many of the studies on access to health care services conducted to date focus on outcomes such as utilization of health care services as previously discussed. Some argue, however, that it is just as important to study the variation in the process indicators since they often reflect problems in access which may not be detected using an outcome-based approach (Daniels, 1982). Newly developed theoretical models, such as those presented, expand the scope of study to include more rigorous process oriented studies that focus on the nature of the barriers and facilitators to access. Given the nature of waiting lists and waiting times and their role in access to health care services, a study of these phenomena requires a shift in focus from outcome indicators to process indicators. Waiting lists and waiting times, therefore,

represent the dependent variables against which a range of health care system and patient factors can be assessed to determine the extent to which they affect these dependent variables.

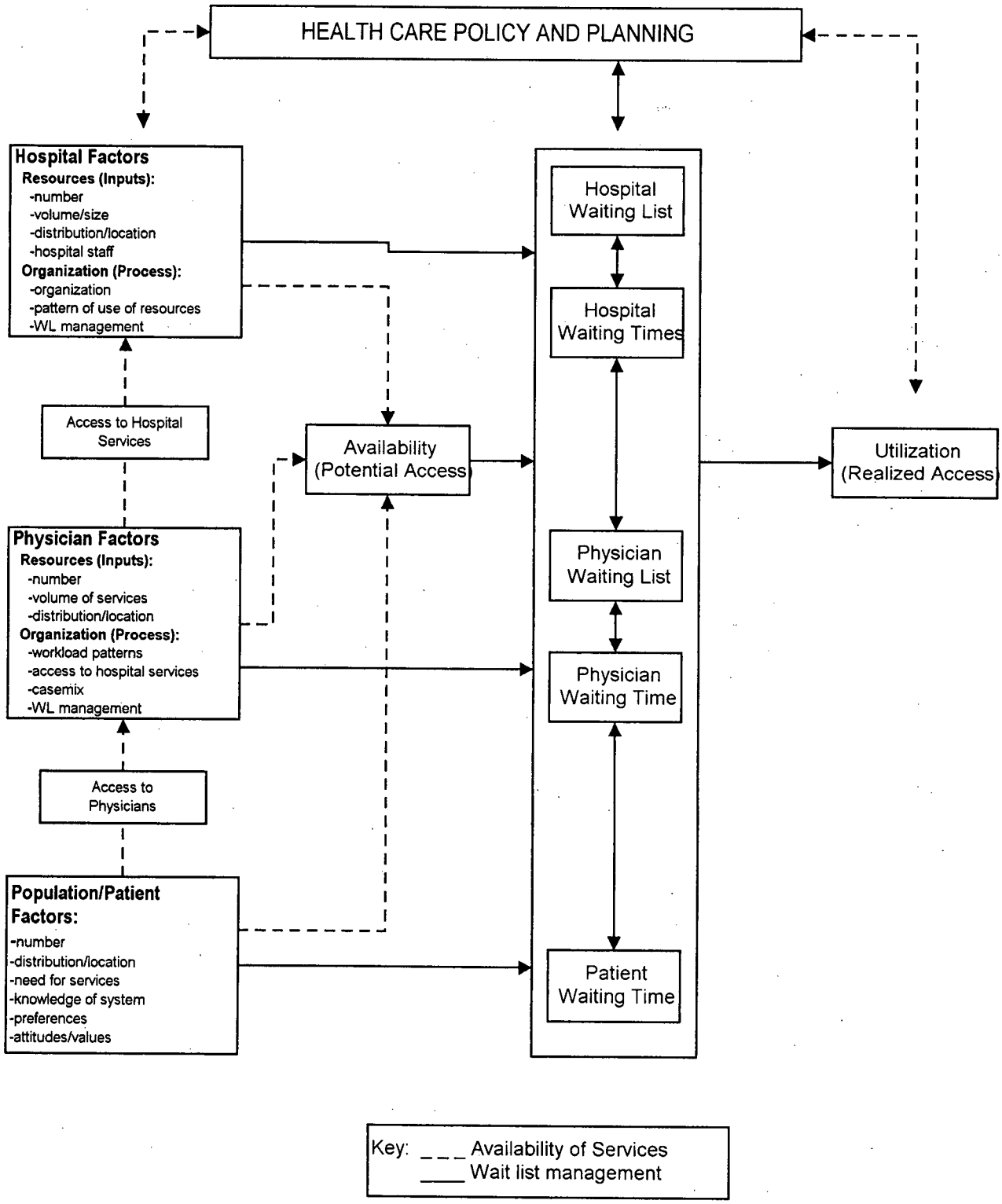
Finally, waiting lists and waiting times for hospital services really represent a study of multiple access relationships occurring at various levels. Access to hospital based services is about more than simply patient access to the hospital. It also involves patient access to physician services, those actually performing the procedures, as well as physician access to hospital resources, the actual location of services such as operating facilities and personnel. These relationships are all occurring at various levels (i.e. patient, physician and hospital levels) and must be considered in order to develop a comprehensive understanding of the role of waiting lists and waiting times and the factors affecting them.

These factors were all considered in the development of a conceptual framework outlined in Figure 3.4. The framework attempts to do two things: (1) situate waiting lists and waiting times for hospital services within a broader context of access to health care services; and (2) identify the factors hypothesized to affect waiting lists and waiting times for hospital services and the possible pathways. The framework represents a complex web of relationships. The final part of this chapter will focus on untangling and describing them.

3.2.2.1 Dependent Variable

Waiting lists and waiting times are expressed as separate phenomena existing at various levels (i.e. hospital, physician and patient). Their distinction is explicitly made since different factors may affect them in different ways. Aggregate expressions of waiting lists and waiting times are often used at the hospital and physician level. Waiting times can also be expressed at the level of the individual patient. These measures of waiting lists and waiting times are not completely

Figure 3.4: Conceptual Framework of Factors affecting Waiting lists and Waiting times



independent since the aggregate measures are comprised of the individual values. What happens, therefore, at the patient level may affect the list sizes and times at the hospital or physician levels and vice verse. A study of waiting lists or waiting times for hospital based services must begin with the explicit identification of the dependent variable of interest and the level at which it is being measured.

3.2.2.2 Independent Variables

In the proposed conceptual framework, three distinct groups of independent factors are identified: hospital factors, physician factors, population/patient factors. Unlike previous access frameworks, they are separated and arranged vertically to illustrate the hierarchical nature of the pathways. These factors are all hypothesized to affect waiting lists and/or waiting times indirectly, through their effects on the availability of services (dashed lines), or more directly through explicit waiting list management practices (solid lines) (see Fig 3.4).

Population/Patient Factors

The characteristics of potential users and actual patients may both indirectly and directly affect waiting lists and waiting times. Indirectly, the access literature contends that the size of the population, their distribution and need for services may affect the availability of services; that is, the demand and need for services may affect the number and level of services made available to them. As well, their level of knowledge and understanding of how the system works may affect their ability to access physician services and in turn hospital services. The clinical status of patients, their previous experiences on waiting lists and their personal choices (e.g. physician, date of surgery, whether or not to receive treatment) regarding treatment may all directly affect their individual waiting times.

Physician Factors

The size of a queue or length of a wait can also be affected both indirectly and directly by physicians. The number of physicians, specifically specialists, performing in-hospital services and their respective workload patterns may affect the availability of services. The availability of surgical services, for example, may be affected by the proportion of time surgeons spend performing surgery versus providing in-office consultations. In addition to the level and distribution of physician resources, their ability to access hospital resources will affect the availability of services and consequently affect waiting lists and waiting times at the physician and patient level. In many cases, limited resources, such as operating space, must be distributed among a number of physicians with hospital admitting privileges.

Waiting lists and waiting times may also be directly affected by the specific wait list management practices used by physicians. Criteria used to determine clinical need will identify those cases that are more urgent and more likely to proceed more rapidly to treatment. Most would agree that placement on a hospital waiting list should follow a decision made by both patient and physician to proceed with treatment. Physicians, however, may place patients on a waiting list following an initial consultation in anticipation of a need for treatment in the future. This practice may lead to longer lists and longer waits for patients. Conversely, physicians may refrain from placing patients on a hospital waiting list until a specific booking date has been obtained resulting in shorter waits for hospital services. Waiting list management practices may also include regular list audits. There is empirical evidence to suggest that audits decrease the size of waiting lists through the removal of patients who no longer require or desire treatment are removed.

Hospital Factors

The access literature clearly demonstrates that the specific characteristics of the system can affect the availability of services or potential access. The availability of services may in turn affect the length of waiting lists and waiting times. The number of hospitals, beds, operating rooms and hospital staff (e.g. OR nurses, cardiac profusionists), for example, represent resource inputs into the system and may have a direct affect on the level of services available to patients. However, just as important, is the manner in which these resources are organized and distributed. Decisions made at the hospital level, for example, regarding the distribution of resources across competing specialty groups may result in differential availability of services; for example, more resources for cardiac care may mean less for orthopaedic surgery. Likewise, resources used to treat a large number of emergency cases may result in a decline in the availability of resources for elective services. Waiting lists and waiting times can also be directly affected by the practices and processes used to manage waiting lists at the hospital level.

Health Policy

Finally, the framework recognizes that these processes and relationships are all occurring within the broader context of the health policy environment. Specific policies and programs adopted at the governmental level may indirectly affect the size of queues and lengths of waits. For example, governments may choose to increase the level of funding to hospitals to increase the availability of services and throughput, a strategy often believed to reduce waiting lists and waiting times at the hospital level. Conversely, policy decisions made in other areas such as contract negotiations and agreements with various health sector unions may have adverse affects on waiting lists and waiting times if such agreements restrict the number of employees and the nature of the work they perform.

This conceptual framework will be used to guide the study of factors affecting waiting times for specific hospital based services. However, based on the findings of the literature review (Chapter 2), the accuracy of the waiting list data must first be determined. In the following chapter, the validity and reliability of the SWL data are assessed.

CHAPTER IV

VALIDITY AND RELIABILITY of the SURGICAL WAITLIST DATA

The primary source of data for this study is the B.C. Surgical Waitlist Registry (SWL), a province wide administrative data set. Like many other sources of administrative health care data, there are specific advantages to, as well as growing concerns regarding, the quality of the data and their use in health-related research. In this chapter, the issues regarding the use of administrative health care data for research purposes are explored. In addition, methods proposed and commonly used to assess the quality of administrative health care data are presented. The second part of the chapter focuses on the validity and reliability assessment of the SWL data to determine the overall quality of the data and the appropriateness of its use in further analyses. The chapter begins with a selected review of the literature regarding the use of administrative data in health related research.

4.1 ADMINISTRATIVE HEALTH DATA

Administrative health data bases are increasingly being used by researchers to address a broad range of health related questions. There is an array of administrative data bases available to health care researchers including vital statistics, disease registries, physicians claims data and hospital discharge data, to name a few (Connell et al., 1987). Administrative health data have been used to develop and validate clinical indices (Jencks et al., 1988; DesHarnais, 1990); to

conduct technology assessments (Fisher et al., 1990); to perform medical audits (Roos et al., 1977); to develop risk models for prediction of post-operative outcomes (Roos et al., 1986; Jencks et al., 1988; Anderson & Steinberg, 1985); for descriptive studies (Roos, 1984; Ashton et al., 1995; Goldacre et al., 1995; Primatesta & Goldacre, 1995); and to conduct outcome based research (Wennberg et al., 1987; Roos, 1989; Hannan et al., 1992; Roos et al., 1992; Roos et al., 1996).

4.1.1 Data Linkage

The majority of studies are based on hospital administrative data containing patient demographic, diagnostic and procedure information. These data are used alone or in conjunction with other sources of health related data such as physician reimbursement data and clinical or chart data. The use of multiple data sets has become more popular since the development of record linkage techniques and the development of high-powered computers. Multiple data sets can be linked on a patient basis through either a deterministic or probabilistic linkage. A deterministic linkage is the simpler of the two methods based on the use of individual identifiers. Pairs of records are considered linked if there is complete agreement on one or more common variables. This method is suitable for use with highly accurate data containing few missing values or errors. Deterministic linkages are practical as well as time and cost-effective (Roos & Wajda,1991; Wajda et al., 1991).

A probabilistic linking represents a more complex undertaking. This method is commonly used when there are few definitive and uniquely identifying fields, such as a personal identifier number, or when the data are not of high quality (i.e. high proportion of missing values). Probabilistic linkages involve the determination of whether two records likely refer to the same

individual as a result of agreement on various items. The linkage is conducted using weights for individual matching variables with a total weight indicating agreement or not. In general, the weights represent the odds ratio of the outcome frequency in linked versus unlinked pairs (Newcombe, 1988; Roos & Wajda, 1991).

4.1.2 Uses of Administrative Health Data

As previously discussed, there are a range of uses for administrative data in health related research. In the following discussion examples from the literature are used to illustrate the more common uses of administrative data in health related research, namely descriptive studies, outcomes studies and model development, with a focus on the type of data used, methodology and general findings.

Over the past two decades, researchers at Oxford University have conducted various descriptive studies focusing on the changing patterns of workload and hospital utilization in general and in particular specialties based on data from the Oxford Record Linkage Study (ORLS). The ORLS is comprised of hospital abstracts from admissions to NHS hospitals in the Oxford Region, Oxfordshire and West Berkshire for the years between 1968 and 1986. The data include both in-patient admissions and day cases and are collected in such a way that information pertaining to the same patient may be linked together to provide a patient profile of hospital use over time. The data were used by Goldacre et al., (1988) to analyze changes in hospital utilization over time, specifically, whether the observed increase was due to an increase in the number of people admitted to hospitals or an increase in the number of re-admissions. Since the data are linked on a patient basis, the ORLS allowed for the analysis of person-based admission rates in addition to the traditional episode-based rates (i.e. all admissions related to the same episode of care),

something that was not possible before the creation of the linked data set. The studies concluded that increases in hospital utilization were due to increases in both types of admission with a higher rate of re-admissions among the elderly population (Goldacre et al., 1988). Similar studies were conducted across general medicine and geriatric medicine admissions with similar findings (Goldacre et al., 1995; Ashton et al., 1995).

Perhaps the most common use of administrative health data is for outcome related research. In the US, one of the primary uses of administrative health data is to evaluate the quality of care provided across regions, hospitals and physicians based on various outcome measures (Steinberg, 1990). A joint US/Canada study conducted by Wennberg et al., (1987) used data from the Maine Medicare file and the Manitoba Health Services Commission to investigate the incidence of post-operative mortality and complications following prostatectomy and to identify hospitals with significantly high and low death rates. The study revealed significant differences in 90-day post-operative mortality between individual hospitals (Wennberg et al., 1987). Data from the Manitoba Health Services Commission have also been used to investigate differences in short-term (i.e. 30 day) post-operative mortality following hip fracture surgery. After adjusting for various patient characteristics and co-morbid conditions using multiple logistic regression, the analysis revealed that the differences were due primarily to the increased proportion of cases with delayed admissions in Manitoba (Roos et al., 1996).

Administrative health data are also used by researchers for the development of various models used to identify risk factors and predict outcomes. This is due in part to the broad range of information provided in these data sets (e.g. patient characteristics, co-morbidities, outcomes) as well as the ability to link the data to other sources of information (e.g. hospital characteristics,

physician characteristics). Anderson and Steinberg (1985) used administrative data to develop a multi-variate logistic regression model to identify demographic, clinical and hospital predictors of re-admission within 60 days of discharge for various chronic and acute conditions. The study was based on data provided by the Medicare file linked to data from the American Hospital Association Annual Survey for additional hospital characteristics information. The researchers identified 10 statistically significant predictors of readmission including patient age, sex and race, number of prior discharges, and hospital site and size (Anderson & Stein berg, 1985). A similar study was conducted by Roos et al., (1985) using administrative hospital and physician claims data from the Manitoba Health Services Commission. The purpose of the study was to identify patient, surgeon, and hospital characteristics associated with post-discharge complications for hysterectomy, cholecystectomy and prostatectomy using multiple logistic regression. The study revealed marked variation in the predictability for the three conditions. The variables adequately predicted outcomes for cholecystectomy, were less for hysterectomy, and had little or no predictive power for prostatectomy. After adjusting for case mix and type of surgery, physician experience proved to be a significant factor for cholecystectomy (Roos et al., 1985).

4.1.3 Advantages and Disadvantages of Administrative Data

The increased use of administrative health data has fostered an ongoing debate regarding the advantages and disadvantages of using such data for health related research. Most researchers agree that the primary advantage is cost-effectiveness, specifically with regard to data gathering. Information provided via administrative data sets is routinely collected for other purposes and does not require primary data collection by the researcher. Other advantages include large sample sizes allowing for broad population-based studies and thus improved generalizability of

results; opportunity for long follow-up; ability to measure variation across providers; relative freedom from biases inherent in randomized control trials including selection and recall bias, and the relative ease of record linkage for research purposes (Connell et al., 1987; Wennberg et al., 1987; Fisher et al., 1990; Flood, 1990; Steinberg et al., 1990; Roos et al., 1991; Romano et al., 1994; Hannan et al., 1997).

Perhaps the most overwhelming concern regarding the use of administrative data for research is the validity and reliability of the data (Roos et al., 1982; Roos et al., 1989; Temple, 1990; Iezzoni LI, 1990; Green & Wintfeld, 1993). This concern arises from the fact that the data are not collected for research purposes but rather to fulfill an administrative function (Roos et al., 1979; Connell et al., 1987). Some of the specific issues include coding errors, the lack of specificity of some procedure and diagnostic codes; and more generally, the accuracy of diagnostic information, in particular secondary diagnoses (Steinberg et al., 1990; Jencks, 1992; Hannan et al., 1992; Hannan et al., 1997).

Additional concerns include the limited scope of clinical information including co-morbid conditions and functional capacity, informal support and other non-clinical information required for risk adjustment and adjusting for confounding variables in outcomes research. This is particularly problematic when comparing outcomes across institutions where adjustments must be made for risk factors to control for differences in the patient population. Furthermore, it is often difficult to distinguish between co-morbid conditions present upon admission and complications during the course of care, required in quality assurance studies (Maklan et al., 1994; Wray et al., 1995; Hannan et al., 1997).

4.1.4 Assessing the Validity and Reliability of Administrative Data

As the use of administrative data for research has increased, so too has the emphasis on ensuring that the data are valid and reliable. Various studies have been conducted that focus exclusively on assessing the quality of administrative data. The following section outlines some of the general threats to validity and reliability as well as various methods used to assess data quality with a specific focus on computer based methods.

Validity is concerned with the extent to which an indicator measures what it purports to measure (Carmines & Zeller, 1979). Administrative data are susceptible to various threats to validity. As outlined by Roos et al (1979), the threats to internal validity, that is, threats to the validity of any conclusions drawn about any demonstrated statistical relationships, can include misidentification of individuals, incomplete data (i.e. missing data) and coding errors. Depending on their use, administrative data may also be subject to threats to construct validity, namely the appropriateness or inappropriateness of a particular measure used to capture an event or situation of interest. This is problematic when, for example, administrative data are used to define concepts such as "episode of illlness". An episode can be defined in various ways including, for example, hospital claims that are 1 week or 2 weeks apart, or alternatively, as a single admission per month.

Reliability is concerned with the extent to which a measure yields the same results on repeated measures. While some degree of error is expected due to chance, a measure should demonstrate some degree of consistency on repeated measures (Carmines and Zellers, 1979). Issues of reliability regarding administrative data are most often associated with the inconsistent use of procedure and diagnostic codes across institutions and physicians (Roos et al., 1979).

Various methods have been proposed in the literature to assess the quality of administrative data. Most agree that the gold standard involves the comparison of administrative data to the information found in patient records. This approach, however, is not always possible since it is costly, time consuming and researchers are rarely able to secure access to patient chart information (Roos et al., 1979). There are, however, a range of approaches, some computer based, that can be used to assess the quality of administrative data. They include: (1) preliminary checks, (2) methods using 1 data base, and (2) methods using 2 or more independent administrative data bases.

Preliminary Checks

The first round assessment of data quality commonly includes the following preliminary checks. A flowchart outlining the process of data creation could be constructed since it can provide some insight regarding possible points of error (Roos et al., 1979). Researchers could also obtain written documentation describing the data elements included, the collection, design and layout of the data as well as the inclusion and exclusion criteria defining the population. Preliminary inspection of data can include a manual examination of a limited number of cases as well as frequency analyses to identify the proportion of missing and extreme cases, unusual distributions, and undocumented codes (Connell et al., 1987).

Single Data Base

The quality of a single administrative data set can be assessed through manual re-abstracting and computerized checks. In the late 1970s, the Institute of Medicine in the US conducted a series of studies to assess the reliability of hospital discharge data. Data were re-abstracted from the original discharge claims by Registered Record Administrators. The re-abstracted data were

then compared to the original data to determine the level of agreement as measured by the proportion of claims with no discrepancy. The results of these studies indicated that non-medical information (i.e. patient information, dates of admission and discharge) was highly reliable with greater than 90% of claims with no discrepancy. Procedure information was correct in approximately 70% of cases while only 60% to 65% of cases had no discrepancies regarding diagnostic information (Demlo et al., 1978; Demlo et al., 1981). A similar re-abstraction study was conducted by Green et al (1993) using US Medicare data. The performance of Medicare data and re-abstracted data were compared in the use of risk-adjusted mortality models. Researchers concluded that coding errors in diagnostic codes in the Medicare data led to differences in post-operative mortality between 0.2 and 2.2 deaths per 100 admissions (Green & Wintfeld, 1993).

Computer checks can also be used to assess the quality of a single administrative database. For example, procedure information can be checked using payment claims data submitted by two or more physicians involved in the procedure such as, the surgeon, attending physician and/or anesthetist. Time sequenced checks can be conducted using a single hospital discharge data set to examine various data elements. For example, the date of the procedure should occur between the dates of admission and discharge. Likewise, the date of post-operative mortality occurring within the hospital should be recorded after the date of admission and procedure if the patient received treatment prior to death (Roos et al., 1993).

Two or More Data Bases

Perhaps the most common method of data quality assessment involves the use of two or more independent sources of data. Most would agree that the superior method involves the

comparison of administrative and clinical data. This method has been used to assess the quality of diagnostic and comorbidity information in administrative data for coronary artery bypass surgery to determine if such data can be used to adjust for risk factors. For example, Hannan et al (1997) compared the use of Medicare claims data and clinical data from the Cardiac Surgery Reporting System from New York state to predict in-hospital mortality. Data were linked using patient identification numbers within the same hospital. The study concluded that the administrative data based model had lower predictive power than the clinical model but the power could be increased with the use of additional clinical data (Hannan et al., 1997). Finally, Roos et al (1991) used sensitivity and specificity analyses to assess the validity and reliability of administrative data for prostatectomy and cholecystectomy using hospital data from the Manitoba Health Services Commission and clinical data from an anesthesia follow-up study. The results revealed low levels of sensitivity for certain co-morbid conditions due primarily to the fact that such conditions were less likely to be reported in the administrative data than the clinical data. The researchers concluded that this situation could be improved by using prior hospitalization in the analysis as a proxy measure for certain co-morbid conditions (Roos et al., 1991).

The use of two or more independent sources of administrative data to assess data quality has been made possible through the use of data linkage. As previously described, health related data collected and recorded on a patient basis can be linked deterministically or probabilistically. Researchers at the University of Manitoba linked hospital separation and physician claims data to determine the level of agreement between the two data sources. The data were linked based on patient identifiers (i.e. identification number, sex and year of birth) as well as on one or more of the following match keys: date of procedure, surgical procedure, and/or surgeon. A link was

considered a perfect match when 2 records agreed on all 3 match keys. Overall, 93% of cases were perfect matches with CABG producing 98.5% perfect matches, total knee replacement 92.5%, total hip replacement 95.6% and cataract 94.0%. There was less agreement, however, regarding diagnostic information. On average, agreement on diagnostic information occurred in approximately 75% of paired records. The rate of agreement varied greatly depending on the type of surgery. There was a higher level of agreement (>80%) for elective surgeries such as cataracts, coronary bypass surgery, and total knee replacement. Agreement tended to be lower for procedures such as biliary tract operations which are complex and involve a wide range of diagnoses (Roos et al., 1989).

There are clearly various methods available to assess the quality of administrative health data. The choice of methods is constrained only by resources and the imagination of researchers. Based on the results of these and other studies, it appears that the quality of administrative health data varies depending on the type of information. The majority of studies conducted to date focus on the reliability of administrative health data. Non-medical information such as patient identifying information, and dates of admission and discharge are considered fairly reliable. Procedure information also appears to be reported with some degree of consistency and reliability. In general, the diagnostic information reported in administrative data remains problematic. This is due in part to the limited amount of space on most administrative records to record such information. The use of such data to adjust for risk and case mix in outcome-related studies is contentious because of the questionable quality of the data.

The second part of the chapter will describe the methods and results of a comprehensive assessment of the SWL data. Given the nature of this data, a complete and thorough assessment

of the quality of the data must be conducted prior to using the data for research purposes. The assessment must focus specifically on the validity and reliability of key measures, namely waiting time and waiting list size. The assessment of the SWL is conducted in a two-part process based on computerized methods for a single database and multiple databases.

4.2 VALIDITY and RELIABILITY ASSESSMENT OF THE SWL DATA: Methods for a Single Database

The purpose of the following section is to present the methodology and results of the validity and reliability assessment of the SWL data based on methods for a single database. The assessment is conducted for the following four surgical procedures: knee replacement (KR), hip replacement (HR), cardiac surgery (CARD), and cataract surgery (CAT). In this first part, methods for a single data base are used to provide a preliminary assessment of the quality of the SWL, beginning with a detailed description of the data base followed by a frequency analysis, missing values analyses and time sequence checks. The results of this assessment will inform the next steps (i.e. Methods for two or more databases).

4.2.1 The Surgical Waitlist Registry (SWL)

In 1993, the British Columbia Ministry of Health initiated the SWL to track waiting times and waiting list sizes for a broad range of surgical procedures. The data are intended to represent all patients presently waiting for treatment as well as historical cases (i.e. those who were waiting and subsequently taken off). The SWL database is comprised of wait list information for all major surgical procedures from 31 hospitals across BC (see Appendix A: Table A-1). Although the SWL was established in 1993, hospital participation and contribution of waiting list data

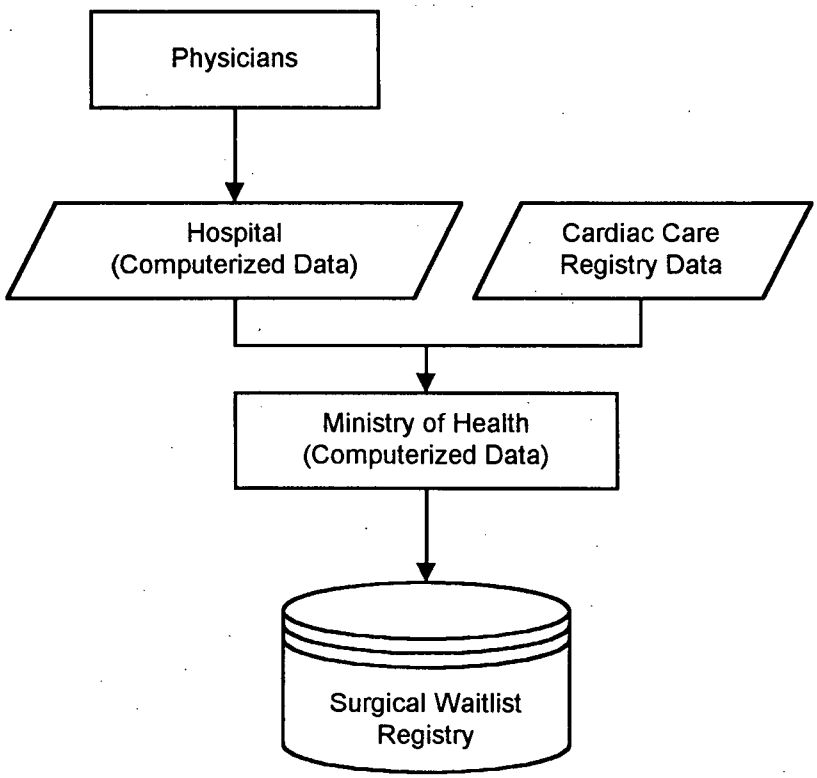
varies. Some hospitals have been contributing data since the inception of the project while others have been contributing only since early 1996. The number of physicians represented in the SWL also varies across procedures and hospitals (see Appendix A: Table A-2).

The creation of the SWL Registry is outlined in Figure 4.1. The data are compiled at the hospital level based on information provided by physicians with admitting privileges requesting operating time. Each hospital provides an electronic copy of the waiting list data to the Ministry of Health on a monthly basis. The data files contain information regarding new patients placed on the waiting list as well as updates regarding patients already on the list. Data managers at the Ministry of Health perform various data validity checks on the information obtained from the hospitals. The Ministry checks for the completeness of the data and conducts a series of logical checks to ensure, for example, that the date the patient was placed on the waiting list precedes the date they were taken off. Patients with excessively long waits are flagged and brought to the attention of the hospitals for further investigation to ensure, for example, that the patient has not already had surgery and was simply not taken off the waiting list. The majority of procedure codes are standardized to two digits of the Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures (CCP) (Statistics Canada, 1986). Once the validity checks have been completed, the data are merged to produce a province wide database.

Information regarding cardiac procedures is obtained from the Cardiac Care Registry. The Cardiac Care Registry was established in 1991 and is an historical database representing all patients in British Columbia who have been diagnosed and/or who underwent cardiac surgery or catheterization since this time. The Registry data are used to generate regular reports for the Ministry of Health and cardiac surgeons detailing the incidence of diagnoses and treatment. This

information is in turn used to manage cardiac care services in the province (Personal Communication with T. Braun, Cardiac Care Registry).

Figure 4.1: Creation of the SWL Registry Data



The SWL data are available to all participating hospitals and physicians in aggregate format through the SWL Data Query System, a software package designed to allow hospitals and physicians to obtain information on the state of waiting lists and waiting times by health region, hospital, specialty or surgeon (BC Ministry of Health, 1995).

The SWL data are used by the Ministry of Health to provide regular updates on waiting times for surgery through the publication of regular "Waiting List Reports". The first report was published in the Fall 1997 (BC Ministry of Health, 1997) and a subsequent report was published

in 1998 (BC Ministry of Health, 1998). The SWL can also be accessed via the Internet (http://www.swl.hlth.gov.bc.ca/swl). Consumers and providers of health care can log onto the Internet and receive the most recent information regarding the number of patients waiting, the median waiting time and the number of procedures performed within a specified period of time by procedure. This information is also provided by hospital and by physician within each hospital.

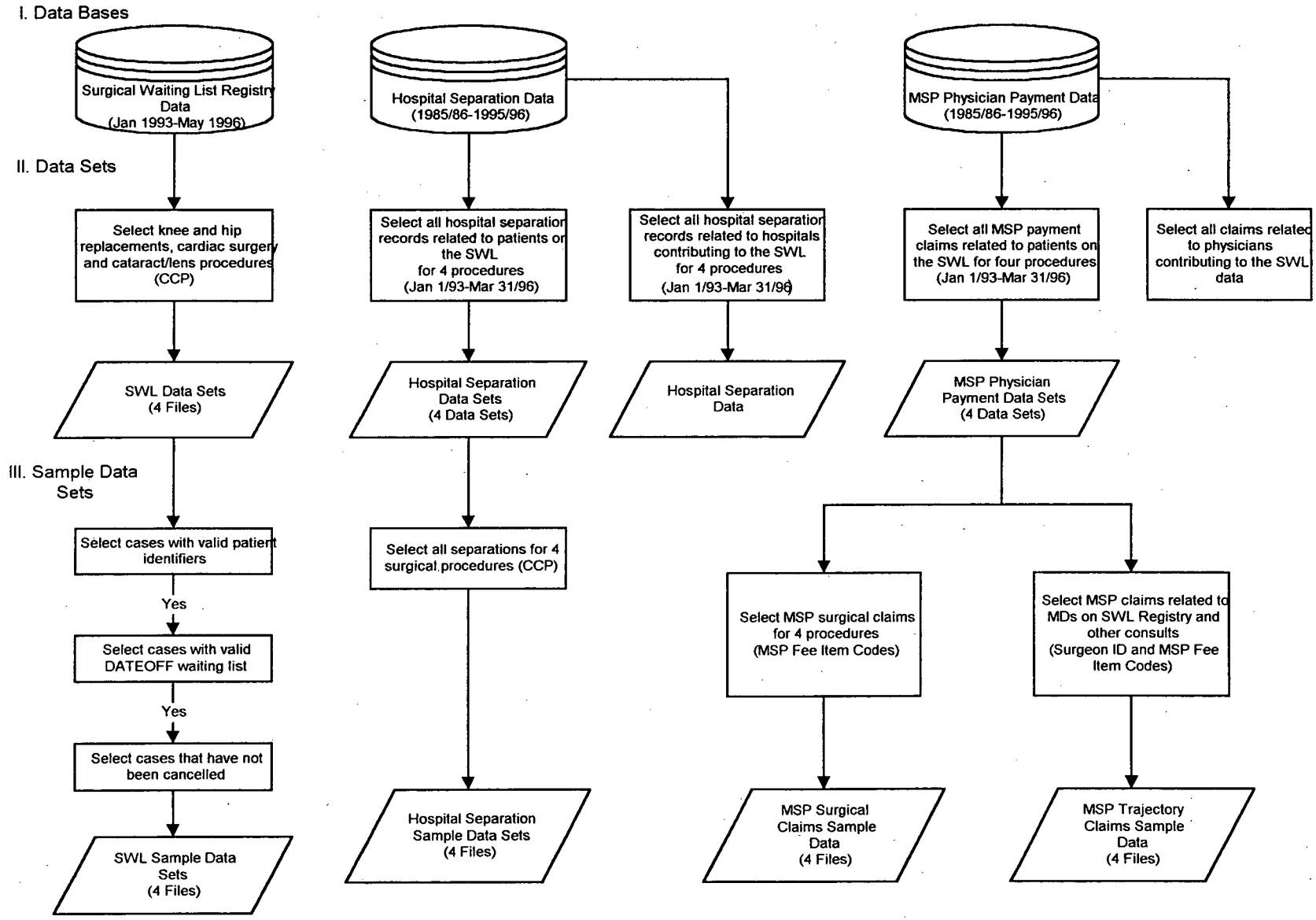
Relevant data variables from the SWL registry are listed in Table 4.1. The SWL data contain information regarding when patients are placed on the list (i.e. DATEON) and taken off the list (i.e. DATEOFF) as well as relevant hospital, physician and patient information. The waiting time is measured by DAYS representing the number of days between DATEON and DATEOFF.

Table 4.1: Data definitions (SWL)

SWL Data
Patient Personal Health Number (PHN)
Hospital Number (HOSP)
Date on Waiting List (DATEON)
Date off Waiting List (DATEOFF)
Reason off Waiting List (REASONOFF)
Patient Type (Inpatient/Day Surgery) (PATTYPE)
Patient Status (Elective, Semi-urgent, Urgent) (PATSTAT)
Procedure 1,2 (PROC1,2)
Days Waiting (DAYS)
Surgeon Identifier (SURGID)
Surgeon Specialty (SPEC)
Sex (SEX)
Birth date (BDATE)

A complete copy of the SWL data between 1993 and 1996 were provided to the Centre for Health Services and Policy Research (CHSPR) at the University of British Columbia by the Ministry of Health. For the purposes of this study, the data were extracted from the SWL by data managers at CHSPR. Figure 4.2 outlines the data extraction process.

Figure 4.2: Data extraction process, SWL, Hospital Separation and MSP Data sets



All knee and hip replacements, cardiac surgery and cataract/lens surgeries were selected from the SWL data based on CCP codes.

In general, the procedure codes provided in the SWL registry are provided to 2-digits except for selected procedures including knee and hip replacement and cataract surgery which are provided to 4 and 3 digits respectively. The following codes were used to select relevant cases: knee replacement (93.41), hip replacement (93.51), cardiac surgery (48.0) and cataract/lens surgery (27.0, 27.7). The code for hip replacement includes both 93.51 and 93.59. The selection of cataract cases includes both operations on the lens (27.0) and cataract surgery (27.7) since cataract cases are coded by some hospitals as both 27.7 and 27.0.

Patient and physician identifiers were scrambled prior to the release of the data to ensure confidentiality. The final sample data sets included: 4,518 knee replacement cases; 5,208 hip replacement cases; 4, 027 cardiac surgery cases; and 43,146 cataract/lens surgery cases.

4.2.2 Frequency Analysis

Between January 1, 1993 and May 31, 1996 there were a total of 56,899 waitlist entries for all procedures combined. A detailed frequency analysis is presented in Table 4.2. Over 90% of cases have a valid PHN. There are 3,499 unique PHNs for knee replacements, 4,264 for hip replacement, 3,498 for cardiac surgery and 31, 957 for cataract/lens surgery. It is evident, therefore, that some patients have appeared on the waiting list more than once.

All waitlist cases have a reported DATEON representing the specific date when the patient was placed on the waiting list. For knee replacement, hip replacement and cardiac surgery, patients

had been placed on the waiting list as far back as 1991 and as recently as May 1996. The majority of cases, over 86% among knee and hip replacements and over 93% among cardiac and cataract/lens surgery cases, were placed on the waiting list between January 1994 and May 1996.

Table 4.2: Frequency analysis for SWL (% of valid cases)

Variable	Knee Replacement (n=4,518)	Hip Replacement (n=5,208)	Cardiac Surgery (n=4,027)	Cataract/Lens Surgery (n=43,146)
Patient PHN	4,157 (92.1%)	4,832 (92.8%)	3,737 (92.8%)	41,143 (95.4%)
Date on Waitlist	4,518 (100%)	5,208 (100%)	4,027 (100%)	43,146 (100%)
Date off Waitlist	3,751 (83.0%)	4,509 (86.6%)	3,733 (92.7%)	36,741 (85.2%)
Days	4,518 (100%)	5,208 (100%)	4,027 (100%)	43,146 (100%)
Reason off Waitlist				
Surgery Done	3,010 (66.6%)	3,870 (74.3%)	3,208 (79.7%)	32,442 (75.2%)
Surgery Cancelled	645 (14.2%)	501 (9.6%)	476 (11.8%)	3,177 (7.3%)
Emergency	3 (0.1%)	9 (0.2%)	0	1 (0.1%)
Trans to other hosp	6 (0.1%)	8 (0.2%)	6 (0.1%)	202 (0.5%)
Patient Died	5 (0.1%)	7 (0.1%)	12 (0.3%)	166 (0.4%)
Still on WL	767 (17.0%)	699 (13.4%)	294 (7.3%)	6,405 (14.8%)
Missing	82 (1.8%)	114 (2.2%)	31 (0.6%)	753 (1.8%)
Hospital	4,518 (100%)	5,208 (100%)	4,027 (100%)	43,146 (100%)
Surgeon	4,494 (99.5%)	5,169 (99.3%)	4,027 (100%)	42,991 (99.6%)
Patient Type				
Inpatient	4,449 (98.5%)	5,115 (98.2%)	3,994 (99.2%)	1,519 (3.5%)
Day Patient	66 (1.5%)	93 (1.8%)	32 (0.8%)	41,623 (96.5%)
Missing	3 (0.1%)	0	1 (0.1%)	4 (0.1%)
Patient Status				
Elective	4,285 (94.8%)	4,616 (88.6%)	2,288 (56.8%)	42,489 (98.5%)
Semi-urgent	135 (3.0%)	214 (4.6%)	51 (1.3%)	369 (0.9%)
Urgent	93 (2.1%)	351 (6.7%)	1,678 (41.7%)	237 (0.5%)
Missing	5 (0.1%)	0	10 (0.2%)	51 (0.1%)
Gender				
Female	2,546 (56.4%)	3,007 (57.7%)	873 (21.7%)	27,066 (62.7%)
Male	1,968 (43.6%)	2,201 (42.3%)	3,148 (78.2%)	16,053 (37.2%)
Missing	4 (0.1%)	0	6 (0.1%)	27 (0.1%)
Birthdate	4,516 (99.9%)	5,204 (99.9%)	4,020 (99.8%)	43,109 (99.9%)

In most cases, patients completed their waiting list experiences during the study period. These cases were identified as those with a data entry for DATEOFF. The proportion of cases taken off the waiting list during this time period ranged from 83% (KR) to 92.7% (CARD). DATEOFF ranged between January 1994 and May 1996 for all four surgical groups. No patients were removed from the waiting list prior to 1994. The proportion of cases remaining on the waiting list as of May 1996 varied by surgical group with 17.0% (n=767) of knee replacement cases

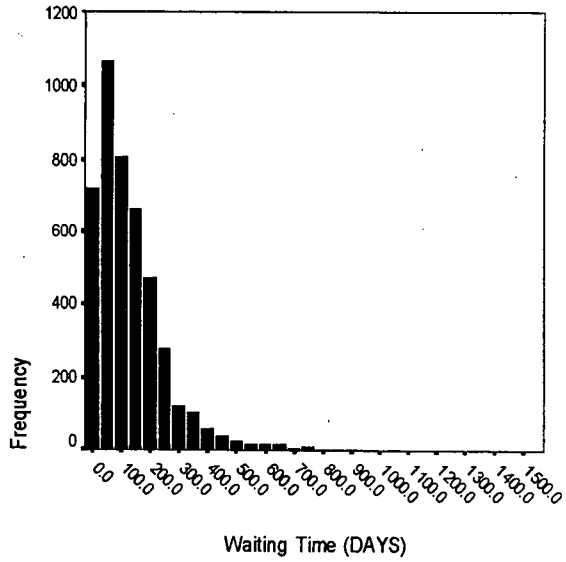
remaining on the waiting list, 13.4% (n=699) of hip replacement cases, 7.3% (n=294) of cardiac surgery cases and 14.8% (n=6,405) of cataract/lens cases.

Patient waiting time is reported in days (DAYS). For those cases taken off the waiting list, waiting time represents the number of days between when the patient was placed on the waiting list (i.e. DATEON) and taken off the waiting list (i.e. DATEOFF). For those still awaiting treatment, waiting time represents the number of days between DATEON and the date of the last data submission from the hospital to the Ministry of Health. As such, all cases have a reported waiting time. The value of DAYS ranges from a minimum value of 0 days to a maximum value of over 1,450 days for knee replacement, hip replacement and cardiac surgery and a maximum value of 3,716 days for cataract/lens cases. The distribution of waiting time for all procedure groups is highly skewed with a significant long right tail (see Figure 4.3). As expected, median waiting times for each procedure group were lower than the means. The mean waiting time ranged between 60.9 days (CARD) and 138.1 days (KR) while the median waiting times ranged between 9 days (CARD) and 103 days (KR). Median waits were shorter than the reported average waits by 30 days for CATS, 35 days for KR and HR, and 51 days for CARD. This clearly demonstrates how reporting average waiting times can be misleading.

The SWL provides information regarding why the patient was taken off the waiting list (REASONOFF). In the majority of cases, patients were taken off the waiting list because they received surgery. Patients receiving care represented between 66.6% (KR) and 79.7% (CARD) of cases. Patients may also have been removed from the waiting list due to surgery cancellations by either the patient, surgeon or hospital. These cases represented between 7.3% (CAT) and 14.2% (KR) of cases. Less than 1% of cases were removed due to emergency surgery, transfer

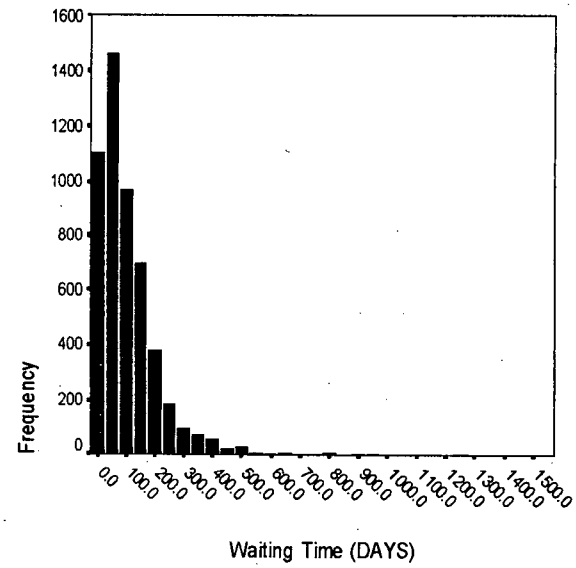
Figure 4.3(a-d): Distribution of waiting time (DAYS) by procedure group

(a) Knee Replacement



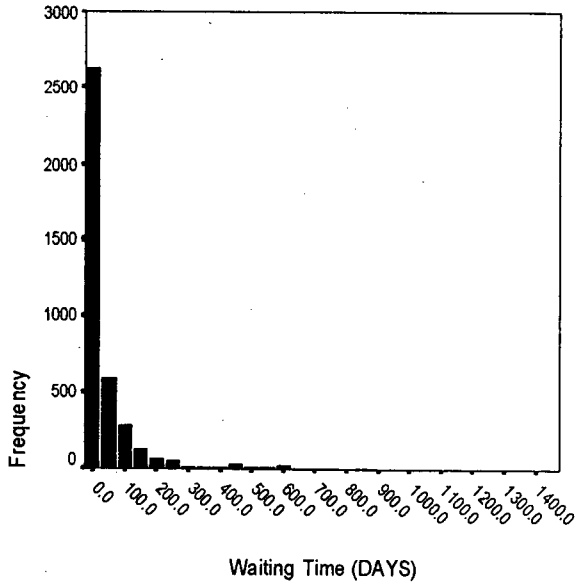
Mean= 138.1 Median=103
Range=1,539 N=4,518

(b) Hip Replacement



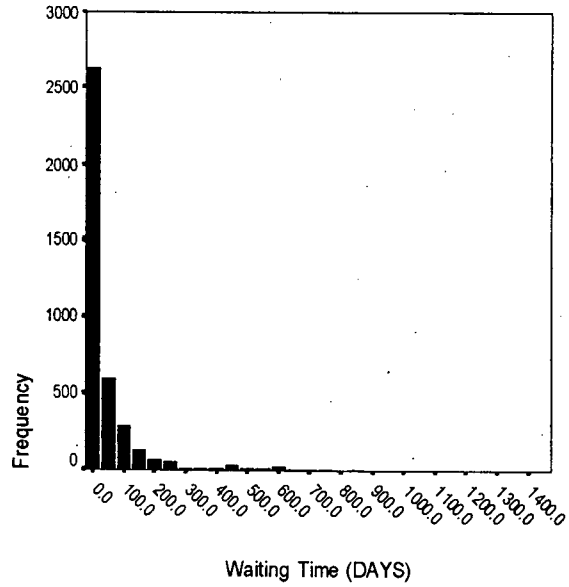
Mean=111.4 Median=76 days
Range=1,551 N=5,208

(c) Cardiac



Mean=60.9 Median=9
Range=1,456 N=4,027

(d) Cataract



Mean=89.9 Median=59
Range=3,716 N=43,146

to another hospital, or patient death. Between 7.3% (CARD) and 17.0% (KR) remained on the waiting list as of May 1996. Information was missing for between 0.6% (CARD) and 2.2% (HR) of cases. The SWL also provides information regarding the hospital and surgeon associated with each case. Hospital information is provided for all cases and surgeon information is provided for over 99% of cases.

Information regarding the type of patient (PATTYPE) and patient status (PATSTAT) is also provided. Each case is categorized as either an inpatient or day surgery case. As expected, the majority of knee replacement (98.5%), hip replacement (98.2%) and cardiac (99.2%) cases are classified as inpatients while the majority of cataract/lens cases (96.5%) are listed as day surgery cases. This information is missing in only 0.1% of cases in three of the four surgical groups. Cases are also categorized as either elective, semi-urgent or urgent based on the patient's status upon placement on the waiting list. As expected, most of the knee replacement (94.8%), hip replacement (88.6%) and cataract/lens (98.5%) cases were listed as elective surgery. Over 55% of cardiac cases were listed as elective while 41.7% were listed as urgent. This information was missing in less than 0.2% of cases. In many cases, urgent and emergent cases may never be placed on the waiting list due to the nature of the case.

Basic patient demographic information is also provided. Gender information is provided for all hip replacement cases and all but 0.1% of cases in each of the three remaining surgical groups. Females represented the majority of cases among knee replacements (56.4%), hip replacements (57.7%) and cataract cases (62.7%). Date of birth is provided for over 99% of cases in all four surgical groups. Patient age upon placement on the waiting list was calculated. The majority of patients on the SWL are over 60 years of age. These patients represent 86.8% of knee

replacement cases, 78.7% of hip replacement cases, 72.1% of cardiac cases and 91.2% of cataract/lens cases.

4.2.3 Patient Experiences on the SWL

Some patients have appeared on the SWL more than once for the same procedure. An understanding of individual patient experiences can provide a more comprehensive understanding of the SWL. Using all cases with a valid PHN, patients' entry on the waiting list can be traced over time. A summary of patient experiences is provided in Table 4.3.

Table 4.3: Patient experiences on the SWL (% of total cases)

No. of Entries	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1 placement	2,917 (83.4%)	3,758 (88.0%)	3,277 (93.7%)	23,661 (74.0%)
2 placements	516 (14.7%)	453 (10.6%)	204 (5.8%)	7,587 (23.7%)
3 placements	57 (1.6%)	45 (1.1%)	16 (0.5%)	567 (1.8%)
>3 placements	9 (0.3%)	8 (0.3%)	1 (0.1%)	142 (0.5%)
Total	**3,499 (100%)**	**4,264 (100%)**	**3,498 (100%)**	**31,957 (100%)**

Overall, the majority of patients in each surgical group appeared on the waiting list for the same procedure only once. Cardiac patients were the most likely to appear only once (93.7%) compared with only 74.0% of cataract/lens patients. Among those appearing only once, most patients were taken off the waiting list due to receipt of treatment (KR: n=2053 (70.3%); HR: n=2,999 (79.8%); CARD: n=2,848 (86.9%); CAT/LENS: n=18,149 (76.7%)). Between 6.6% (CARD) and 17.9% (KR) of these patients remained on the waiting list as of May 1996. The number of cancellations among patients appearing once ranged from a low of 4.4% (HR, CAT) to a high of 9.7% (KR).

The second largest group of patients within each surgical group was those appearing twice on the waiting list. These patients represented between 5.8% (CARD) and 23.7% (CAT) of all patients.

The experiences of patients awaiting knee replacement, hip replacement and cataract/lens surgery was similar. For most patients, both entries on the waiting list resulted in surgery (KR: n=225 (44%); HR: n=200 (44%); CAT: n=5,034 (66%)). However, it is not clear whether the second surgery represented further surgery on the same knee or hip or represented surgery on a second knee or hip. The second most common route for knee and hip replacement patients was a cancellation on the first entry followed by surgery on the second waiting list entry (KR: n=89 (17%); HR: n=111 (25%)). The second most common path for cataract patients was receipt of surgery following the first placement and then remaining on the waiting list following the second placement (n=1,341; 17.7%) presumably awaiting surgery on the second eye. For cardiac patients, there were two equally common paths. Thirty-five percent (n=71) of cardiac patients placed on the waiting list twice received treatment following their first placement followed by a cancellation on their second placement. An additional 37% (n=76) of patients were cancelled on their first placement and received treatment following their second waiting period.

In some cases, patients were placed on the waiting list a second time before their first waiting period had come to an end. For example, approximately 6% of knee replacement (n=32) and hip replacement (n=29) patients were placed on the waiting list a second time while still awaiting surgery from a first placement. Approximately 40% of these patients (KR: n=13; HR: n=14) received surgery following their second placement on the waiting list when their first waiting list experience had not yet come to an end.

Between 1% and 2% of patients within each surgical group were placed on the waiting list 3 times for the same procedure. Patient experiences varied greatly both within and across procedure groups. For example, among knee replacement patients placed on the waiting list 3

times (n=57), 9 patients received surgery following all three placements on the waiting list and 9 other patients experienced two consecutive cancellations followed by surgery after the third placement. Among cardiac patients placed three times (n=16), most patients (n=7) experienced two consecutive cancellations followed by surgery after their third placement on the waiting list. Approximately 1.8% of cataract/lens patients (n=567) were placed on the waiting list three times. The majority of these patients (n=141) experienced surgery following their first wait, a cancellations following their second wait and finally, surgery once again following their third wait.

Less than 1% of patients within each surgical group was placed on the waiting list more than 3 times. The maximum number of placements for a single patient was 4 times for cardiac, 5 times for knee and hip replacement and 6 times for cataract/lens surgery. These multiple wait patients had vastly different experiences on the waiting list. For example, one patient waiting for cardiac surgery was placed on the waiting list four times, each waiting period ending in surgery. Two patients waiting for knee replacement and 4 patients waiting for hip replacement experienced a cancellation following their first wait, surgery following their second wait, a second cancellation after their third wait and a second surgery after their fourth and final wait. Fourteen patients waiting for cataract/lens surgery experienced 3 consecutive cancellations followed by surgery after their fourth wait. An additional 14 patients experienced 4 cancellations with only 4 patients receiving care following a fifth placement on the waiting list.

4.2.4 Time Sequence Checks

Time sequence checks have been proposed as another method of assessing the accuracy of administrative data using a single database. This type of analysis is based on assumptions

regarding the purpose and processes involved in generating the data. Given the nature and purpose of waiting lists, specific courses of events are expected to occur. In the following discussion several time sequence checks are explored using information from patient experiences on the SWL.

Does DATEON precede DATEOFF?

Given the nature of waiting lists, date-on the waiting list is expected to precede date-off the list. Cases removed from the SWL prior to May 1996 were selected from each surgical group (KR: n=3,751; HR: n=4509; CARD: n=3,733; CAT/LENS: n=36,741). In most cases, DATEON precedes DATEOFF. In 2% of knee (n=76) and hip (n=73) replacements cases, 3% of cardiac cases (n=108) and 1% of cataract/lens cases (n=376), however, DATEON was the same as DATEOFF. The most likely scenario in which this would occur would be if a patient was considered an urgent case or if surgery was performed on an emergency basis. An analysis of patient status, however, indicated that most of these patients (>90%) waiting for knee replacement, hip replacement or cataract/lens surgery and 48% of patients waiting for cardiac surgery were listed as elective. Furthermore, none of the patients awaiting hip replacement or cardiac surgery were removed from the waiting list due to an emergency procedure and only 1.3% of patients awaiting knee replacement and 0.3% of patients awaiting cataract/lens surgery were removed due to emergency surgery.

Another explanation may be found in the waiting list management practices of individual physicians. Physicians may refrain from placing patients on the waiting list until a confirmed booking or OR time has been secured. In some cases, OR times may come available suddenly due to cancellations and elective patients may be summoned for surgery on short notice. For

those patients not previously placed on the waiting list, their DATEON and DATEOFF would appear as the same date. Conversely, a patient may have the same date for DATEON and DATEOFF as a result of a clerical error. Confirmation of these and other explanations may be reached using additional administrative data bases to check the accuracy of the information.

Do patients who die while on the waiting list appear again after death?

In a small number of cases, patients on the waiting list may die while awaiting treatment. These patients were not expected to be placed on the waiting list following death. Among those patients appearing on the waiting list more than once, only 3 patients awaiting cataract/lens surgery appeared on the waiting list a second time after they were reported dead following their first waiting list event. This is most likely a result of clerical errors. There were no such cases for knee replacement, hip replacement, or cardiac surgery.

The results of the preliminary assessment of the accuracy of the SWL indicate that the data are very complete; there are very few missing data elements. The analysis also reveals specific limitations/characteristics of the data. First, there are no reported cases taken off the SWL prior to January 1994. Patients placed on the waiting list prior to this time, therefore, may be biased toward longer waiting times and will be removed from further analyses. Second, as expected, patient waiting time is highly skewed with significant right end tails, demonstrated in all four procedure groups.

The time sequence checks revealed very few problems. In less than 3% of the cases, patients had the same DATEON and DATEOFF. The use of additional administrative health care data will provide an opportunity to check and validate the information provided for both DATEON and

DATEOFF the waiting list. Based on these results, therefore, one can conclude that the waiting list functions, for the most part, as expected.

4.3 VALIDITY and RELIABILITY ASSESSMENT OF THE SWL:

Methods using Two or More Databases

The reliability and validity of an administrative database can also be assessed via comparisons with other administrative databases. The SWL data were compared with two independent administrative databases, namely hospital separation and physician payment data. The purpose of the assessment was to determine the accuracy of three distinct sets of variables: (1) hospital, procedures, physician and patient information (i.e. demographic, patient type and patient status information); (2) waiting time; and (3) waiting list size. To achieve the first two objectives, the SWL data were deterministically linked to both the hospital separation and physician claims data. In the following discussions, the data, methods and results of the multi-database assessment are presented.

4.3.1 Data

Both the hospital separation and Medical Services Plan (MSP) physician payment data are part of the BC Linked Health Database (BCLHD) jointly established by the Ministry of Health and the CHSPR at UBC to link several sources of health care and health information at the individual level. Unique PHNs as well as other sources of personal identifying information are used in a probabilistic linkage process where necessary to link the sources of information through a central coordinating file representing all health service recipients in the province. The hospital separation and MSP payment data are available from 1985/86 through to 1997/98 (CHSPR, 1996; Chamberlayne et al., 1998).

The hospital data base is comprised of all hospital separations in the province. All hospitals are required, by law, to submit to the Ministry of Health a record of all services received by the patient upon discharge. The hospital separation data contain information regarding admission and separation dates, diagnoses, procedures, procedure dates, physician identifications and patient information (see Table 4.4). All procedures are coded based on the CCP. A complete description of all data variables is provided in the "Annotated Specifications for Hospitalization Data" (BC Ministry of Health, 1994).

Table 4.4: Selected data fields for Hospital Separation and MSP Data

Hospital Separation Data	MSP Physician Data
Patient PHN	Patient PHN
Hospital Number	Date of Contact
Admission Date	Service Code
Separation Date	Fee Item Code
Admission Category	Physician Number
Entry Code	Physician Specialty
Procedure Codes (10)	Referring Physician
Procedure Date (10)	Sex
Procedure Surgeons (10)	Birth date
Day Procedure Group	
Physician Number	
Sex	
Birth date	

The MSP physician payment database represents all physician services paid by the Ministry of Health on a fee-for-service basis. In order to receive compensation, physicians are required to submit a medical claim to the Ministry of Health. The data provide information regarding service and/or procedure provided, date of contact, physician identifier and patient information (see Table 4.4). Procedures are identified by unique fee item codes provided by the Medical Services Commission (BC MSC, 1995).

A deterministic linkage was conducted using the patient PHNs provided in the SWL to abstract all hospital separations and MSP physician payment claims between January 1, 1993 and March 31, 1996 for all patients listed on the SWL registry data sets for the four selected procedures (see Fig 4.2). At the time of the data extraction, the hospital and MSP data were only available up to March 1996. A total of 8 files were created, a hospital separation and MSP data set for each of the four procedures representing all separations and claims related to patients identified in the SWL for each procedure group. Patient and physician identifiers were again scrambled using the same algorithm as with the SWL data to ensure confidentiality. The final data sets are presented in Table 4.5.

Table 4.5: Hospital Separation and MSP data extractions (n)

Data Source	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
Hospital Separations	9,397	10,710	14,704	86,144
MSP Physician Claims	612,465	612,465	595,206	3,967,295

A final data extraction was conducted to identify all hospital separations submitted between April 1, 1993 and March 31, 1996 for all hospitals contributing waiting list information to the SWL registry (n=1,723,468). These data will be used to assess the reliability of the waiting list size and to conduct additional analyses.

4.3.1.1 Data Sample Sets

The next step was to create 4 data files for each procedure for use in the validity and reliability assessment of the SWL data (see Fig 4.2). For each procedure the following sample data sets were created: (1) SWL sample data; (2) hospital separation sample data; (3) MSP surgical claims sample data; and (4) MSP trajectory claims sample data.

Surgical Waitlist Registry Data

A subset of cases was selected from the SWL for each procedure. Given the nature of the data assessment, the cases in the SWL data had to meet specific inclusion criteria. First, the case had to have a patient identifier to allow a deterministic linkage. The proportion of cases without a patient identifier varied from a low of 4.6% among cataract/lens patients to a high of approximately 7%-8% among the remaining procedures.

Second, as described earlier, the SWL data included all patients who completed their waiting times as well as all patients still waiting for treatment at the end of the study period. The validity and reliability assessment is retrospective in nature since both the hospital separations and MSP payments represent services already provided. Hence, the sample of SWL patients could only include those cases removed from the waiting list (i.e. had a DATEOFF); the proportion of cases with a date-off the waiting list varied from 92.7% (CARD) to 83% (KR). Furthermore, the hospital and MSP data available at the time of the data extraction extended only to March 31, 1996 compared to the waiting list data that included patients on the waiting list up to the end of May 1996. Cases included in the sample, therefore, had a DATEOFF between January 1, 1994 and March 31, 1996. Finally, patients can be taken off the waiting for several reasons including cancellations by the patient, physician or hospital or patient death. The interest here was in patients who were removed from the SWL because they supposedly received the procedure. Cases that were removed from the waiting list due to cancellations were excluded. The final data samples for the SWL are reported in Table 4.6.

Table 4.6: Sample Selection for SWL Data (% of original sample)

Selection Criteria	Knee Replacement (n=4,518)	Hip Replacement (n=5,208)	Cardiac Surgery (n=4,027)	Cataract/Lens Surgery (n=43,146)
Valid ID number	4,517 (99.9%)	4,832 (92.3%)	3,737 (92.8%)	41,143 (95.4%)
Dateoff	3,440 (76.1%)	4,166 (79.9%)	3,484 (86.5%)	35,148 (81.5%)
Surgery done	2,890 (63.7%)	3,763 (72.3%)	3,135 (77.9%)	32,177 (74.6%)
Sample Size	2,890	3,763	3,135	32,177

Hospital Separation and MSP Data

As previously described, the data sets containing the hospital separation and MSP payments data include all services provided to patients listed on the waiting list. For the purposes of the validity and reliability assessment, only those claims pertaining to the four procedures of interest are required. The CCP procedure codes were used to identify all relevant hospital separations representing knee replacement, hip replacement, cardiac surgery and cataract/lens surgery. The fee item codes, provided in the MSP Payment Schedule (1995), were used to identify the relevant surgical claims for the four procedures of interest. The procedure codes are outlined in Table 4.7.

Table 4.7: Sample selection procedure codes, Hospital Separation and MSP data

Procedure	Hospital Separation Data (CCP)		MSP Physician Data (MSP Fee Item Codes)
Knee Replacement	93.41-93.47	Arthrpolasty of Knee	5519 Polycentric knee prosthesis 5520 Knee arthroplasty 5524 Knee arthroplasty-revision
Hip Replacement	93.51,93.59 93.61-93.64, 93.69	Total Hip Replacement Other Arthroplasty of Hip	5515 Revision of failed hip 5523 Hip arthroplasty 5529 Total hip prosthesis
Cardiac Surgery	48.0 48.1 48.2 48.3 48.9	Removal of CoronaryObstruction Bypass anastomosis Heart revascularization Other heart revascularization Other operations on vessels heart	7908 Coronary artery bypass graft
Cataract/Lens Surgery	27.0-27.9	Operations on Lens	2188 Cataract extraction 2191 Cataract extraction 2193 Cataract extraction-subsequent

The hospital separation data provide procedure codes for up to 10 procedures. The procedure of interest may or may not appear as the first procedure listed. Separations were selected if the procedure codes appeared as one of the first 4 procedures documented in the separation claim. In over 95% of cases, procedure information was not available for procedure fields 5 to 10.

There was also some concern that if the procedure code appeared much later (i.e. in fields 5-10), it would have not been considered the primary procedure.

As indicated in Table 4.7, the sample selection of hospital separations extended beyond the specific codes used in the SWL to address the possibility of miscoding in the latter. Hence, the data file for knee replacements included all separations related to arthroplasty of the knee (93.41-93.47) and the data file for hip replacements included all claims related to total hip replacements (93.51, 93.59) as well as other arthroplasty of the hip (93.61-93.64, 93.69). To ensure that all relevant hospital separations for cardiac surgery and cataract surgery were included, all claims associated with operations on vessels of the heart (48.0-48.9) and operations on lens (27.0-27.9) were selected.

Relevant MSP claims were selected using the MSP fee item codes listed in Table 4.7. The selection of physician claims was restricted to specific procedures including only knee and hip replacements, coronary artery bypass graft (CABG) and cataract surgery. Both the cardiac and cataract/lens surgical groups contain a broad range of procedures. To ensure an accurate linkage to the MSP claims data, the selection of MSP data for the cardiac and cataract/lens procedure groups was limited to CABG (MSP Code 7908) and cataract respectively (MSP Code 2188, 2191, 2193).

A final data extraction was conducted to create MSP data sample files for the creation of patient trajectories. The trajectories were used to assess the validity of DATEON since this information does not appear in either the hospital separation or the MSP data. The trajectory of care created included all specialist visits prior to surgery. The following claims were selected for each patient

and procedure: (1) all claims associated with the surgeons listed on the SWL, and (2) all other surgical consultation claims. The fee item codes for surgical consultations are outlined in Table 4.8. The sample selection for CABG includes angiographies since this specific procedure is often used to mark the point at which patients are placed on the CABG waiting list. Furthermore, the trajectory file for cataract surgery includes diagnostic ophthalmology claims identified by the service code (89) on the MSP claims.

Table 4.8: Fee item codes for MSP surgical consultations

Procedure	MSP Physician Data (MSP Fee Item Codes)
Knee and Hip Replacement	5010 Consultation
	5012 Repeat or limited consultation
	5007 Subsequent office visit
	5005 Emergency visit
CABG	7810 Consultation
	7811 Repeat or limited consultation
	7807 Subsequent office visit
	7805 Emergency visit
Cataract	2010 Consultation
	2011 Repeat or limited consultation
	2012 Special consultation
	2007 Subsequent office visit
	2005 Emergency visit
	2014-2075 Eye Examination

The final sample sizes for each file are outlined in Table 4.9 by procedure group.

Table 4.9: Final sample sizes for the validity/reliability assessment

Data Sample	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
Hospital Separations	3,106	3,967	6,559	41,763
MSP Data – Surgical	3,022	3,945	2,711*	36,847**
MSP Data – Trajectory	24,604	28,377	18,494	439,612

Note: * CABG only ** Cataract surgery only

4.3.2 Methods

The quality of the SWL data was assessed using the standard method of comparing 2 or more independent sources of administrative data. The first step involved the linkage of all three data sets for each patient-procedure combination. Once the data were linked the assessment of the

reliability and validity of the SWL data could be conducted. The following section outlines the methods used to link the data and to conduct the subsequent validity and reliability assessment.

4.3.2.1 Data Linkage

The data were linked deterministically in a three step process: (1) link SWL and hospital separation data; (2) link SWL/hospital data and MSP surgical data; and (3) internal single database link of MSP data to create patient trajectories.

SWL and Hospital Separation Data Linkage

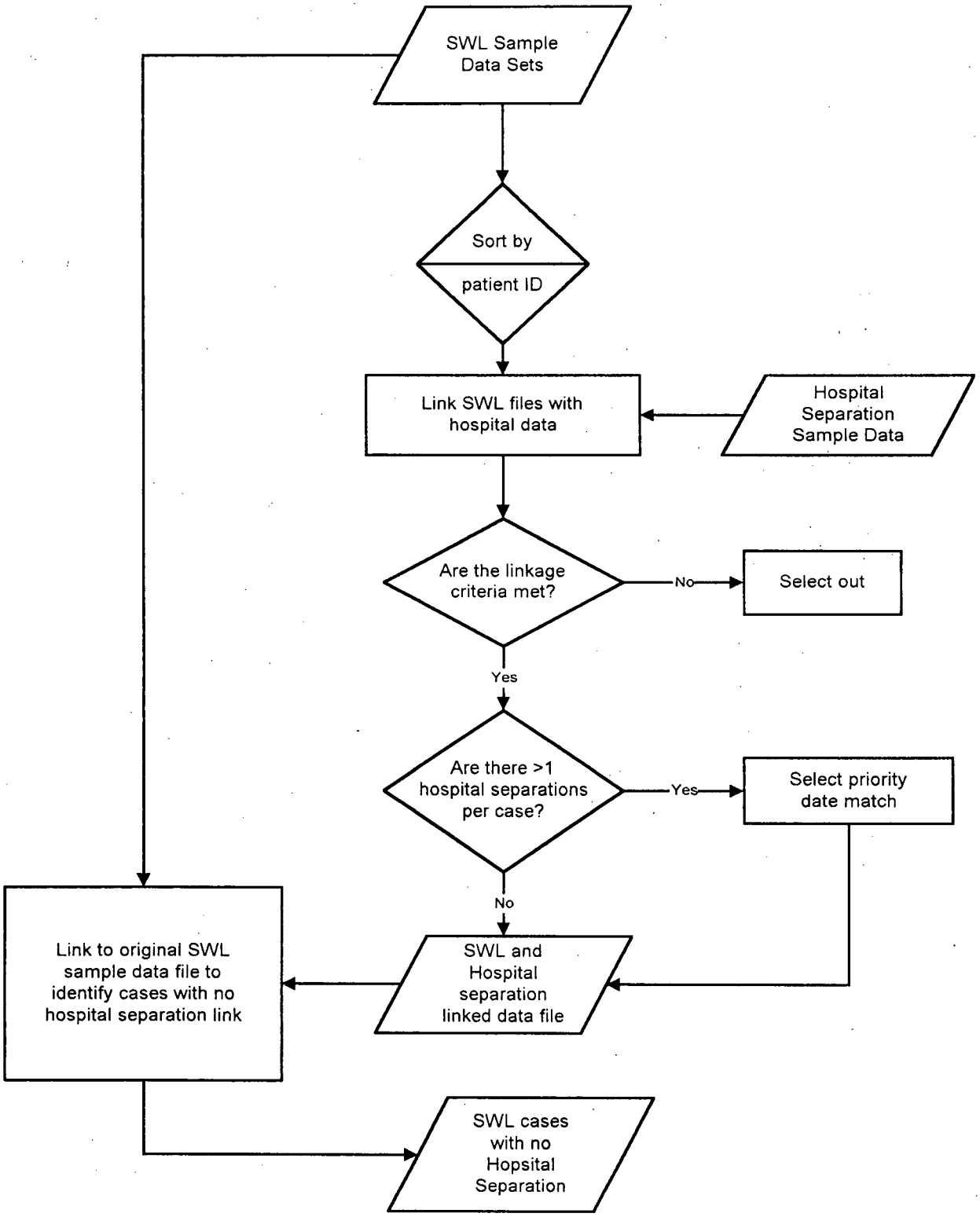
The SWL data were first linked deterministically to the hospital separation data. The primary linkage keys for the SWL were the patient identifier and DATEOFF the waiting list. The linkage criteria are outlined in Table 4.10. To be considered a valid link, pairs of cases had to agree on the patient identifiers and at least one of four date criteria. The date criteria represent various scenarios under which a patient may be taken off a waiting list. They are presented in order of priority starting with the most likely scenario. Theoretically, patients should be taken off the waiting list upon receipt of treatment (i.e. Criterion 1). It is possible, however, that patients may have been taken off any time during their hospital stay (i.e. Criterion 2), or immediately prior to admission or following discharge (i.e. Criterion 3). Given the high proportion of day cases among the cardiac surgery (i.e. angiographies) and cataract/lens surgery patients, separation dates could not be used as selection criteria since they appear as "000000" in the hospital separation data; hence, the match criteria for these procedures are based solely on admission dates. Finally, it is possible that a patient had surgery but was not taken off the list for an extended period of time due to some oversight or administrative problem. In such cases, hospital admissions occurring any time during the waiting time were selected (i.e. Criterion 4).

Table 4.10: Data Linkage criteria

Criteria	Status	Hospital Separation Data	MSP Physician Data
Patient	Must match	Patient identifiers	Patient identifiers
Dateoff (Hip and Knee replacement)	Must match on at least one	1) Same as procedure date 2) Between admission & separation 3)Between 1 wk prior to admission & 1wk after separation 4) Admission & separation occur between dateon & dateoff	1) Same as date of contact 2) Date of contact is between admission & separation 3) Date of contact is between dateon & 1 wk after dateoff
Dateoff (Cardiac and CABG Surgery)	Must match on at least one	1) Same as procedure date 2) Between admission &1 wk after admission 3) Between 1 wk prior & 1 wk after admission 4) Admission occurs between dateon & dateoff	1) Same as date of contact 2) Date of contact is between admission & 1 wk after admission 3) Date of contact is between dateon & 1 wk after dateoff
Dateoff (Cataract/Lens and Cataract Surgery)	Must match on at least one	1) Same as procedure date 2) Between admission & 1 wk after admission 3) Between 1 wk prior &1 wk after admission 4) Admission occurs between dateon & dateoff	1) Same as date of contact 2) Date of contact is between admission & 1 wk after admission 3) Date of contact is between dateon & 1 wk after dateoff

Although the linkage was conducted for each procedure separately, the same process was used for all four procedures as outlined in Figure 4.4. Pairs of cases were selected if they met the mandatory linkage criteria. In some cases, ties occurred (i.e. more than one hospital separation linked to a single SWL case). For example, if a patient had more than one surgery during their waiting time, one surgery may have occurred early during the waiting time (i.e. Criterion 4 met) while the second may have occurred at the end of the waiting period (i.e. Criterion 1 met). Ties were resolved by selecting the hospital separation with the highest priority match on date.

Figure 4.4: Linking SWL and Hospital Data



SWL and MSP Data Linkage

Once the hospital separation matches were completed, the SWL data were then linked deterministically to the MSP payment data. To meaningfully match the SWL data to the MSP data, procedure codes for knee replacement, hip replacement, CABG and cataract had to be specifically defined (i.e. to the 3 or 4 digit level) in order to ensure a match to the appropriate fee item code in the MSP data. The fee item codes in the MSP data are specific to each procedure and are not organized into broad categories similar to those used in the CCP codes. Knee replacement and hip replacement cases were clearly identified in the SWL data since the 4-digit CCP codes were used (i.e. 93.41, 93.51). As previously mentioned in the description of the SWL data, most procedure codes were provided only to the 2-digit level rendering it difficult to select specific procedures within a broad surgical group. All cardiac surgical cases appearing on the SWL were listed under a single 2-digit code for cardiac surgery (i.e. 48). More detailed information was required to identify the CABG cases; this was provided by the CCP procedure code information in the hospital data where CABG cases were clearly identified as 48.1.

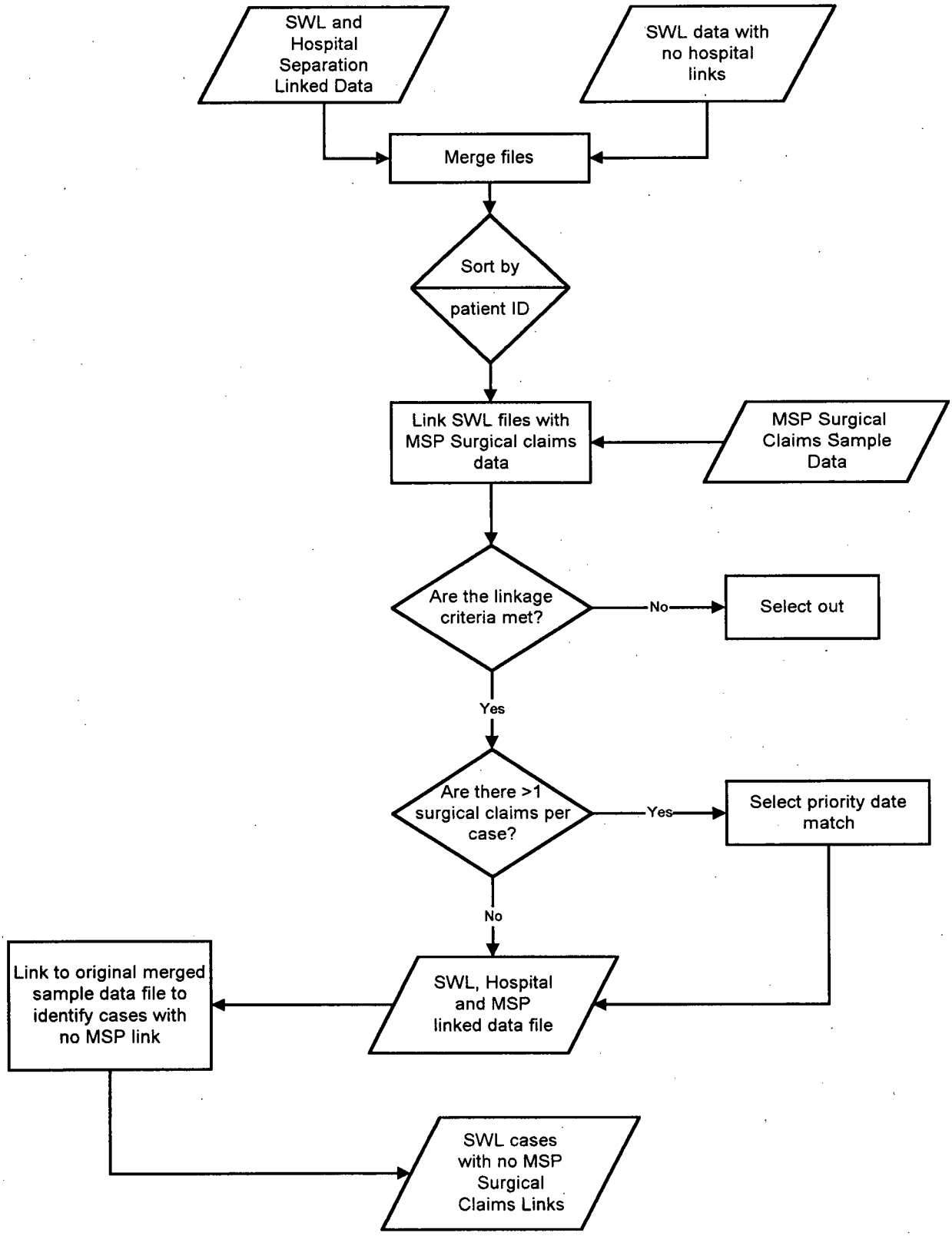
These cases were selected for linkage to the MSP data. Likewise, cataract surgical cases were listed in the SWL data as either 27.7 or more generally as 27. More detailed information was required to identify cataract cases from the latter group; this was provided by the CCP procedure code information in the hospital data where cataract cases were clearly identified as 27.7. All SWL cases within the cardiac surgical and cataract/lens surgical groups with no successful hospital link were assumed to be CABG and cataract surgery respectively, for the purposes of linking MSP data.

The MSP data were linked deterministically to the SWL data. The primary linkage keys were patient identifier and date criteria (see Table 4.10). Each link required a perfect agreement on the patient identifiers and had to meet at least one of 3 date criteria to be considered a valid match. The date criteria are comprised of possible matches between the MSP payment file and either the SWL file or the hospital separation file. Hence, the date of contact provided on the MSP payment data could either match DATEOFF (i.e. Criterion 1), or could occur during the hospital stay (i.e. Criterion 2) or anytime between DATEON the waiting list and 1 week after DATEOFF (i.e. Criterion 3). Once again, the linkage selection criteria were adjusted for cataract surgeries, given the high proportion of day cases resulting in separation date values equal to "000000".

The linkage was conducted for each procedure separately. The same process was used for all four procedures as outlined in Figure 4.5. The process began with all SWL cases with and without a hospital match. Pairs of cases were selected if they met the mandatory linkage criteria.

As with the hospital linkage, ties occurred (i.e. more than 1 MSP claim per SWL case). For example, a tie may occur if a patient had two similar surgeries (i.e. hip replacements) during a single hospital stay. In such cases, ties were resolved by selecting the MSP claim with the highest priority match on date. Matches for all other variables including hospital, surgeon, patient status, patient type, gender and birth date were optional. The MSP data do not contain information regarding hospital, patient status or patient type.

Figure 4.5: Linking SWL and MSP data

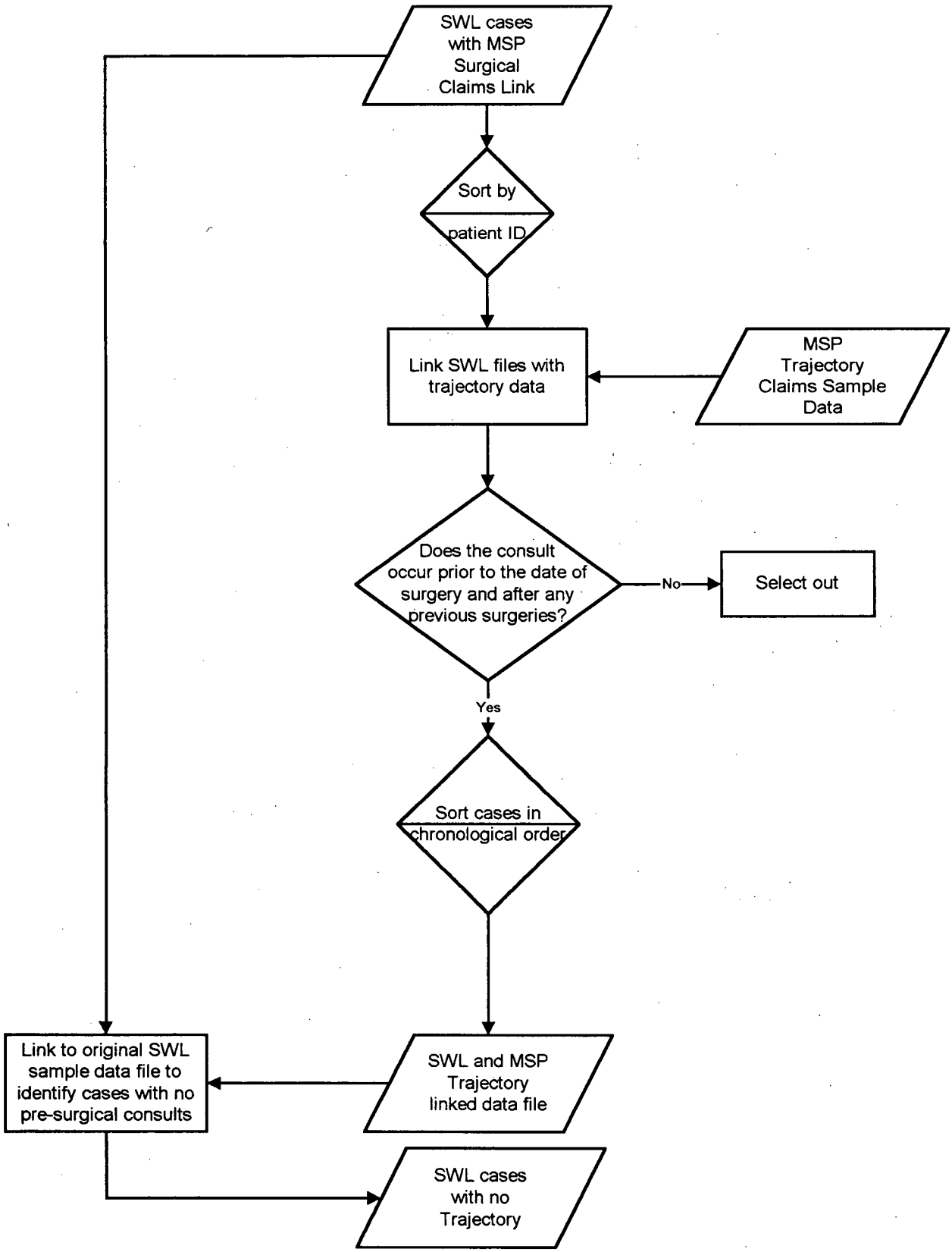


Patient Trajectories

The final linkage was conducted to create patient trajectories of care. The purpose of the linkage was to identify all surgical consultations prior to surgery. SWL cases with a successful MSP surgical claim match were linked deterministically to the MSP trajectory file using the patient identifier. The linkage process is outlined in Figure 4.6.

The trajectory of care is comprised of all surgical consultations occurring between January 1993 and prior to the date of surgery related to the surgery for which the patient was placed on the waiting list. In some cases, however, a patient may have received more than one surgery of the same type between January 1993 and March 1996 (e.g. two knee replacements). To ensure that only those consultations related to the surgery of interest were captured (i.e. the surgery for which the patient was taken off the SWL), the patient trajectory was comprised of only those specialist consultations occurring prior to the date of surgery of interest and after any previous surgery and with any surgeon of the relevant specialty. For example, a patient listed on the SWL for a knee replacement in April 1994 and a second knee replacement in November 1995 would require two separate patient trajectories, one for each surgery. The trajectory for the surgery conducted in April 1994 would include all consultations provided between January 1993 and April 1994; the second trajectory would include all consultations occurring after April 1994 and prior to November 1995. The second trajectory would not include the consultations provided prior to April 1994, since they were assumed to be related to the first surgery. Once the relevant claims were identified for each case, they were sorted in chronological order and numbered from the first to last surgical consultation prior to surgery.

Figure 4.6: Linking SWL and MSP to create patient trajectories



4.3.2.2 Validity/Reliability Assessment

Methods used to assess the accuracy of the data are based on comparing the SWL data to the hospital separation and/or MSP data. Reliability assessments were conducted to ensure the results were consistent across hospitals and physicians.

Hospital, Procedure, Physician and Patient Data

The accuracy of various patient, physician, hospital and procedure variables is determined by calculating the level of agreement (i.e. proportion of matched cases) between the SWL data and hospital and MSP data (see Table 4.11). Kappa values were calculated for categorical variables.

Table 4.11: Validity of patient, physician, hospital and procedure variables

SWL Data	Hospital Separation Data	MSP Physician Data
Procedure	Procedure 1,2,3 or 4	Fee Item
Hospital	Hospital number	n/a
Surgeon	Surgeon number	Practitioner number
Patient Type	Admission Category:	n/a
Elective	1 (Elective)	
Semi-Urgent/ Urgent	2 (Urgent)	
Patient Status	Day procedure Groupings:	n/a
Inpatient	0 (Inpatient)	
Day	>0 (Day)	
Birthdate	Birthdate	Birthdate
Gender	Gender	Gender

Waiting Time

The assessment of waiting time was conducted via two separate analyses: (1) validity and reliability of DATEON and (2) validity and reliability of DATEOFF. The validity of DATEON the waiting list was determined using the patient trajectories to identify the point during the course of care when patients were placed on the waiting list. Patients were classified in one of the following groups: (1) before the 1st consultation; (2) after the 1st consult (1 consultation); (3)

after the 1st consult (>1consultations); (4) after the nth consultation (i.e. after the second or subsequent consultations but before the last); or (5) after the last consultation prior to surgery (>1 consultations). The second category applies only to those cases with a single consultation prior to surgery; categories 3-5 apply to those cases with more than one consultation prior to surgery.

Theoretically, patients should be taken off the waiting list once they have received care. The validity of DATEOFF, therefore, was assessed by comparing date off the waiting list to the date of surgery provided in both the hospital separation and MSP surgical claims data. The level of agreement was determined by calculating the proportion of cases matching on these variables. The reliability of both DATEON and DATEOFF was assessed across hospitals to assess the consistency of the results.

Waiting list Size

The validity of waiting list size can be evaluated by determining if all patients having any one of the four selected procedures were in fact placed on the SWL. It is assumed that all elective patients would be placed on the SWL prior to surgery. Validity of waiting list size was determined, retrospectively, by comparing the number of patients taken off the waiting list due to surgery, to the number of procedures performed for all hospitals contributing to the SWL. The hospital and SWL were linked deterministically using patient identifiers (i.e. PHNs, birthdate) and relevant procedure dates. The assessment was conducted for each procedure separately and included elective, semi-urgent and urgent cases. Only the hospital separation data from hospitals appearing on the SWL for each procedure were selected. Furthermore, hospitals began contributing waiting list data at various points between January 1993 and May 1996; the data were adjusted to capture only those hospital separations occurring after the hospital began

contributing to the SWL.

4.3.3 Results

The following outlines the results of both the data linkage and validity assessments of the SWL data.

4.3.3.1 Data Linkage

The results of the data linkages are summarized in Table 4.12. Although there are currently no standards or universally accepted guidelines to evaluate the success of linkages, the literature suggests that linkage rates greater than 70% are acceptable and rates greater than 90% are considered very good to excellent (Demlo et al., 1978; Demlo et al., 1981; Roos et al., 1982; Roos et al., 1989). Overall, the linkage was very good to excellent for the SWL and hospital separation linkage, with match rates equal to or greater than 90% for each procedure.

Table 4.12: Results of data linkage of SWL, Hospital Separation and MSP Data (% of matched cases)

Linkage	Knee Replacement (n=2,890)	Hip Replacement (n=3,763)	Cardiac Surgery (n=3135)	Cataract/Lens Surgery (n=32,177)
Hospital Claims	2659 (92.0%)	3516 (93.4%)	2824 (90.0%)	31,142 (96.8%)
MSP Surgical Claims	2564 (88.7%)	3438 (91.3%)	2629 (84.5%)*	29,677 (93.4%)**
Hospital and MSP Surgical Claims	2485 (86.0%)	3386 (90.0%)	2611 (83.9%)*	29,557 (93.0%)**
MSP Trajectory***	2564 (100%)	3398 (97.1%)	2613 (99.4%)	29,621 (99.8%)

Note: * Percentage of CABG cases (n=3113)
** Percentage of cataract cases (n=31,777)
*** Percentage of cases with an MSP Surgical Claims match with at least one consult

The linkage rates for the MSP surgical claims varied by procedure. Among knee and hip replacement cases, 88.7% and 91.3% of cases respectively were successfully matched with an MSP surgical claim.

As previously noted, the linkage for the cardiac and cataract/lens groups were restricted to CABG and cataract procedures respectively. Approximately 99.2% of all cardiac cases were identified as CABGs based on procedure information from the hospital separation. Given this result, cardiac cases without a hospital separation match were assumed to be a CABG procedure and therefore, included in the sample to be linked to the MSP surgical data. In all, 3,113 cases were identified as CABGs and were linked to the MSP payment file. Among these cases, 84.5% were successfully matched with an MSP surgical claim.

Approximately 99% of cataract/lens cases with a hospital separation match were confirmed to be a cataract case. Given this result, cataract/lens cases with no hospital separation match were assumed to be a cataract surgery and therefore, included in the MSP linkage. In all, 31,777 cases were identified as cataract surgeries and were linked with the MSP surgical claims data resulting in over 93% of these cases being successfully mached.

Trajectories of patient care were created for all cases with an MSP surgical claims match. This process was highly successful, creating patient trajectories for over 97% of cases within each procedure group. For the remaining cases, a pre-operative consultation was not found.

4.3.3.2 Validity/Reliability Assessment: Hospital, Procedure, Physician & Patient data

Results of the validity assessment of the SWL patient, physician, hospital and procedure information based on comparisons with the hospital separation data are presented in Table 4.13. Overall, the data appear to be highly accurate based on matching rates for most variables. The hospital information matched in over 90% of cases for all procedures except cardiac surgery in which only 86.2% of cases matched. Subsequent analyses by hospital revealed that a single

hospital (Hospital #14) demonstrated consistently lower rates of matching across procedures, ranging from a low of 3.5% for cardiac surgery to a high of 45.5% for cataract/lens surgery (see Appendix B: Table B-1). Analyses of unmatched cases and corresponding hospital data confirmed that the waiting list data for two hospitals were merged and identified as a single hospital (Hospital #14).

Table 4.13: Match results of SWL and Hospital Separation Linkage (% of matched cases)

Variable	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
Total Matches	2659	3516	2824	31,142
1st Procedure	2650 (99.7%)	3502 (99.6%)	2675 (94.7%)	30,808 (99.4%)
Hospital	2513 (94.5%)	3251 (92.5%)	2435 (86.2%)	29,533 (94.8%)
Physician Identifier	2613 (98.3%)	3437 (97.8%)	2757 (97.6%)	30,766 (98.9%)
Patient Type	2630 (98.9%)	3467 (98.6%)	2810 (99.5%)	18,992 (61.0%)
Patient Status	2527 (95.0%)	3201 (91.0%)	1868 (66.1%)	30,489 (98.4%)
Birthdate	2573 (96.8%)	3421 (97.3%)	2791 (98.8%)	29,610 (95.1%)
Gender	2648 (99.6%)	3506 (99.7%)	2816 (99.7%)	30,909 (99.3%)

In over 99% of cases for knee and hip replacement and cataract/lens surgery, the procedure codes in the SWL matched the first procedure code appearing on the hospital separations. The results were consistent across hospitals (see Appendix B: Table B-2). There was a very high match rate for physician identifier with close to 98% of cases in all procedure groups matching. Once again, the results are consistent across hospitals (see Appendix B: Table B-3).

Over 98% of cases agreed on patient type for knee replacement (Kappa=.978), hip replacement (Kappa=.972) and cardiac surgery (Kappa=.990). The results were consistently high across the

hospitals (see Appendix B: Table B-4). However, only 61% of cases agreed among the cataract/lens surgery cases (Kappa=.220). Almost all (99%; n=12,150) of the unmatched cataract/lens cases indicated day surgery on the SWL but did not have a valid day procedure grouping code listed in the hospital data. However, most of the cases (96%; n=11,765) had a separation date equal to "000000", an indication of a day procedure. The low match rate, therefore, is a result of coding error in the hospital separation data and is not reflective of a problem with the SWL.

Patient status information was also found to be highly accurate for three of the four procedure groups. The proportion of cases matching on this information was 95% among knee replacements, 91% among hip replacements and 98.4% among cataract/lens surgery. This was expected since the majority of these cases are performed on an elective basis. The results were consistent across hospitals (see Appendix B: Table B-5).

Patient status becomes more difficult to validate when more cases are performed on an urgent or emergent basis. Given the nature of CABG cases, a lower match rate was expected and found (66.1%). This result was due primarily to changes in patient status while on the waiting list. Patient status in the SWL refers to the patient's condition while awaiting care; in the hospital separation data, patient status is determined on admission to hospital. The status of cardiac care patients can change quickly from, for example, "elective" to "urgent" or "urgent" to "emergent", thus requiring immediate admission to hospital. Approximately 75% (n=722) of unmatched cases were listed as "elective" in the SWL data and as "urgent" in the hospital separation data. It appears likely that for these cases, the status of the patient changed while they were awaiting care requiring an immediate admission to hospital. The SWL data may be not be easily updated

in these situations.

Finally, the linkage of the SWL and hospital data indicates a high level of reliability regarding patient demographics. Over 95% and 99% of cases across the four procedures agreed on patient birth date and gender respectively. Kappa levels suggest that the agreement on gender was well above the level of chance agreement for all four procedures (KR kappa=.992; HR kappa=.994; CARD kappa=.994; CAT kappa=.986). The results were consistently high at the hospital level (see Appendix B: Table B-6 & B-7).

The validity of patient and physician information was also assessed by comparing the SWL and MSP data. The results of the match for the SWL and MSP surgical claims data are presented in Table 4.14. The surgeon identification information was highly consistent with matches ranging from 94.5% for knee replacement to 99.1% for CABG.

Table 4.14: Match results of SWL and MSP Surgical Claims Data

Variable	Knee Replacement	Hip Replacement	Coronary Artery Bypass Graft	Cataract Surgery
Total Matches	2564	3438	2629	29,677
Surgeon	2422 (94.5%)	3327 (96.8%)	2605 (99.1%)	29,374 (99.0%)
Birthdate	1640 (64.0%)	2219 (64.5%)	1851 (70.4%)	17,503 (59.0%)
Gender	2507 (97.8%)	3347 (97.4%)	2589 (98.5%)	28,678 (96.6%)

Overall, there was a low level of agreement regarding patient birth date across all four procedures with the proportion of cases matching ranging from 59% to 70.4%. Further analyses revealed that over 90% of unmatched cases in all four procedure groups had incomplete birth date information in the MSP data. These cases had "00" listed as day of birth.

Finally, there was a high level of agreement between the SWL and MSP data regarding patient gender. The proportion of cases matching was greater than 96% for all four procedure groups. The Kappa values indicate a high level of agreement beyond chance (Knee k=.956; Hip k=.948; CABG k=.97; Cataract k=.932).

4.3.3.3 Validity/Reliability Assessment: Waiting Time

The assessment of waiting time was conducted through separate analyses DATEON and DATEOFF the waiting list.

DATEON

As previously discussed, the trajectory of patient care includes all surgical consultations occurring after January 1993 and prior to the date of surgery for those patients with only a single surgery. For those patients with more than one surgery, the patient trajectory includes all surgical consultations between the date of surgery of interest and any previous surgery. In a small number of cases, the visit immediately prior to the surgery of interest was another surgery. Hence, all consultations prior to surgery could be considered related to the first surgery and not to the surgery of interest. The proportion of cases fitting this scenario varied by procedure (4.0% KR; 2.3% HR; 0.2% CABG; 18% CAT). Only those cases where the last visit prior to surgery was not another surgery were used for the validity assessment of DATEON. The trajectories of care differed for each procedure. As outlined in Table 4.15, approximately 60% of knee and hip replacement patients and 81% of CABG patients had less than 3 specialist visits prior to surgery (median=2). The median number of visits among cataract patients was 3 with 62.5% of cases with 1 to 3 visits prior to surgery.

Table 4.15: Patient care trajectories

No. of Visits	Knee Replacement	Hip Replacement	CABG	Cataract Surgery
1	714 (29.1%)	1061 (32.0%)	670 (25.7%)	3292 (13.6%)
2	764 (31.2%)	957 (28.8%)	1462 (56.0%)	7018 (28.9%)
3	410 (16.7%)	557 (16.8%)	295 (11.3%)	4862 (20.0%)
4	235 (9.6%)	324 (9.8%)	115 (4.4%)	3082 (12.7%)
≥5	328 (13.4%)	421 (12.6%)	67 (2.6%)	6018 (24.8%)
Total	2451 (100%)	3320 (100%)	2609 (100%)	24,272 (100%)

The results of the validity assessment of DATEON are presented by procedure in Table 4.16. For all procedures, the majority of patients with one or more consultations were placed on the waiting list following the last surgical consultation prior to surgery. The points of placement on the waiting list varied by procedure. Knee and hip replacement demonstrated a similar pattern. The most common point of placement on the waiting list for patients with more than 1 visit was following the last pre-surgical consultation (KR: 37.7%; HR: 39.5%). An additional 26.0% (KR) to 28.9% (HR) of patients respectively were placed on the waiting list following their one and only consultation. The remaining patients with more than one visit were equally likely to be placed on the waiting list following their first visit (KR: 15.6%; HR 13.0%) and at some point during the episode of care (KR: 15.4%: HR 14.4%).

Table 4.16: Results of the validity assessment of date on the waiting list

When placed on waiting list	Knee Replacement	Hip Replacement	CABG	Cataract
Before 1st visit	129 (5.3%)	111 (3.3%)	20 (0.8%)	805 (3.3%)
After 1st visit (1 visit)	638 (26.0%)	989 (28.9%)	655 (25.1%)	2713 (11.2%)
After 1st visit (>1 visit)	383 (15.6%)	431 (13.0%)	424 (16.3%)	3471 (14.3%)
After nth visit (>1 visit)	378 (15.4%)	478 (14.4%)	132 (5.1%)	6719 (27.7%)
After last visit (>1 visit)	923 (37.7%)	1311 (39.5%)	1378 (52.8%)	10,564 (43.5%)
Total	2451 (100%)	3320 (100%)	2609 (100%)	24,272 (100%)

While the results varied slightly across hospitals, in the majority of hospitals providing knee replacements (n=20) and hip replacements (n=21), most patients were placed on the waiting list following the last consultation prior to surgery (see Appendix B: Table B-8 & Table B-9).

The majority of CABG patients (52.8%) were placed on the waiting list following their final consultation and an additional 25.1% were placed following their one and only consultation prior to surgery. The majority of the remaining patients (16.3%) were likely to be placed on the waiting list following their first visit. The results varied across hospitals providing CABG (see Appendix B: Table B-10). The proportion of cases placed on the waiting list following their one and only pre-surgical visit ranged from a high of 40.9% (Hospital #2) to a low of 5.5% (Hospital #5). For all hospitals, the common point of placement among those with more than one visit was after the last surgical consultation prior to surgery; the proportion of patients placed on the list at this time ranged between 38.3% (Hospital #2) and 75.0% (Hospital #5). Overall, 40.4% (n=1,054) of the CABG cases were placed on the waiting list immediately following angiography.

The majority of cataract patients (43.5%) were placed on the waiting list following their last visit prior to surgery and an additional 11.2% of cases were placed on the waiting list following their only pre-surgical consultation. The remaining patients had more than one visit and were likely to be placed on the waiting list some time after their first visit and prior to their last visit (27.7%), or after the first consultation (14.3%). In most hospitals providing cataract surgery (n=21), most patients were placed on the waiting list following their final visit prior to surgery (i.e. one or more pre-surgical visits). In 10 hospitals, more than 30% of patients were placed on the waiting list during the course of care (i.e. after the nth visit) (see Appendix B: Table B-11).

DATEOFF

The results of the validity assessment of DATEOFF based on the SWL and hospital separation linkage are presented by procedure group in Table 4.17. In almost all cases, DATEOFF was the same as to the procedure date for all four procedures. The proportion of patients taken off the waiting list upon receipt of treatment ranged from 89.6% (HR) to 98.7% (CAT). This result is consistently found across most hospitals (see Appendix B: Table B12-B15).

Table 4.17: Validity assessment of date off waiting list (SWL and Hospital Data Linkage)

When taken off Waiting list	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
Same as procedure date	2392 (90.0%)	3151 (89.6%)	2611 (92.5%)	30,580 (98.7%)
Between adm & sep/ Between adm & 1wk after adm*	256 (9.6%)	326 (9.3%)	168 (5.9%)	339 (1.1%)
Between 1wk before adm & 1wk after sep/ Between 1wk before adm & 1 wk after adm*	4 (0.2%)	7 (0.2%)	29 (1.0%)	61 (0.2%)
Adm & sep between date on & date off/ Adm between date on & date off *	7 (0.3%)	32 (0.9%)	16 (0.6%)	162 (0.6%)
Total Matches	2659 (100%)	3516 (100%)	2824 (100%)	31,142 (100%)

Note: * Cardiac Surgery and Cataract/Lens Surgery

For all four procedure groups, the next most likely time patients were taken off the SWL was some time between admission and separation for knee replacement (9.6%) and hip replacement (9.3%) and between admission and 1 week following admission for cardiac surgery (5.9%) and cataract/lens surgery (1.1%).

The validity of DATEOFF was also assessed using the MSP surgical claims. For the majority of patients in all procedure groups, DATEOFF was the same as the date of surgery as shown on the payment claim for the surgical procedure. The proportion of matched cases varied by procedure: knee replacement (92.2%), hip replacement (91.6%), CABG (96.5%) and cataract (97.7%).

Calculating Waiting Time

There is currently no single universally accepted method used to calculate waiting times. The validity assessment of the SWL's DATEON clearly demonstrates that patients are placed on the waiting list at various times during the course of care. It is unclear at this point, however, if and/or to what extent the definition of date-on the waiting list affects the length of patient waiting time. This can be assessed to some extent using the information derived from the patient trajectories to calculate waiting time using various methods. In the following section, patient trajectories are used to compare waiting time estimates calculated three ways: (1) SWL method (DATEON-DATEOFF); (2) first consultation method (FC) (Date of first pre-surgical consultation-DATEOFF); and (3) last consultation method (LC) (Date of last pre-surgical consultation – DATEOFF).

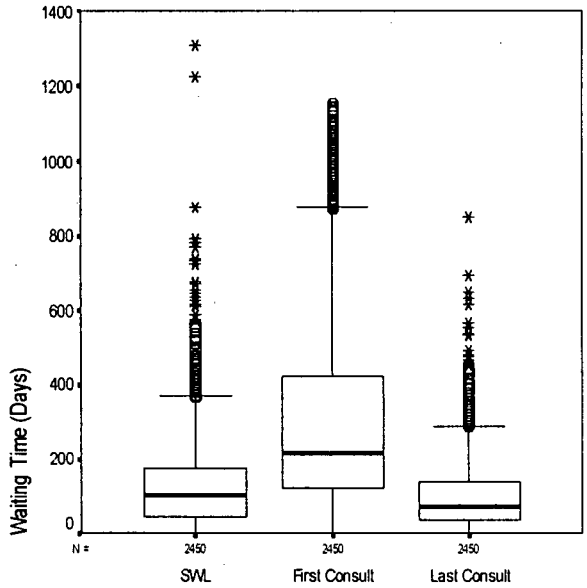
Table 4.18: Waiting times (days) calculated using SWL, First Consultation (FC) and Last Consultation (LC) prior to surgery

Statistics	Knee Replacement (n=2,451)			Hip Replacement (n=3,320)			CABG (n=2,609)			Cataract (n=24,272)		
	SWL	FC	LC	SWL	FC	LC	SWL	FC	LC	SWL	FC	LC
Mean	124.5	302.9	96.1	98.9	287.4	87.7	30.1	121.9	45.8	80.0	368.3	73.0
Median	103.0	216.0	72.0	75.0	194.5	64.0	7.0	57.0	14.0	56.0	290.0	48.0
Range	1306	1151	848	1112	1162	922	893	1088	952	3716	2083	1112

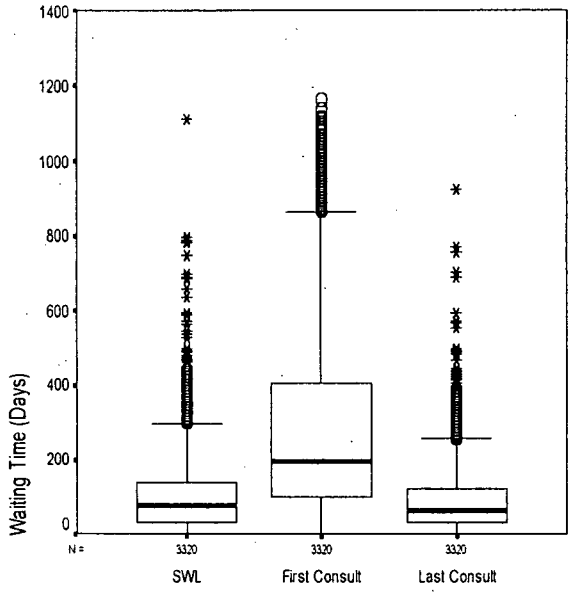
Descriptive statistics for the three waiting time estimates are presented in Table 4.18. Box plots were used to illustrate the distribution of the waiting time estimates (Fig 4.7). The box represents the interquartile range (i.e. cases between the 25th and 75 percentile); the median is represented by the single bold line contained within the box. The lines represent the range above and below the box to the highest and lowest value not including outliers. Outliers are defined as any case with a value between 1.5 and 3 times the box length from the upper or lower edge of the

Figure 4.7: Distribution of waiting times (DAYS) based on the SWL, First Consult (FC) and Last Consult (LC) methods, by procedure

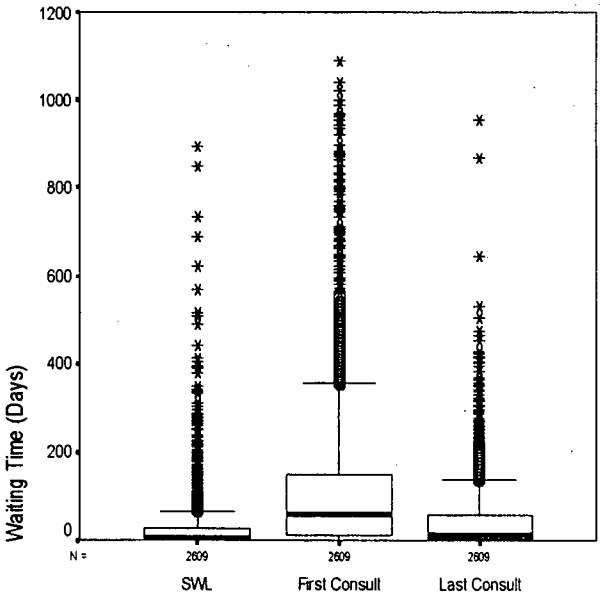
a) Knee Replacement



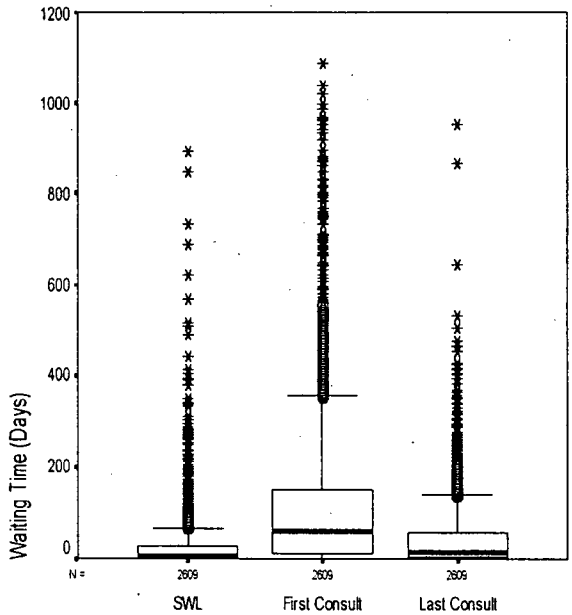
b) Hip Replacement



c) CABG



d) Cataract



box; they are represented by circles (o). Extreme values are defined as cases with values more than 3 box lengths from the upper or lower edge of the box; they are represented by stars (*).

There appears to be a consistent pattern across each procedure group. The distribution of waiting times is skewed regardless of the method used to calculate waiting times; the skewness is due primarily to a significant number of outliers. For all methods, the median is substantially smaller than the mean estimate of waiting time; in some cases, the median is less than half of the mean. The distributions of waiting times are right skewed with range values varying from 848 days to a high of 3,716 days.

Within each procedure group, there is a similar pattern regarding the three estimates of patient waiting time. The distributions of waiting time produced using the SWL most closely resembles the distributions produced using the LC method. Furthermore, the estimates of waiting time derived using the first surgical consultation (FC) produced higher estimates of median waiting times compared with the SWL estimates (SWL).

The difference was less marked for CABG in which FC median estimate was 50 days greater than the SWL. The greatest arithmetic difference was observed in the cataract group in which the FC median estimate exceeds the SWL median estimate by over 230 days. In addition to producing higher estimates of median waiting time, the FC method also produces a more dispersed distribution of patient waiting times. This is immediately apparent in Figure 4.7(a-d).

The LC method produced the lowest estimates of median waiting times except for CABG. These estimates are closer to those produced by the SWL than the FC method and both methods exhibit

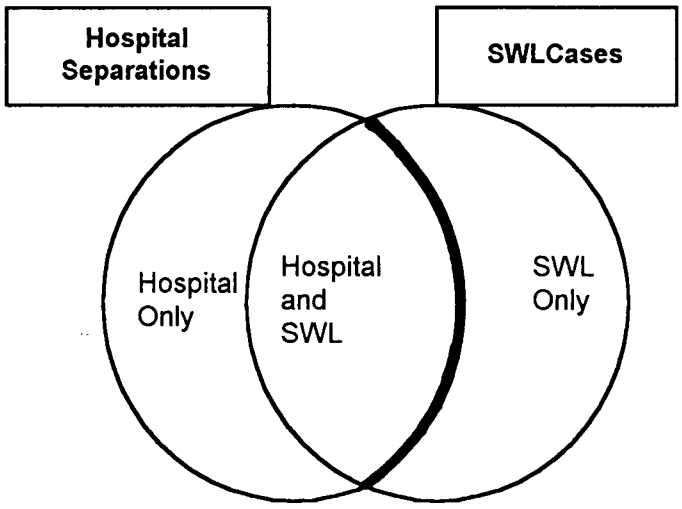
similar distribution patterns. For three of the four procedure groups, the median estimates of waiting time based on the LC were between 7 days and 31 days less than the SWL estimates. This result is expected since over half of all cases within each procedure group were placed on the waiting list following their last pre-surgical consultation. However, the LC median estimate for CABG waiting time is 7 days more than the SWL method. Results of the validity assessment of DATEON indicate that over 75% of CABG cases (n=2,033) were placed on the waiting list following their last pre-surgical consultation. Among these patients, over 90% (n=1,849) were placed on the waiting list some time after the last consultation (i.e. not on the day of the final consultation). Half of these patients were placed on the waiting list between 1 day and 9 days following their last consultation. Their waiting times, therefore, are somewhat shorter than if they were calculated using the LC method.

The results of the analysis clearly indicate that waiting time estimates vary depending on the criterion used to establish date-on the waiting list. Estimates of waiting time tend to be higher with greater dispersion when the first specialist consultation prior to surgery (FC) is used as an estimate of when patients are placed on a waiting list. Conversely, estimates of waiting time based on the last specialist consultation prior to surgery (LC) as the date-on a waiting list tend to be lower. The latter more closely approximates the waiting time of patients as provided in the SWL data. This result provides evidence of a degree of consistency and reliability in the measurement of waiting times in the SWL data in general and across three of the four procedure groups.

4.3.3.4 Validity/Reliability Assessment: Waiting List Size

The validity of waiting list size was assessed by comparing the number of patients taken off the SWL due to surgery to the number of procedures performed for all hospitals contributing to the SWL. This assessment was conducted for data available between January 1994 and March 1996. The SWL cases and hospital separations were categorized into one of the following groups: (1) case found in both the SWL and hospital data; (2) case found only in the hospital data; and (3) case found only in the SWL (see Fig 4.8).

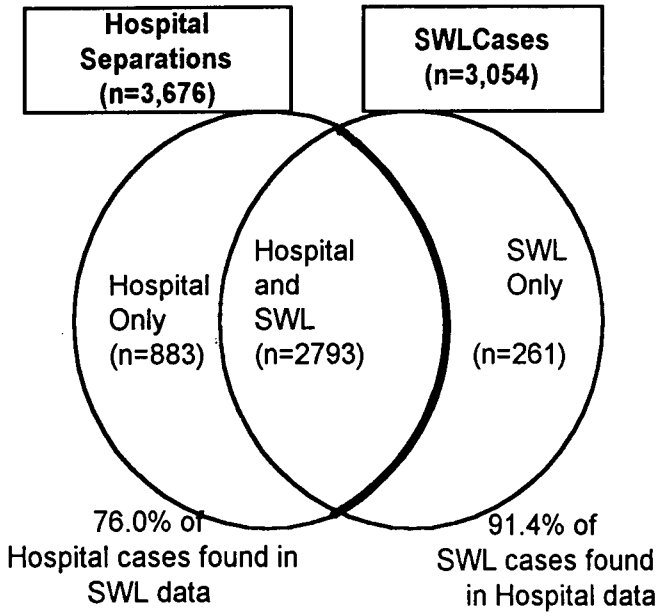
Figure 4.8: Schematic representation of the validity assessment of waiting list size



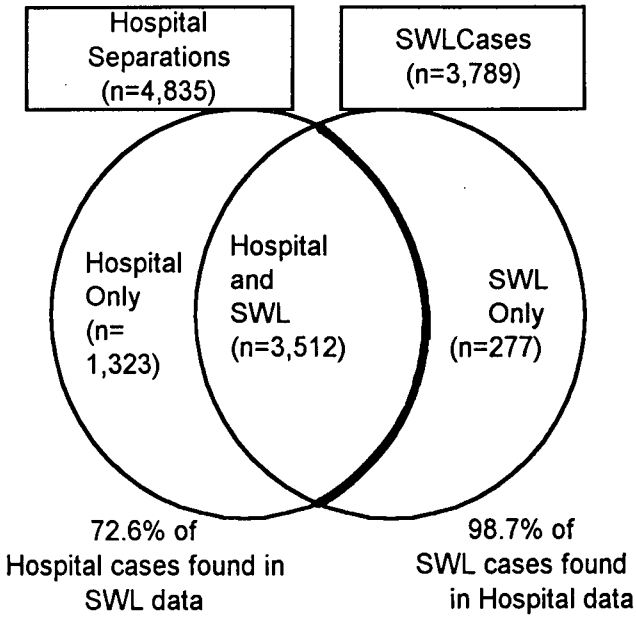
The results of assessment are presented in Figure 4.9. Overall, the total number of SWL cases completed between January 1994 and March 1996 represented 83.1% of KR cases, 78.4% of HR cases, 72.2% of CABG cases and 76.9% of CAT cases performed during the same time period at all hospitals represented in the SWL database.

Figure 4.9: Results of the validity assessment of waiting list size

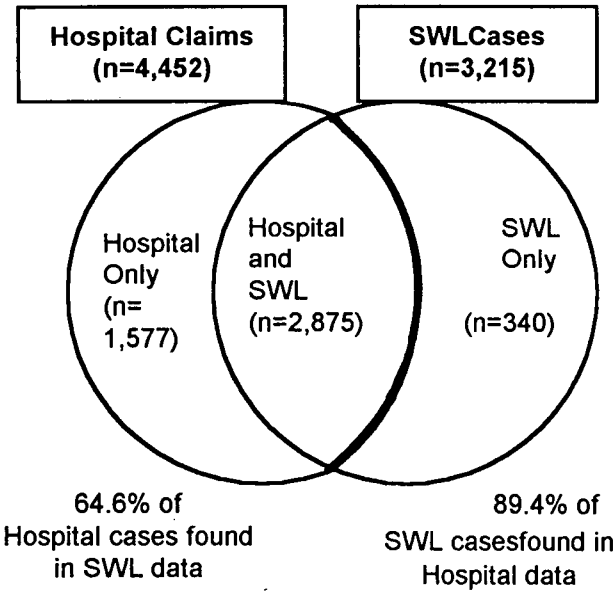
a) Knee Replacement



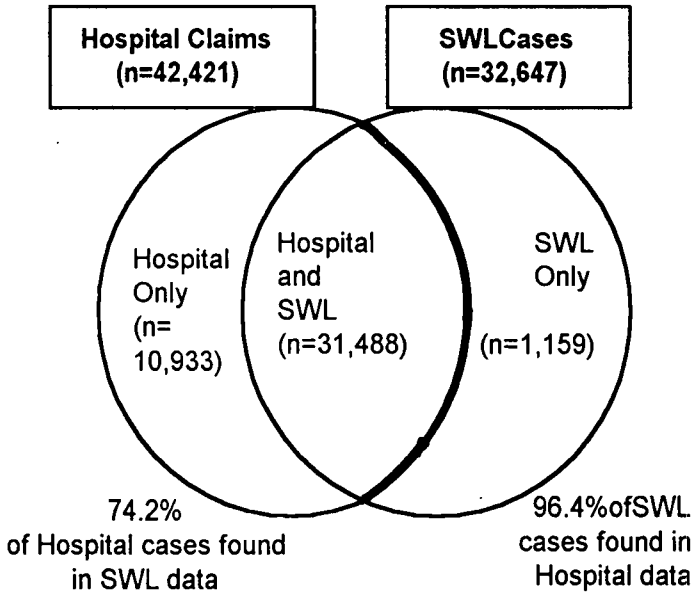
b) Hip Replacement



c) CABG



d) Cataract



Within each procedure group, approximately 90+% of the SWL cases were identified in the hospital claims data. Conversely, the proportion of hospital claims identified in the SWL data ranged from a low of 64.6% (CABG) to a high of 76.0% (KR). Therefore, between 25% and 35% of hospital cases could not be located in the SWL data.

Some of these cases may be represented among those cases recorded as "SWL only" which could not be linked due to lack of personal identifier information. Up to 40% of cases found only in the SWL did not have a patient PHN, rendering it difficult to match to the hospital data.

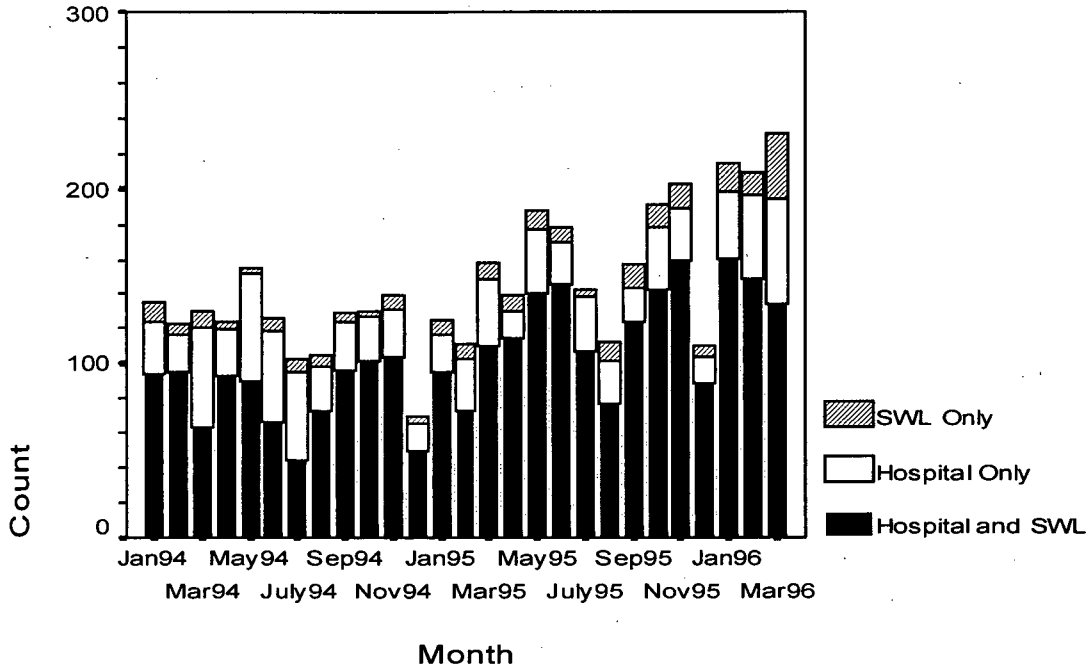
Discrepancies between the number of patients taken off the waiting list and the number of procedures performed can be the result of several factors. First, cases identified in the "Hospital Only" group may have been performed on an urgent or emergent basis and thus were never placed on the SWL. This is certainly the case for CABGs in which 81.7% (n=1289) of cases found only in the hospital data were performed on an urgent or emergent basis. The proportion of urgent/emergent cases among the "Hospital Only" cases was 11.5% (n=101) for knee replacement 32.0% (n=424) for hip replacement and only 2.7% (n=285) for cataracts.

Second, waiting list data are submitted by hospitals to the Ministry of Health on a monthly basis. Differences, therefore, could be the result of likely difficulties in transferring the data or missed months. Results of the assessment are presented by month in Figure 4.10(a-d).

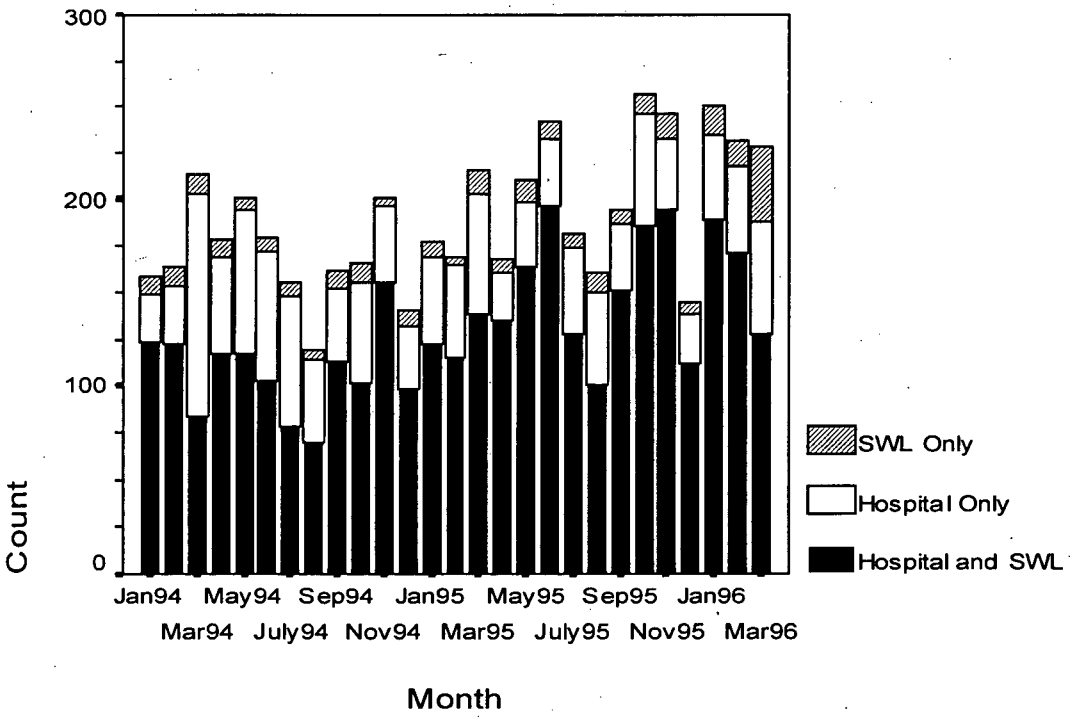
The proportion of hospital cases placed on the SWL prior to surgery varied from month to month. For knee replacements, the proportion of hospital claims found in the SWL data ranged from a low of 52.5% in March 1994 to a high of 87.7% in April 1995.

Figure 4.10: Results of validity assessment of waiting list size by month

a) Knee Replacement



b) Hip Replacement



On average, there were 33 cases per month identified in the hospital data but not in the SWL. The proportion of SWL cases identified in the hospital data ranged from 74.8% in March 1996 to 97.1% in October 1994; on average, 10 cases per month were identified in the SWL but not the hospital data. The largest number of cases (n=37) in the "SWL Only" category occurred in the final month of the study (March 1996). It is possible that some patients underwent surgery in the latter part of the month and were removed from the SWL but remained in hospital as of March 31, 1996. Since this date marks the end of the fiscal year for hospitals, the separation claims would appear in the 1996/97 hospital data.

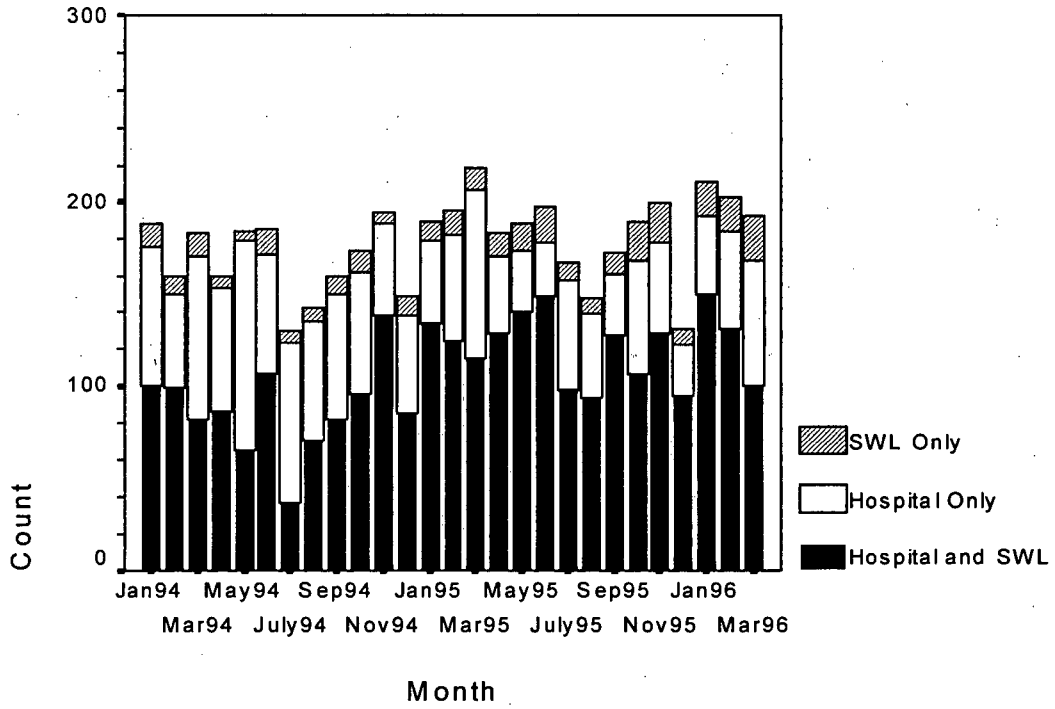
Among hip replacements, the proportion of hospital cases identified on the SWL ranged from 40.9% in March 1994 to 84.9% in June 1995. On average, there were 49 cases per month identified in the hospital data but not in the SWL data and 10 cases identified in the SWL data but not the hospital data. Like the knee replacements, the largest proportion of cases (23.8%) identified as "SWL Only" occurred in March 1996 (n=60).

For CABG cases, between 29.8% (July 1994) and 84.2% (June 1995) of hospital claims were identified in the SWL data. On average, 58 cases per month were identified as "Hospital Only" and 13 cases per month were identified as "SWL Only". The proportion of SWL cases identified in the hospital data varied substantially from 29.8% July 1994 to 84.2% in June 1995.

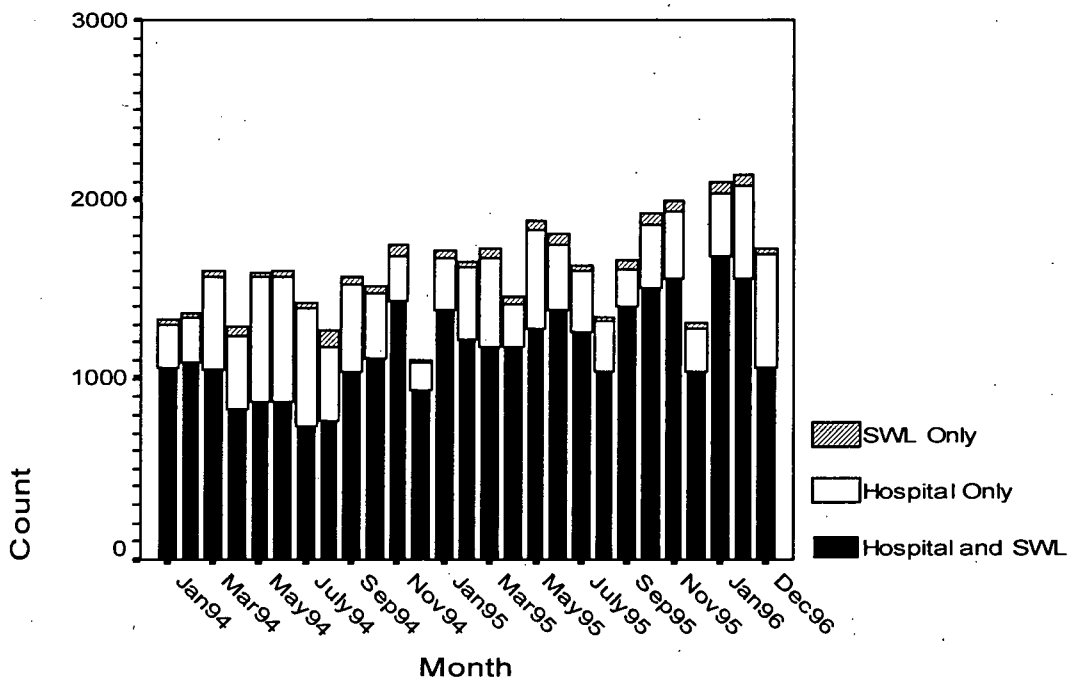
Among cataract cases, the proportion of hospital claims identified in the SWL data ranged from a low of 53.3% in July 1994 to a high of 87.2% in September 1995. An average of 398 cases per month and 43 cases per month were identified as "Hospital Only" and "SWL Only" cases respectively.

Figure 4.10(c-d): Results of validity assessment of waiting list size by month

c) CABG



d) Cataract



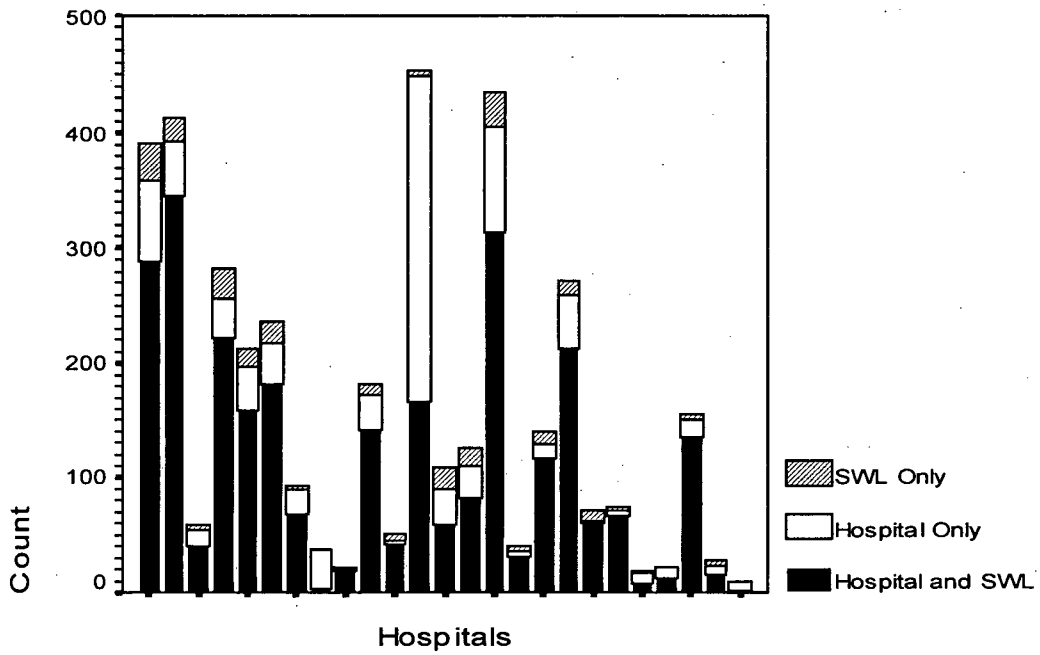
Discrepancies between the waiting list and hospital data could also occur due to unreliable data from selected hospitals which may either grossly over- or under-represent the total number of procedures actually performed. The differences may be due to large discrepancies from one or two hospitals or due to less severe discrepancies across the majority of hospitals contributing to the SWL. The results of the validity assessment are presented for each procedure by hospital in Figure 4.11(a-d).

The results for knee replacement are presented in Fig 4.11a. In 18 hospitals, more than 70% of hospital cases were matched to SWL cases. The proportion of hospital cases identified in the SWL data varied greatly from a low of 8.1% to a high of 96.8%; 31.9% (n=282) of unmatched hospitals cases were identified within a single hospital. Similar results were observed for hip replacement (Figure 4.11b). The proportion of hospital cases identified in the SWL data ranged from a low 8.1% to a high of 100% of cases; 20 hospitals demonstrated match rates of greater than 70% of hospital claims. Approximately 30% (n=323) of "Hospital Only" claims were attributed to a single hospital.

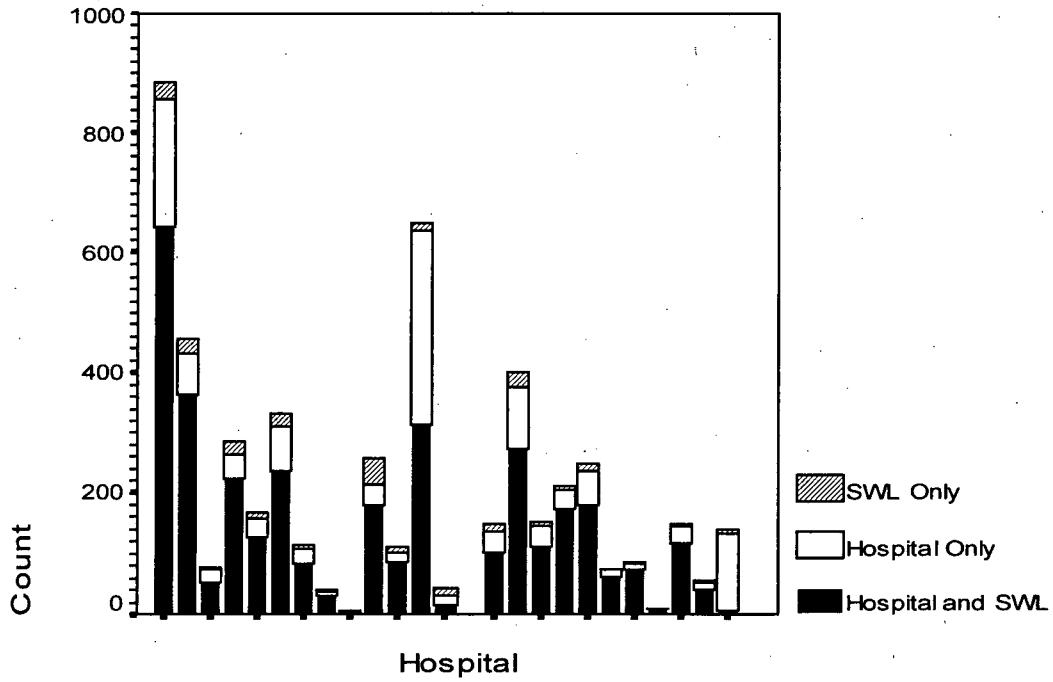
The results for CABG are presented by hospital in Figure 4.11c. Between 43.1% and 75.3% of hospital cases were placed on the waiting list prior to surgery. Over 50% (n=523) of the hospital claims not identified in the SWL were attributable to a single hospital. There were five hospitals reporting CABG cases in the SWL but for which no CABGs were actually performed in those hospitals; three of these hospitals, however, had only 1 or 2 cases listed in the SWL. In the 21 of the hospitals performing cataract surgeries, more than 70% of the hospital claims were identified in the SWL data; the results ranged from 7.5% to 99% across hospitals. Over 40% of unmatched hospital claims (n=4533) were identified in two hospitals.

Figures 4.11(a-b): Results of the validity assessment of waiting list size by hospital

a) Knee Replacement

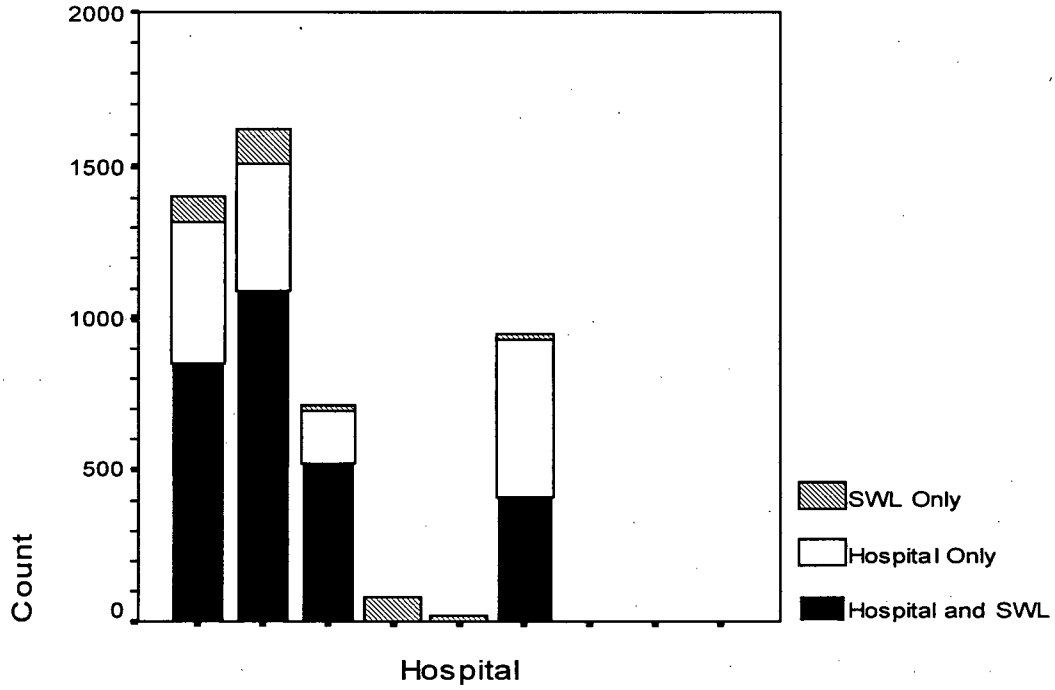


b)Hip Replacement

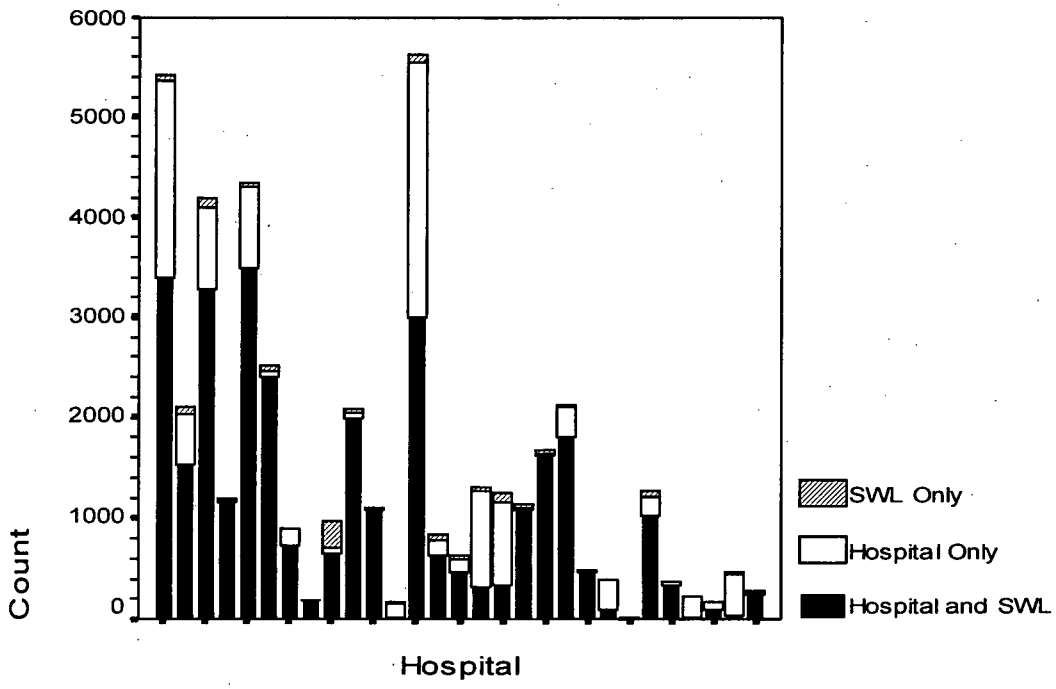


Figures 4.11(c-d): Results of the validity assessment of waiting list size by hospital

c) CABG



d) Cataract



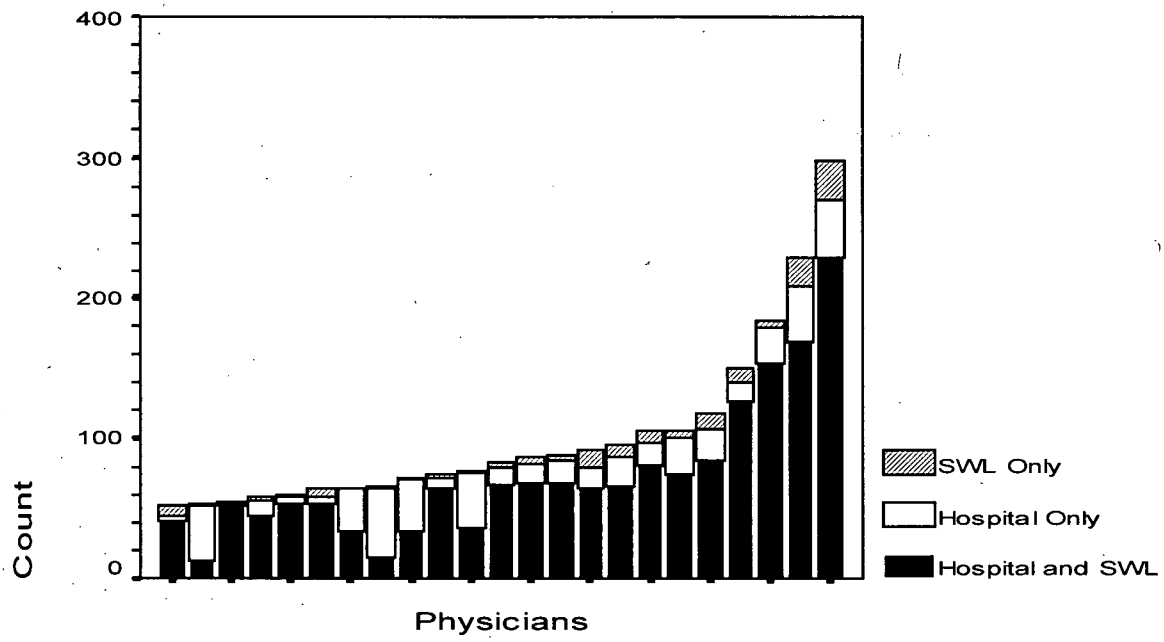
Finally, discrepancies between the hospital and SWL data could occur at the level of the individual physician. Physicians may differ in their ability or willingness to place patients on the hospital waiting list. This explanation may be explored by analyzing the results of the validity assessment of waiting list size across physicians (Figs 4.12(a-d)). Physicians with 50 or more cases were selected for knee replacement, hip replacement and CABG and those with 500 or more cases were selected for cataract.

The results for knee replacement indicate variation in the estimates of waiting list size across physicians with more than 50 cases or more. The proportion of hospital cases identified in the SWL data ranged from 23.0% to 98.1%. The remaining "Hospital Only" cases were fairly evenly distributed across physicians. Approximately 32% (n=48) of cases found only in the SWL data were attributed to the two physicians with the highest number of total cases; in both cases, the "SWL only" cases represented less than 10% of the physicians total volume of surgery.

Similar variability was observed among physicians performing hip replacement. The proportion of hospital cases found in the SWL data ranged from 37.5% to 93.0% across physicians; the single largest group of unmatched hospital claims (12.5%; n=119) was associated with a single physician.

Figure 4.12(a-b): Results of the validity assessment of waiting list size by physician

a) Knee Replacement (≥ 50 cases)



b) Hip Replacement (≥ 50 cases)

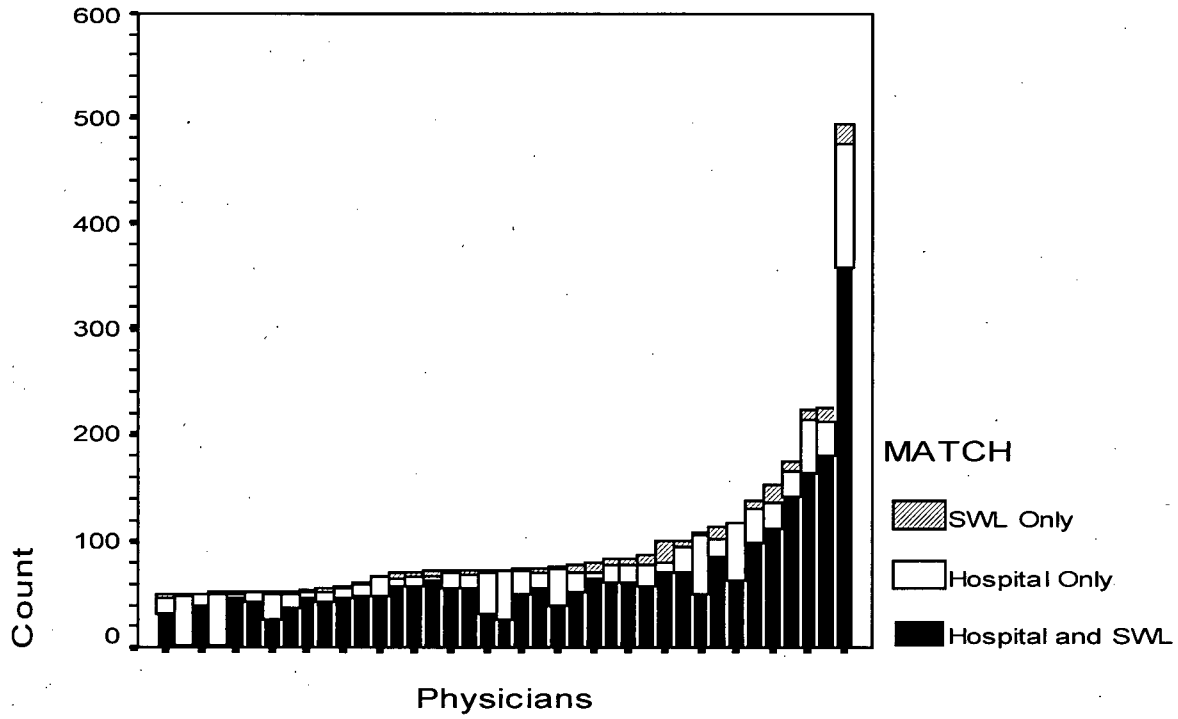
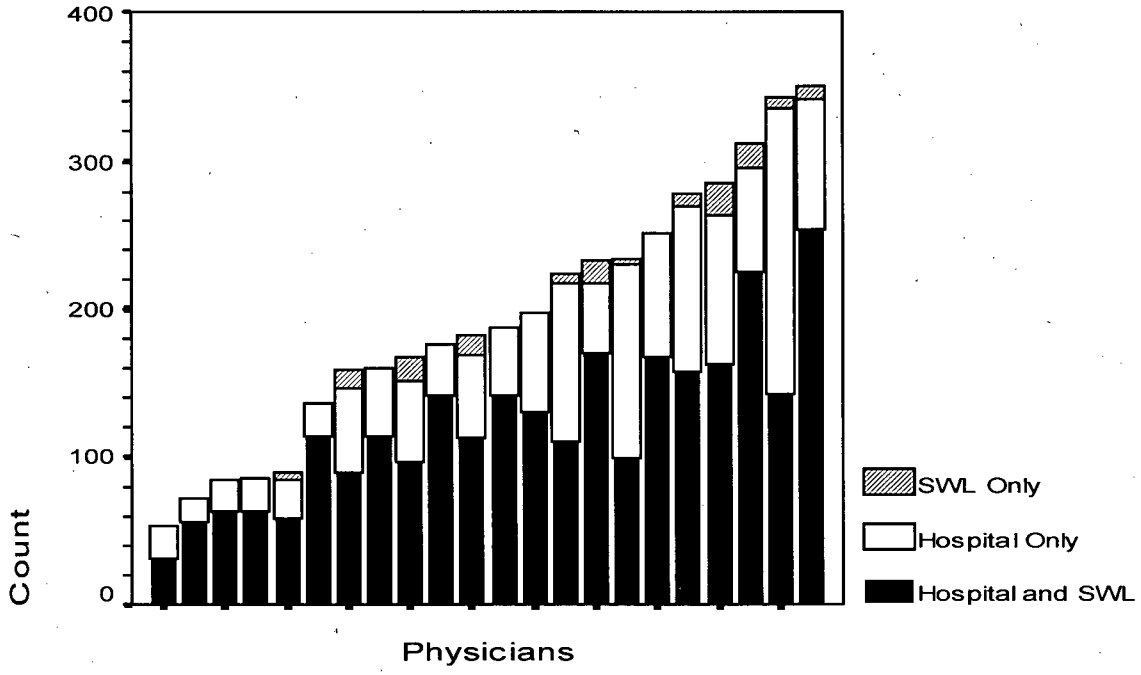
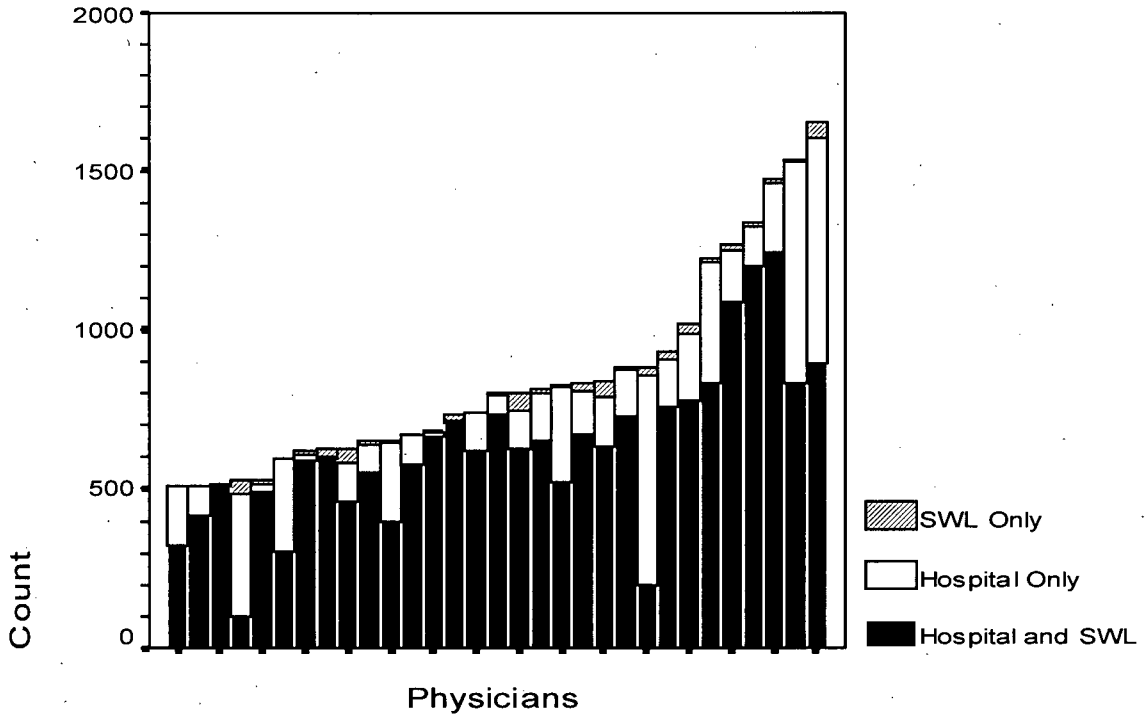


Figure 4.12(c-d): Results of the validity assessment of waiting list size by physician

c) CABG (≥ 50 cases)



d) Cataract (≥500 cases)



The results for CABG reveal slightly less variability across physicians with 50 or more cases. The proportion of matched hospital cases ranging from 42.6% to 83.2%. Like hip replacements, the largest single group of unmatched cases (13.5%; n=193) were attributed to a single physician. The validity of waiting list size also varied across physicians who performed 500 or more cataracts. Between 20.5% and 100% of hospital claims were identified in the SWL data. Eight of the 31 physicians had 200 or more hospital cases that could not be located in the SWL data; 2 physicians had close to 700 cases unaccounted for in the SWL data. The majority of physicians (n=29) had 90+% of SWL cases identified in the hospital data.

Results of the assessment clearly indicate that the validity of waiting list size is acceptable at best and the results are not reliable across hospitals and physicians. Overall, the total number of SWL cases represented only between 72.2% (CABG) and 83.1% (KR) of the total number of procedures performed. Therefore, even if all SWL cases were identified in the hospital data, there would still be between 17% and 28% of hospital cases unaccounted for in the SWL data. As already demonstrated, some of these cases were performed on an urgent or emergent basis and therefore, may not have been placed on the SWL registry. Since it cannot be determined retrospectively at what point the patient's condition became urgent or emergent, they cannot be removed from the analysis. In the case of hip replacements, for example, the patient may have been scheduled for surgery and at some time during their wait their condition deteriorated from elective status to urgent or emergent status; they would be, therefore, expected to have appeared on the waiting list.

The results of the assessment vary month to month, across hospitals and across physicians. While there is some degree of variation across month for all procedures, there does not appear to be any specific pattern. In three of the four procedure groups, there was a higher incidence of SWL cases not found in the hospital data in the final month of study (March 1996) for reasons already explained. The validity of waiting list size also varied across hospitals for all procedure groups; selected hospitals within each procedure group accounted for large numbers of the hospital cases not identified in the SWL data. Finally, the results also varied considerably across high volume physicians.

4.4 CONCLUSIONS

Overall, the SWL data appear to be valid and reliable, accurately representing those patients placed on the waiting list. The results of the frequency analysis indicate low levels of missing data, thus reducing threats to the internal validity of the data. Linkage rates achieved with the hospital and MSP data were very good to excellent for all procedure groups. Hospital, procedure, and physician data appear to be valid and reliable across hospitals; hospital identification number was not valid for a single hospital since two hospitals were merged in the SWL data. Patient type and status information was valid for knee replacement and hip replacement cases but problematic for cardiac and cataract cases respectively. In the case of the latter, coding problems were identified in the hospital data. Patient birth date and gender are also valid and reliable across hospitals; low levels of agreement between the SWL and MSP data regarding patient birthdate reflect internal validity problems with the MSP data.

The validity assessment of DATEON the waiting list clearly indicates that the majority of patients with 1 or more pre-surgical consultations were placed on the waiting list following the last consultation prior to surgery. This result is consistent across procedure groups and hospitals. The assessment of DATEOFF the waiting list confirms that most patients were removed upon receipt of care. In most cases, patients were removed from the list on the day of surgery.

Despite these results, the SWL data appear to underestimate the total number of procedures actually performed. Results of the validity assessment of waiting list size indicate that between 17% and 28% of cases identified in the hospital data did not appear in the SWL data. In the case of CABG, many of these cases were performed on an urgent or emergent basis and therefore, there may not have been any wait prior to surgery. The results were not consistent across hospitals or physicians.

The results of the analysis do indicate, however, that the SWL data are accurate for those patients identified on the list. Therefore, in the following chapter, the SWL data are used to assess the variation in waiting times across physicians and hospitals and to identify significant factors associated with waiting times. The results of the validity assessment of waiting list size, however, will have some implications for future analyses based on the SWL data. The fact that the SWL data may under-represent the total number of surgical cases performed, may limit the generalizability of any results to those actually represented in the SWL data. This is particularly true if the experiences of those not found on the SWL are systematically different from those patients who were placed on the list.

CHAPTER V

FACTORS AFFECTING WAITING TIME

While there is mounting evidence to support the existence of variation in patient waiting time at various levels, there is considerably less known about the factors that may explain this variation. In this chapter, a broad range of patient, physician and hospital factors are investigated to determine their effect on waiting time for knee replacement, hip replacement and cataract surgery. The analysis will not include CABG since the evidence to date, as outlined in Chapter 2, clearly indicates that most of the variation in patient waiting time is explained by specific clinical factors. However, this information was not available in the SWL data and, therefore, their effects could not be estimated empirically.

The analysis for the three remaining procedures begins with a brief look at the level of variation in waiting time at the physician and hospital levels. This is followed by a detailed account of the methods and results of the regression analyses.

5.1 DATA

Data samples were selected from the SWL for three procedure groups: knee replacement, hip replacement and cataract surgery. Case inclusion criteria were as follows:

- placement on the SWL between January 1, 1994 and June 30, 1995;
- DATEOFF between January 1, 1994 and March 31, 1996
- not taken off the SWL due to cancellation or death

The first criterion ensures the sample is not biased toward excessively long or short waiting times. Cases placed on the waiting list prior to January 1994 were more likely to have long waiting time since there were no patients taken off the waiting list prior to this time. Less than 10% of patients placed on the waiting list between January 1994 and June 1995 remained on the waiting list by the end of the study period. However, greater than 10% of cases placed on the waiting list after June 1995 had not yet completed their waiting period as of the end of this data set. Hence, to ensure that the sample was not biased toward shorter waits, only those patients placed on the list on or prior to June 30, 1995 were selected.

Cases must have been taken off the waiting list on or before March 31, 1996 to coincide with relevant hospital and MSP data used in the analysis. Hospital separation and MSP physician data were also used for fiscal years 1993/94-1995/96 to create relevant hospital and physician variables. Final sample sizes are presented in Table 5.1.

Table 5.1: Sample SWL data for regression analysis (% of original sample)

Selection Criterion	Knee Replacement (n=4,518)	Hip Replacement (n=5,208)	Cataract Surgery (n=43,146)
Dateon (Jan94-June95)	2,260	2,873	24,359
Dateoff (≤ Mar 31/96)	2,196	2,795	23,816
Not cancelled or died	1,841	2,491	21,655
Final Sample Size	**1,841 (41%)**	**2,491 (48%)**	**21,655 (50%)**

5.2 VARIATION IN WAITING TIME

Variation in patient waiting time is well documented in the literature (see Chapter 2). There are numerous examples of intra-procedure variation occurring at different levels including across physicians, hospitals and regions. The presence of variation at these levels of aggregation is an

indication of the possible effects of non-patient related factors on waiting time. It is important, however, to first identify the level at which waiting time may vary. Having established the validity of the SWL, the data are used to determine the degree of intra-procedure variation at the physician and hospital levels.

The variation in waiting times is illustrated using Box-plots (see Fig 5.1-5.4). (The Box-plot method is explained in Chapter 4). The inter-quartile ranges, represented by the box, provide information regarding the degree of dispersion within each unit of analysis as well as a means to compare the level of variation across physicians, and hospitals. Medians are used to compare waiting time values within each level of aggregation, providing a more accurate summary of patient waiting time since they are less affected by outlying cases.

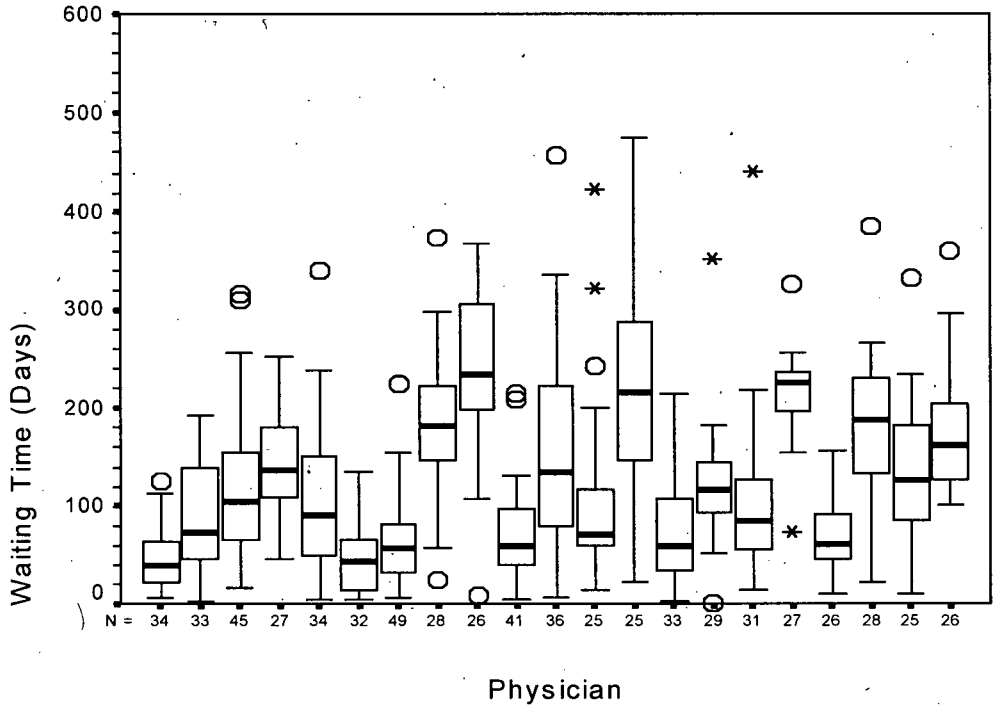
5.2.1 Physician Level

Physicians with at least 25 cases on the SWL during the study period were selected and grouped into one of the following categories: (1) 25-49 cases or (2) ≥ 50 cases. Due to larger volumes of cataract surgery performed by each physician, the following categories were used for ophthalmologists: (1) 100-249 cases, or (2) ≥ 250 cases. The results are presented by procedure group.

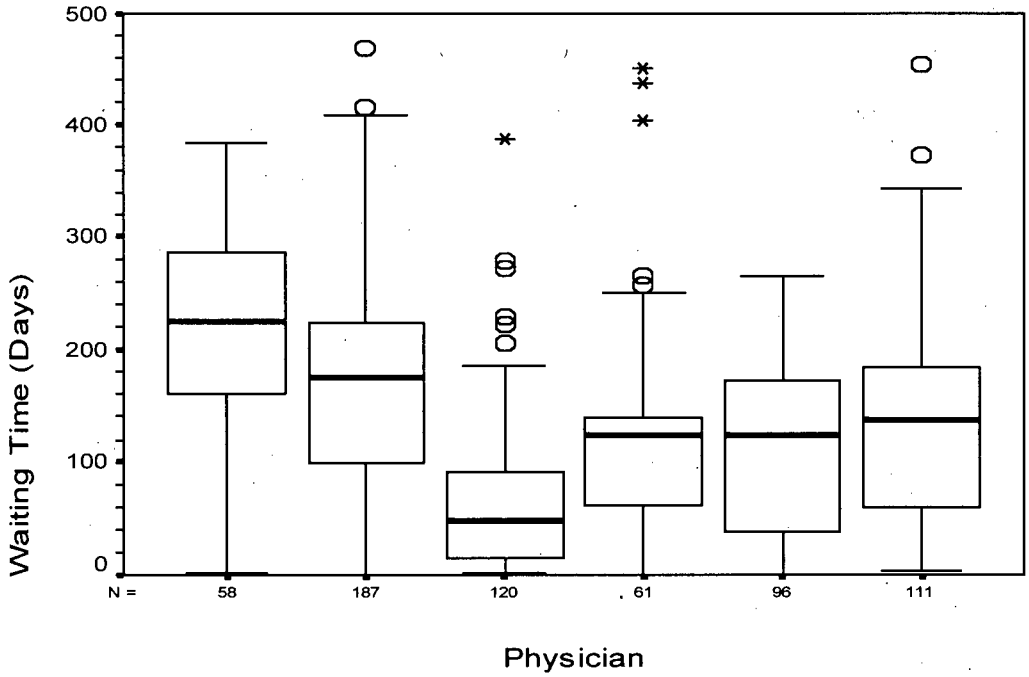
The majority of physicians performing knee replacement surgery (n=21) had between 25 and 49 cases and the remaining physicians (n=6) reported more than 50 cases; the maximum number of cases reported by a single physician was 187. Among the first group (25-49 cases), the median waiting time ranged from 39 to 234 days compared to 47 days to 224 days among those with 50 or more cases (see Fig 5.1 a,b).

Figure 5.1: Variation in waiting time (days) by physician, Knee Replacement

a) Physicians with 25-49 cases



b) Physicians with ≥ 50 cases



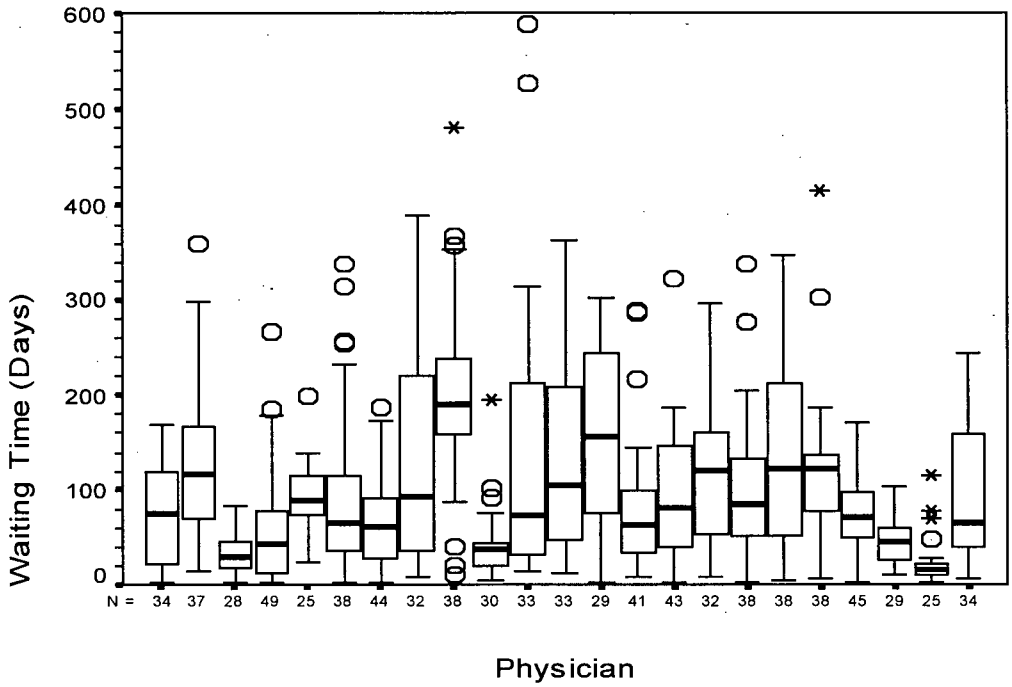
The inter-quartile (IQ) ranges varied considerably across physicians. Among those with 25-49 cases, the lowest reported range was 44.75 days and the highest was 176 days. Among those with more than 50 cases, the IQ range varied only between 75.75 days and 134 days.

For hip replacements, the majority of physicians (n=23) reported between 25 and 49 cases and 10 physicians reported more than 50 cases. The maximum number of cases reported by a single physician was 246. Among the first group (25-49 cases), the median waiting time was reported to be between 15 days and 189 days while the median waiting time for the second group (≥50 cases) varied between 28 days and 203 days (see Fig 5.2 a,b). The distribution of waiting time varied in both groups. The IQ range was reported to be between 12.50 and 199.25 days and between 30 and 165 days for the first and second group respectively.

Among physicians performing cataract surgery, there were 33 physicians with 100 to 249 cases and 32 physicians performing 250 or more cases. The median waiting time ranged from 7 days to 151 days (100-249 cases) and from 12 days to 258 days among those with 250 cases or more (see Fig 5.3a,b). The dispersion of patient waiting times appeared to be greater among physicians with more cases. The IQ range varied between 9 days and 99 days and 12 days and 261 days in the first and second group respectively .

Figure 5.2: Variation in waiting time (days) by physician, Hip Replacement

a) Physicians with 25-49 cases



b) Physicians with ≥ 50 cases

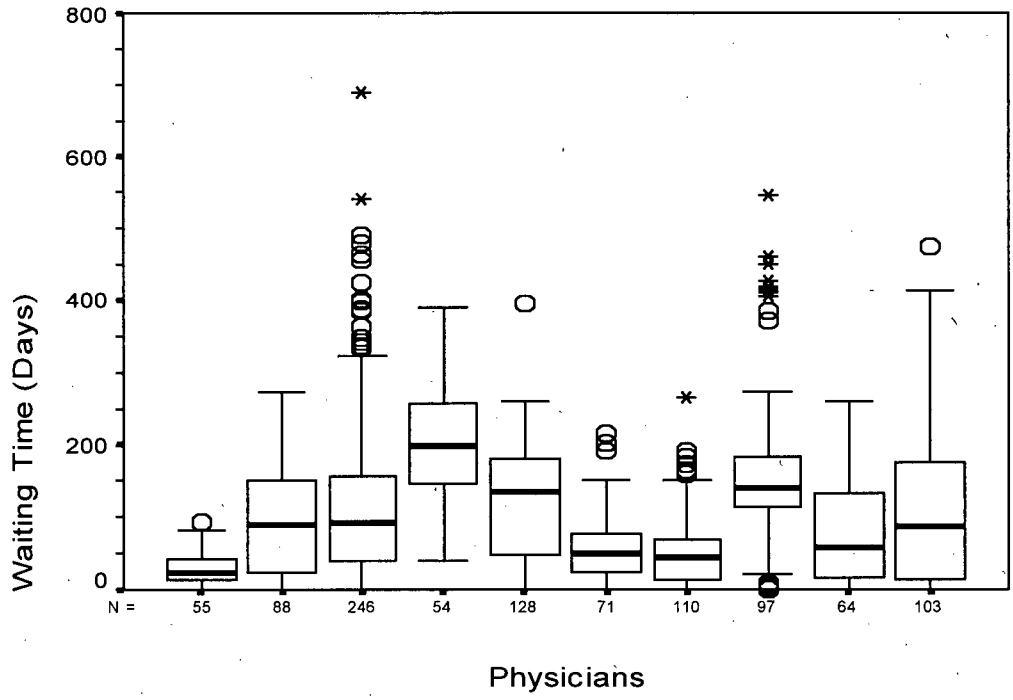
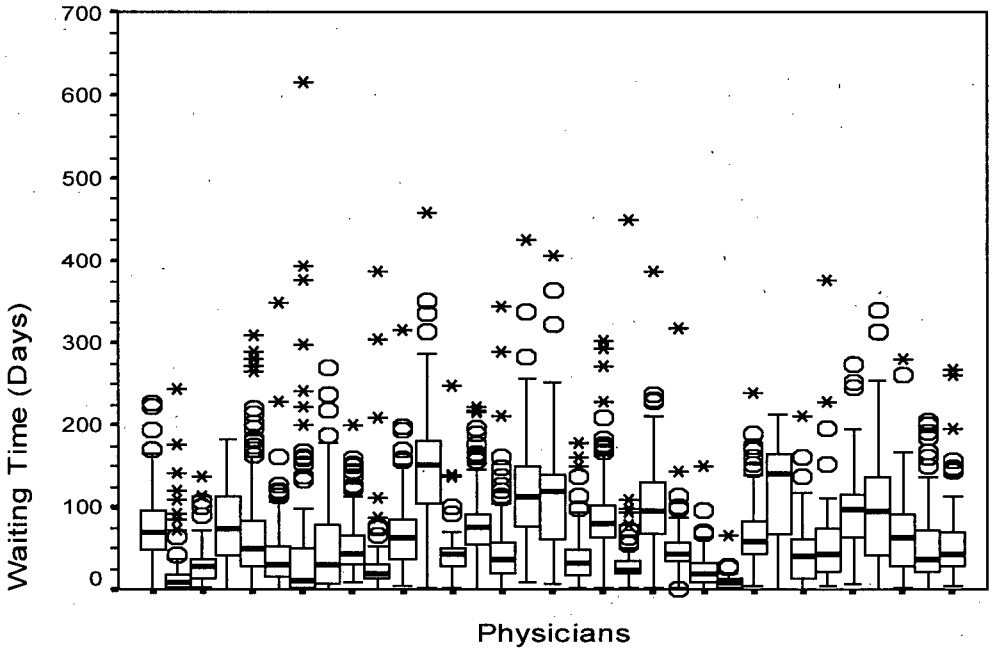
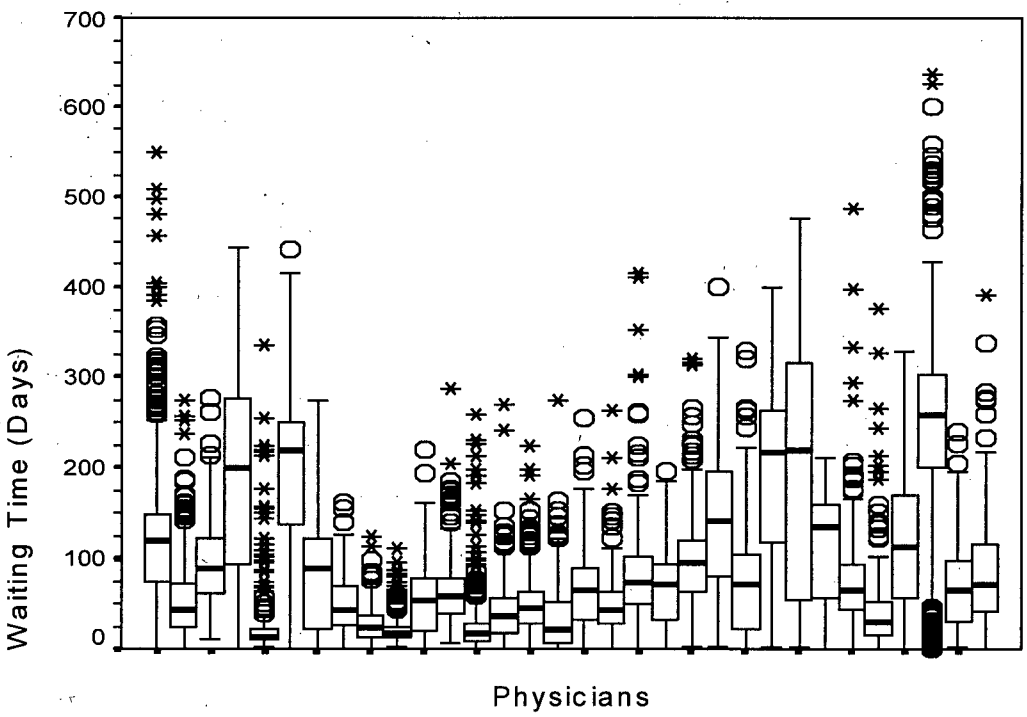


Figure 5.3: Variation in waiting time(days) by physician, Cataract

a) Physicians with 100-249 cases



a) Physicians with ≥250 cases



5.2.2 Hospital Level

Hospitals with 25 or more cases on the SWL during the study period were selected. The results are presented by procedure.

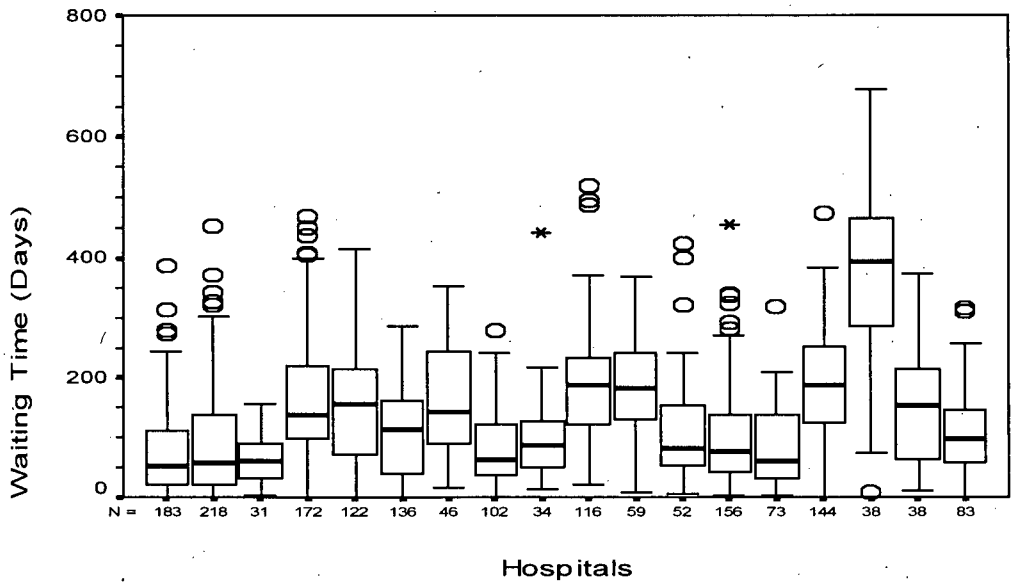
Eighteen of 23 hospitals were selected for knee replacement. The total number of cases ranged from 31 to 218 cases and the median waiting time ranged from 52 days to 394 days (see Fig 5.4a). Nine hospitals had median waiting times less than 100 days. The lowest reported IQ range was 59 days and the highest was 187.50 days. In half of the hospitals (n=12), the IQ range exceeded 100 days.

Similar results were observed for hip replacement. Twenty hospitals were included in the analysis out of a possible 25 hospitals with the total number of cases ranging from 33 to 398. The median patient waiting time varied between 27 days and 244 days (see Fig 5.4b). The majority of hospitals (n=13) reported median waiting times less than 100 days. Approximately half of the hospitals (n=11), reported IQ ranges of less than 100 days; the lowest IQ range was 38 days and the highest was 216 days.

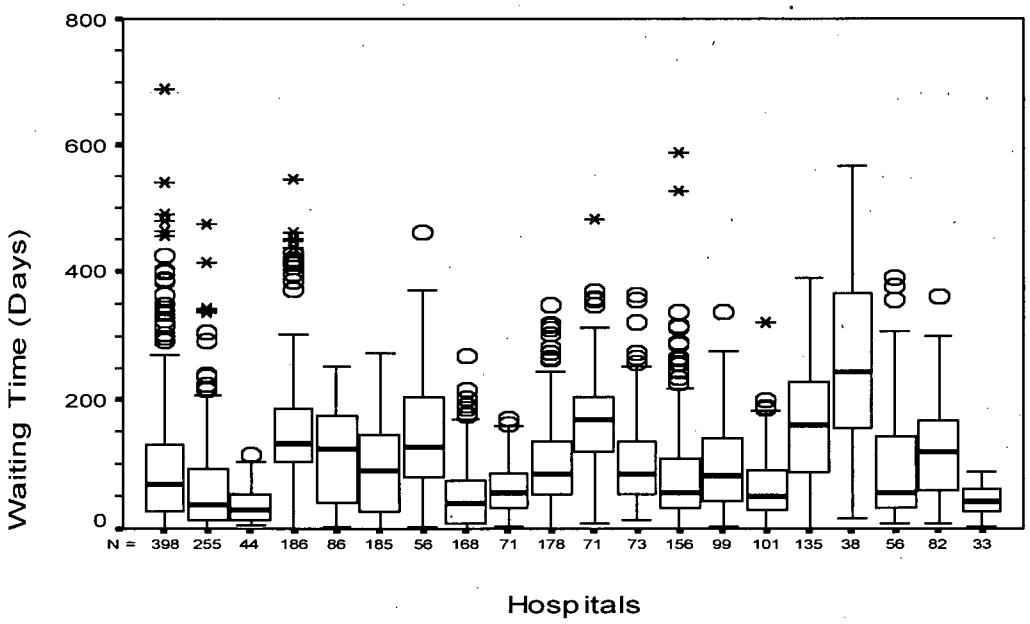
Finally, the analysis of patient waiting time for cataract surgery was conducted based on data from 24 hospitals. The total number of cases varied between 36 cases and 2,542 cases. Median waiting time ranged from 11 days to 244 days (see Fig 5.4c). The IQ range varied from a low of 38 days to a high of 203 days. Only six hospitals reported an IQ range greater than 100 days.

Figure 5.4(a-c): Variation in waiting time (days) by hospital (≥25 cases)

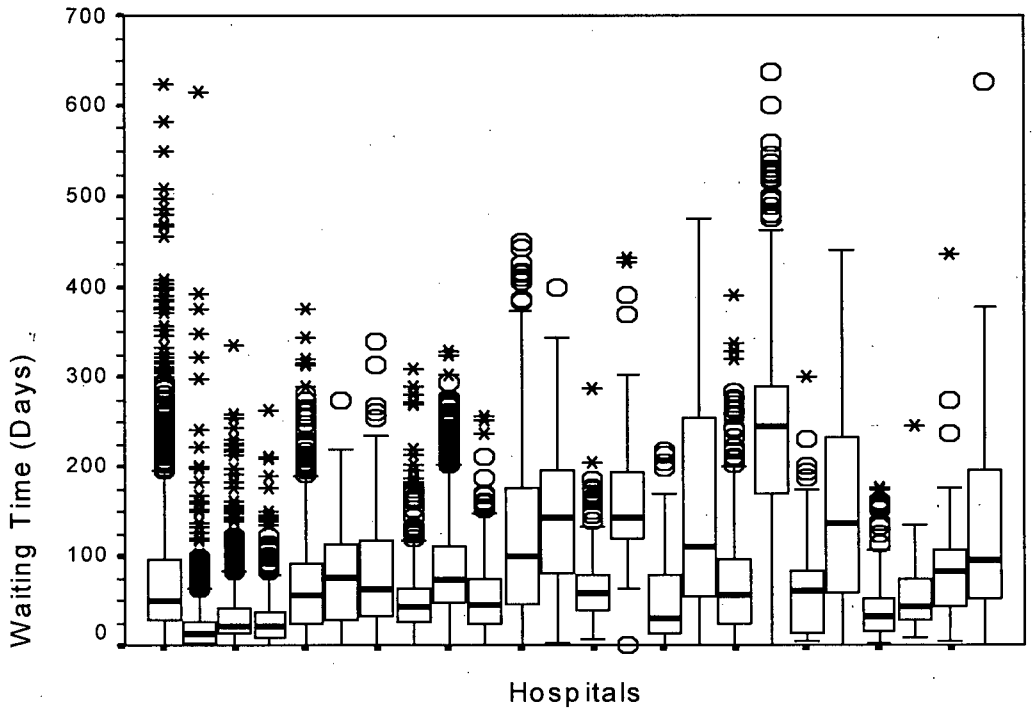
a) Knee Replacement



b) Hip Replacement



c) Cataract



Results of the analyses clearly demonstrate the presence of considerable intra-procedure variation in waiting time at both the physician and hospital level. Differences in median waiting times, as well as differences in the distribution of waiting times, across physicians and hospitals were noted in all three procedure groups.

5.3 METHODOLOGY

The remainder of this chapter focuses on developing and estimating a model to explain these variations in waiting time, specifically, to identify those patient, physician and/or hospital factors that significantly affect waiting times. In the following section, the methodology used to achieve this goal is outlined.

5.3.1 Modeling Considerations

5.3.1.1 Autocorelation

A regression model was deemed most appropriate to identify the factors affecting patient waiting time. However, the unique nature of waiting list data precludes the use of a simple or multiple linear models due to the lack of independence between the individual cases. In theory, the waiting times of patients awaiting surgery from the same physician and/or at the same hospital are not entirely independent. Individuals' waiting time will be affected by the waiting time of patient(s) placed before them.

Independence between observations is a basic assumption underlying the use of linear regression models. These models are based on the assumption that the error terms of consecutive observations are independent. Correlation in the error terms suggests that there is additional explanatory information in the data that has not been identified by the model. If the autocorrelation is not addressed, the resulting parameter estimates (i.e. coefficients) may be correct but their respective confidence intervals and p-values would not be valid. That is, p-values may be too conservative or too liberal thus increasing the possibility of falsely identifying significant variables (Chatterjee & Price, 1991; Marion, 1994).

Autocorrelation can be addressed in one of two ways. First, if it is the result of an omission of an independent variable that should be in the model, the inclusion of this variable will adequately adjust for the autocorrelation. For example, if plotting regression residuals against time (e.g. day, month, year) reveals a pattern of autocorrelated residuals, then the addition of a time variable (e.g. date) or variables that change over time may correct for the autocorrelation problem. If, however, the autocorrelation is not due to the omission of an independent variable or if the data for that variable are not available, a more specialized analysis, such as an

autoregressive (AR) model, is required. In an AR model, the estimated value of an observation is based, in part, on the value(s) of the previous observation(s). Depending on the nature of the autocorrelation, the AR model could use information from the most recent observation (i.e. AR(1) or first-order AR) or from several previous observations (AR(n)).

For the purposes of this study, the first step was to assess the significance and nature of the autocorrelation in the waiting list data. The Autocorrelation Function (ACF) and Partial Autocorrelation Functions (PACF) in SPSS were used to conduct the analysis. The ACF was used to estimate the correlations between each observation and each case preceding it. The PACF calculates the correlations between each observation and each case preceding it, after adjusting for the effects of the intervening cases. The results of the analysis will determine if there is indeed autocorrelation within the data and if so, the pattern of autocorrelation, will provide the necessary information to select the appropriate AR model.

5.3.1.2 Multi-collinearity

Correlation analyses were conducted to assess the level of multi-collinearity among groups of variables (i.e. patient, physician and hospital). High levels of correlation, or collinearity, among variables will likely lead to unstable coefficient estimates with large standard errors (SE). There is currently no universally agreed on criteria for "acceptable" levels of correlation between independent variables. For the purposes of this study, correlations <.6 (or >.-6) were considered acceptable. In cases where the correlation exceeded this criterion, one variable must be selected to enter into the model. The selection of most appropriate variable was based on a two step process: (1) assess the contribution of each variable to the model (i.e. R^2, β values and significance, SE, and BETAs); and (2) assess the importance of each variable in explaining the variation in waiting time on a conceptual or theoretical level. It is possible that each variable

may contribute equally to the model (i.e. no difference in Criterion 1); this is expected to be the case with highly correlated variables. In such cases, selection was then based on the importance, plausibility or general interest in the model.

5.3.1.3 Model Development

Model variables were entered in three separate stages: (1) patient factors (Model 1), (2) patient and physician factors (Model 2), and (3) patient, physician, and hospital factors (Model 3). In addition to identifying the significant individual factors, this strategy allowed for the identification of the group of factors most responsible for explaining the variation in patient waiting time.

5.3.1.4 Interaction Effects

The final model, however, would not be complete without the inclusion of relevant interaction terms. An interaction occurs when the effect of a significant independent variable (X_1) on the dependent variable (Y) is not constant but varies across different values or levels of a second significant independent variable (X_2) and vice versa. If there is an interaction between variables X_1 and X_2 (i.e. coefficient of $X_1 \times X_2 > 0$), then they are said to be dependent in their effect on Y. It is no longer meaningful, therefore, to speak about the independent effects of X_1 and X_2 on Y (Marion, 1994).

Given the number of variables used in the proposed model and the potential for numerous significant independent variables, it is not feasible to test all possible interactions. Therefore, only those variables with the greatest explanatory power and contribution to the overall R^2 of the model were considered and entered into the final model.

5.3.2 Model Variables

5.3.2.1 Dependent Variable

The dependent variable is patient waiting time measured at the individual level. Given the skewed nature of the data, a natural log (LN) transformation was conducted to normalize the data.

5.3.2.2 Independent Variables

Selected patient, physician and hospital factors identified in the conceptual framework (Chapter 3) as potential factors affecting waiting time were created from various sources of data for use in the final regression model. Each group of factors is described in the following discussion followed by a detailed description of the regression model.

Patient Variables

Patient information used in the model includes basic demographic data, the nature of the pre-operative medical care, and the nature of the waiting list experience:

- Month on the Waiting list: (MONTHON)

  The date of placement on the waiting list ranging from January 1994 (MONTHON=1) to June 1995 (MONTHON=18) to control for the effects of time.

- Demographic Information: (GENDER, AGEON)

  Data from the SWL and hospital separation files were used to create GENDER and AGEON variables. GENDER (0 Male; 1 Female) and age when placed on the waiting list (AGEON) are included in the model to control for the possible effects of age and sex on wait times.

- Urban, Semi-Urban or Rural Residence: (LHAGR)

Concerns have been raised regarding inequitable waiting times between urban and rural patients. The patient's place of residence at the time of placement on the waiting list was identified as urban (Reference Group), semi-urban (LHAGR1=1) or rural (LHAGR2=1). LHAGR3 represents all patients with missing information. The groupings were created based on information regarding the patient's Local Health Area (LHA). The 1996 Census data were used by researchers at the CHSPR to calculate the population per square km for each of the 83 LHAs in BC. The LHAs were then categorized into one of the following groups based on their pop/sqkm: urban (≥1,000 pop/sqkm), semi-urban (200≥pop/sqkm<1,000), or rural (<200 pop/sqkm).

- First Patient on Waiting List: (FIRSTPAT)

Identification of the first patient on the physician's waiting list. This variable is included as a control variable since there is no preceding case on the waiting list affecting this individual's waiting time.

- Patient Residence vs Hospital Location: (COMPHR)

The waiting times for patients who must travel to receive care may be different compared to the waits experienced by patients who receive care in the same health region (HR) within which they live. British Columbia is divided into 20 Health Regions (HR). Patients who received care in a hospital not located in the same HR as their place of residence were identified (COMPHR=1) otherwise COMPHR=0.

- Patient Status: (URGEMERG)

Patient status is broadly reflective of the clinical status of the patient. Those listed as urgent or emergent are expected to have shorter waiting times compared to elective patients. Patient status information from the SWL and hospital data were used to identify cases that were placed on the SWL as urgent and emergent cases or admitted to hospital as an urgent or emergency case (URGEMERG=1).

- Visit to Other Specialist: (OTHSPEC)

Consultations prior to surgery may involve a referral to another specialist. Information from the trajectory of care was used to determine if a patient visited a specialist other than the surgeon prior to surgery (OTHSPEC1=1). Cases with no information regarding their trajectory of care were assigned to the missing group (OTHSPEC2=1).

- Placement on the Waiting List: (VDTONGR)

Patient waiting time is likely to be affected by when patients are placed on the waiting list. Patients placed on the waiting list following their final pre-surgical consultation are expected to have shorter waiting times compared to those patients placed on the list following their initial consultation. Information from the validity assessment was used to create dichotomous variables to identify when patients were placed on the waiting list. Patients may have been placed on the waiting list following their last of several consultations (Reference Group: VDTONGR0), during their pre-operative care (VDTONGR1=1), after their first of several visits (VDTONGR2=1), after their first and only consultation (VDTONGR3=1), or before their first consultation (VDTONGR4=1). Patients with missing information regarding placement on the waiting list were assigned to the missing group (VDTONGR5=1).

- Waiting list Administration: (WLADMIN)

Patient waiting time can often be affected by the administrative procedures governing the management of the waiting list. There is often a waiting period occurring between when the decision to have surgery is made and when physicians officially notify the hospital and patients are placed on the hospital waiting list. Patient waiting time may be longer or shorter depending on whether hospitals are notified immediately after the decision for surgery is made or if physicians withhold notification until they are assured that the patient will receive surgery within a short period of time. The practice of physicians regarding waiting list management is captured by measuring the number of days between the last consultation prior to date-on the waiting list (i.e. decision to have surgery) and date-on the waiting list.

- Prior SWL Experience: (PRESWL)

Analyses of patient experiences on the SWL in the previous chapter indicate that some patients were placed on the waiting list more than once due to multiple surgeries or cancellations. Their previous experiences on the waiting list may affect their waiting time. Patients with a prior cancellation, for example, may experience a shorter wait for surgery. Patients with a previous surgery may be more knowledgeable about the processes involved in accessing care and, therefore, may be more likely to do so in a more timely fashion. The Reference Group (PRESWL0) represents patients with no prior experience on the waiting list. Patients with previous placement on the SWL were identified (PRESWL1=1). This information could not be determined for cases with no valid identification and, therefore, they were assigned to the missing data group (PRESWL2=1).

- Hospital "Slow" Down: (SLOW)

Most hospitals experience a slow down in operating capacity during certain times of the year (e.g., August, December). During these periods, fewer surgeries are conducted thus reducing output and possibly increasing the waiting times of those patients awaiting surgery. Patients on a waiting list during either July/August or November/December are identified as waiting during a "slow" period (SLOW=1).

- Waiting List Movement: (MOVE)

Waiting time is likely affected by the movement of patients on the waiting list. If a patient is moved ahead of other patients on the list, their waiting time is likely to be shortened; this may result in delays to surgery for other patients who may experience longer waits. MOVE represents the number of positions within the waiting list that a person moves ahead or is delayed (MOVE=(dateon order)-(dateoff order)). For example, if a patient is placed third on a waiting list (i.e., dateon order=3) but is the first patient to be removed (i.e., dateoff order=1), then they will have moved ahead 2 places (i.e., MOVE=2). If a patient were delayed, they will exhibit a negative value; for example, if a patient was placed first on the waiting list but was the third patient removed, they would be delayed by 2 places (i.e. MOVE=-2).

MOVE is used as a categorical variable in the model with patients represented by one of the following dummy variables: MOVEGR1 (MOVE<-10), MOVEGR2 (-10≤MOVE≤-6), MOVEGR3 (-5≤MOVE≤-1), MOVEGR4 (Reference Group MOVE=0), MOVEGR5 (1≤MOVE≤5), MOVEGR6 (6≤MOVE≤10), MOVEGR7 (MOVE>10).

Descriptive analyses of patient variables are presented in Table 5.2 for each procedure group.

Table 5.2: Descriptive analysis of patient variables

Variable (Value)		Knee Replacement (n=1841)	Hip Replacement (n=2491)	Cataract (n=21,655)
GENDER	Male (0)	820 (44.5%)	1039 (49.7%)	8149 (37.6%)
	Female (1)	1021 (55.5%)	1452 (51.3%)	13506 (62.4%)
AGEON	(Mean)	69.08	67.18	73.27
	(Median)	70.00	70.00	75.00
LHAGR	0 Urban	611 (33.2%)	808 (32.4%)	9871 (45.6%)
	1 Semi-urban	349 (19.0%)	485 (19.5%)	4394 (20.3%)
	2 Rural	722 (39.2%)	996 (40.0%)	5716 (26.4%)
	3 Missing	159 (8.6%)	202 (8.1%)	1673 (7.7%)
COMPHR	Different (0)	727 (39.5%)	945 (37.9%)	6907 (31.9%)
	Same (1)	1114 (60.5%)	1546 (62.1%)	14748 (68.1%)
URGEMER	Elective (0)	1708 (92.8%)	2111 (84.7%)	21169 (97.8%)
	Urgent/Emer(1)	133 (7.8%)	380 (15.3%)	486 (2.2%)
OTHSPEC	0 No	1215 (66.0%)	1660 (66.6%)	13541 (62.5%)
	1 Yes	363 (19.7%)	818 (20.4%)	6201 (28.7%)
	2 Missing	263 (14.3%)	323 (13.0%)	1913 (8.8%)
VDTONGR	0 After last visit (>1)	594 (32.3%)	853 (34.2%)	7139 (33.0%)
	1 After nth visit (>1)	259 (14.1%)	327 (13.1%)	4576 (21.1%)
	2 After 1st visit (>1)	242 (13.1%)	264 (10.6%)	2391 (11.0%)
	3 After 1st visit (1visit)	391 (21.2%)	651 (26.1%)	4817 (22.2%)
	4 Before 1st visit	92 (5.0%)	73 (2.9%)	819 (3.8%)
	5 Missing	263 (14.3%)	323 (13.0%)	1913 (8.8%)
PRESWL	0 No	1484 (60.8%)	2130 (85.5%)	16997 (78.5%)
	1 Yes	252 (13.7%)	231 (9.3%)	4157 (19.2%)
	2 Missing	105 (5.7%)	130 (5.2%)	501 (2.3%)
SLOW	No (0)	1447 (78.6%)	2009 (80.7%)	17155 (79.2%)
	Yes (1)	394 (21.4%)	482 (19.3%)	4500 (20.8%)
MOVEGR	1 Move <-10 positions	107 (5.8%)	189 (7.6%)	5101 (23.6%)
	2 Move -6 to -10 positions	131 (7.1%)	150 (6.0%)	1425 (6.6%)
	3 Move -1 to -5 positions	457 (24.8%)	568 (22.8%)	2561 (11.8%)
	4 No movement	385 (20.9%)	461 (18.5%)	2116 (9.8%)
	5 Move 1 to 5 positions	506 (27.5%)	672 (27.0%)	4044 (18.7%)
	6 Move 6 to 10 positions	131 (7.1%)	246 (9.9%)	1740 (8.0%)
	7 Move >10 positions	124 (6.7%)	205 (8.2%)	4668 (21.6%)

Physician Variables

A range of data sources were used to create variables reflecting physician access to hospital services, workload patterns, and waiting list management practices.

- Access to Hospitals: (NUMHOSP)

A physician's ability to access operating time and resources in hospitals may have an effect on patient waiting time. Hospital separation data were used to create a proxy measure of physician access to operating facilities. The data were analyzed by physician

to determine the number of hospitals in which each physician performed the type of surgery in question. All physicians with hospital admissions were assigned to at least one hospital. Physicians with admissions in more than one hospital had to have at least 5 patients admitted in a year for the selected surgery to count the hospital.

- Full-time Equivalent: (FTE)

Physician workload levels are often assumed to be positively associated with patient waiting time. Overall workload is measured using full-time equivalent (FTE). The estimates used for the purposes of this analysis are based on annual FTE estimates routinely calculated for all active physicians in BC with positive income reimbursed on a FFS basis. FTE estimates are calculated by the Health Human Resources Unit at the CHSPR based on MSP billing data for each specialty. FFS payments to physicians for services rendered during the fiscal year to BC residents, excluding Northern and Isolation Allowance and interest payments, are summed. For each specialty, the 40th and 60th percentiles of total payments are identified. Physicians with total payments between the 40th and 60th percentile are assigned an FTE of 1. Physicians below the 40th percentile as are assigned an FTE <1 (FTE=(practitioner total)/(40th percentile of payments)). An FTE >1 is assigned to physicians with total payments above the 60th percentile (FTE=1 - ln [(practitioner total)/(60th percentile of total payments)). FTE estimates were provided for each fiscal year (1993/94 -1995/96). The estimate used corresponded to the year the physician's patient was placed on the waiting list. For example, if the patient was placed on the waiting list on May 1995, the FTE estimate for 1995/96 was used.

- Surgical Workload (AVSURG)

Physicians' surgical workload represents a specific workload measure as well as an alternate proxy measure for access to operating time and resources. Physicians performing more surgery may, in general, have greater access to operating rooms. Using the MSP data, the average number of surgical procedures per month is calculated for each fiscal year between 1993/94 to 1995/95. The AVSURG values used corresponded to the year the patient was placed on the waiting list. Service codes (43, 44) were used to identify surgical claims.

- Waiting List Size: (SURGWL)

Physicians with longer waiting lists are often assumed to have longer waiting times. This variable represents the length of the surgeon's waiting list on the month the patient was placed on the SWL.

Descriptive analysis of physician variables is provided in Table 5.3 for each procedure group.

Table 5.3: Descriptive analysis of physician variables (Mean(Median))

Variable	Knee Replacement	Hip Replacement	Cataract
NUMHOSP	1.25 (1.00)	1.25 (1.00)	1.32 (1.00)
FTE	1.03 (1.02)	0.99 (1.00)	1.10 (1.04)
AVSURG	42.81 (41.04)	43.46 (41.75)	61.07 (51.70)
SURGWL	6.59 (4.00)	6.86 (4.00)	40.03 (21.00)

Hospital Variables

The final factors included in the model are hospital-based variables focussing primarily on operating capacity and patterns of care.

- Length of Stay: (LOS)

Hospital length of stay (LOS) is hypothesized to be positively associated with waiting times. The average length of stay (in days) for inpatient care by hospital is provided by the Ministry of Health for each fiscal year.

- Operative Cases: (OPCASE)

The total number of operative cases provides information regarding the use of operating facilities. Cases are considered operative when they have received one or more operative procedures. The latter is defined as "a procedure which in most institutions would be performed in an operating room" (CIHI, 1998). Procedures listed in the CCP deemed operative were identified by CIHI for the purpose of calculating CMGs (CIHI, 1998, Appendix C.2, H.1-H.4). The relevant procedure codes were used to identify operative cases within the hospital separation data. The total number of operative cases was calculated per hospital for each fiscal year.

- Emergency Operative Cases: (EMEROP)

The admission of operative cases on an emergency basis to hospital affects the availability of operating facilities and, in some cases, the availability of surgical beds. This, in turn, may affect the waiting times of elective patients. Hospitals with a high demand for emergency surgeries and/or admissions may have to cancel planned elective cases to deal with the demand, thus increasing the waiting times of elective cases. The hospital separation data were used to determine the proportion of operative cases admitted on an emergency basis for each hospital for each fiscal year.

- Urgent Operative Cases: (URGOP)

In a similar way, urgent admission to hospital of operative cases will also affect the availability of operating facilities and beds and, consequently, the waiting times of elective patients. The hospital separation data were used to determine the proportion of operative cases admitted to hospital on an urgent basis for each hospital and fiscal year.

- Type of Operative Cases: (KNEEHSP, HIPHSP, CATHSP)

The proportion of total operative cases representing a specific procedure may affect the length of time patients wait for that procedure. It is often argued that simply increasing the number of cases will reduce the waiting list and waiting time for patients. These variables represent the proportion of operative cases representing knee replacement (KNEEHSP), hip replacement (HIPHSP) and cataract surgery (CATHSP) annually for each hospital.

- Waitlist Size: (HOSPWL)

As with physician waiting lists, the length of the hospital waiting list may have a positive effect on patient waiting time. This variable represents the length of the hospital waiting list on the month the patient was placed on the SWL.

Descriptive analyses of physician and hospital variables are provided in Table 5.4.

Table 5.4: Descriptive analysis of hospital variables (Mean(Median))

Variable	Knee Replacement		Hip Replacement		Cataract	
LOS	6.20	(6.10)	6.18	(5.80)	6.20	(5.8)
OPCASE	9117.03	(7628)	8571.43	(6725)	8115.70	(5586)
EMEROP	9.76%	(7.66%)	9.36%	(7.66%)	8.86%	(7.64%)
URGOP	19.81%	(18.72%)	19.96%	(18.75%)	19.57%	(18.10%)
HOSPWL	18.36	(13.00)	19.44	(14.50)	137.58	(79.00)

5.4 RESULTS

The results of the analysis are presented in three parts. First, the results of the autocorrelation assessment are presented in section 5.4.1 followed by the results of the multi-collinearity analysis and regression analysis.

5.4.1 Autocorrelation

To properly assess the level of autocorrelation, the data were ordered chronologically by DATEON the waiting list and by physician within hospital. It is assumed that an individual's waiting time is most affected by the waiting time of the patient placed on the list immediately before.

The ACF was conducted on the natural log of days waiting (LNDAYS). Results are presented in Figure 5.5a-c. For all three procedure groups, the ACF shows autocorrelation that does not decrease rapidly with lag number. The PACF does decrease rapidly following LAG=1. This pattern is the signature of an AR(1) or first-order AR model. An AR(1) regression model, adjusts for the effects of the waiting time of the previous case when estimating a patient's waiting time, therefore, adjusting for the autocorrelation in the data.

Figure 5.5a: Results of the autocorrelation function (ACF) analysis, LNDAYS Knee Replacement

```
Variable:  LNDAYS       Missing cases:  19     Valid cases:  1822
Some of the missing cases are imbedded within the series.

Autocorrelations:   LNDAYS

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                  +----+----+----+----+----+----+----+----+----+
  1   .383   .023                     .I.*******                 270.560   .000
  2   .332   .023                     .I.******                  474.187   .000
  3   .303   .023                     .I.*****                   644.071   .000
  4   .272   .023                     .I.****                    780.994   .000
  5   .268   .023                     .I.****                    913.905   .000
  6   .268   .023                     .I.****                   1046.688   .000
  7   .286   .023                     .I.*****                  1197.894   .000
  8   .260   .023                     .I.****                   1322.502   .000
  9   .255   .023                     .I.****                   1443.380   .000
 10   .211   .023                     .I.***                    1525.609   .000
 11   .216   .023                     .I.***                    1611.702   .000
 12   .204   .023                     .I.***                    1689.183   .000
 13   .211   .023                     .I.***                    1771.810   .000
 14   .197   .023                     .I.***                    1843.733   .000
 15   .200   .023                     .I.***                    1918.127   .000
 16   .190   .023                     .I.***                    1985.360   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  1841     Computable first lags:  1803

Partial Autocorrelations:   LNDAYS

   Pr-Aut- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1
                  +----+----+----+----+----+----+----+----+----+
  1   .383   .023                     .I.*******
  2   .217   .023                     .I.***
  3   .148   .023                     .I.**
  4   .097   .023                     .I.*
  5   .094   .023                     .I.*
  6   .090   .023                     .I.*
  7   .106   .023                     .I.*
  8   .055   .023                     .I*
  9   .055   .023                     .I*
 10  -.002   .023                     .*.
 11   .029   .023                     .I*
 12   .019   .023                     .*.
 13   .035   .023                     .I*
 14   .013   .023                     .*.
 15   .027   .023                     .I*
 16   .015   .023                     .*.

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .
Total cases:  1841     Computable first lags:  1803
```

Figure 5.5b: Results of the autocorrelation function (ACF) analysis, LNDAYS Hip Replacement

```
Variable:  LNDAYS       Missing cases:  20     Valid cases:  2471
Some of the missing cases are imbedded within the series.

Autocorrelations:   LNDAYS

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                  +----+----+----+----+----+----+----+----+
  1   .339   .020                    .I.******                   286.719   .000
  2   .262   .020                    .I.****                     457.832   .000
  3   .229   .020                    .I.****                     588.934   .000
  4   .225   .020                    .I.****                     715.862   .000
  5   .232   .020                    .I.****                     850.143   .000
  6   .224   .020                    .I.***                      975.211   .000
  7   .203   .020                    .I.***                     1078.233   .000
  8   .215   .020                    .I.***                     1193.391   .000
  9   .191   .020                    .I.***                     1284.935   .000
 10   .190   .020                    .I.***                     1375.354   .000
 11   .174   .020                    .I.**                      1451.340   .000
 12   .183   .020                    .I.***                     1535.126   .000
 13   .189   .020                    .I.***                     1624.597   .000
 14   .190   .020                    .I.***                     1714.712   .000
 15   .210   .020                    .I.***                     1825.204   .000
 16   .197   .020                    .I.***                     1922.468   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  2491     Computable first lags:  2452

Partial Autocorrelations:   LNDAYS

   Pr-Aut- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1
                  +----+----+----+----+----+----+----+----+
  1   .339   .020                    .I.******
  2   .166   .020                    .I.**
  3   .115   .020                    .I.*
  4   .107   .020                    .I.*
  5   .106   .020                    .I.*
  6   .084   .020                    .I.*
  7   .054   .020                    .I*
  8   .074   .020                    .I*
  9   .037   .020                    .I*
 10   .043   .020                    .I*
 11   .024   .020                    .*.
 12   .043   .020                    .I*
 13   .046   .020                    .I*
 14   .043   .020                    .I*
 15   .067   .020                    .I*
 16   .038   .020                    .I*

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  2491     Computable first lags:  2452
```

Figure 5.5c: Results of the autocorrelation function (ACF) analysis, LNDAYS Cataract

```
Variable:  LNDAYS       Missing cases:  91     Valid cases:  21564
Some of the missing cases are imbedded within the series.

Autocorrelations:   LNDAYS

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                  +----+----+----+----+----+----+----+----+
  1   .669   .007                     I*************           9684.375   .000
  2   .583   .007                     I************           17032.704   .000
  3   .537   .007                     I***********            23269.840   .000
  4   .520   .007                     I**********             29126.457   .000
  5   .510   .007                     I**********             34749.779   .000
  6   .505   .007                     I**********             40266.972   .000
  7   .497   .007                     I**********             45614.133   .000
  8   .496   .007                     I**********             50933.851   .000
  9   .487   .007                     I**********             56065.931   .000
 10   .479   .007                     I**********             61034.814   .000
 11   .480   .007                     I**********             66035.998   .000
 12   .478   .007                     I**********             70979.938   .000
 13   .475   .007                     I**********             75876.022   .000
 14   .478   .007                     I**********             80826.450   .000
 15   .480   .007                     I**********             85821.609   .000
 16   .474   .007                     I*********              90689.124   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  21655     Computable first lags:  21485

Partial Autocorrelations:   LNDAYS

   Pr-Aut- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1
                  +----+----+----+----+----+----+----+----+
  1   .669   .007                     I*************
  2   .245   .007                     I*****
  3   .152   .007                     I***
  4   .137   .007                     I***
  5   .113   .007                     I**
  6   .102   .007                     I**
  7   .082   .007                     I**
  8   .082   .007                     I**
  9   .059   .007                     I*
 10   .051   .007                     I*
 11   .063   .007                     I*
 12   .051   .007                     I*
 13   .048   .007                     I*
 14   .055   .007                     I*
 15   .053   .007                     I*
 16   .034   .007                     I*

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  21655     Computable first lags:  21485
```

5.4.2. Multi-Collinearity Analyses

Results of the multi-collinearity analyses are presented in Appendix C Tables C1-C3. There were no correlations exceeding the criteria (i.e. >.6) for knee replacement. The correlation analyses indicate selected problems with multi-collinearity among variables for hip replacement and cataract surgeries. For hip replacement, the total number of operative procedures performed at the hospital (OPCASE) on an annual basis was highly correlated with the length of the hospital waiting list (HOSPWL) (r=.736). Preliminary regression analyses indicate that the variables perform better when entered in the model separately along with the other patient, physician and hospital variables (see Appendix C: Table C-4). The regression coefficients (βs) and significance levels increased slightly and the SE for each variable decreased when the variables were entered into the model separately versus together, indicating greater stability if only one variable were entered. However, when entered separately, there were few differences in the overall contribution of each variable to the model. There was little change in the total amount of variation explained (OPCASE: R^2 =.608; HOSPWL: R^2 =.609) and the BETA values, which can be used to compare effect size across variables, were the same (BETA=-.10). The only difference lies in the SE values (OPCASE: SE=.000003; HOSPWL: SE=.0014). However, given the current debates regarding the effect of hospital outputs on waiting times, OPCASE was considered to be the more important variable on a theoretical basis and, therefore, was retained for the regression analysis.

In the case of cataract surgery, high levels of correlation were found among selected physician and hospital variables. Physician FTE status was highly correlated with the average number of surgeries performed per month (AVSURG) (r=.884). Preliminary regression analyses indicate that the variables perform better when entered in the model separately along with the other patient and physician variables (see Appendix C: Table C-5). In both cases, the regression

coefficients become significant ($p<.05$) when added to the model individually versus together and SE estimates decreased. There were no changes in R^2 (.563) and, as expected, the BETA values were the same (-.014). The SE estimate for AVSURG was smaller (.0004) compared to the estimate for FTE (.044). While there are few differences between the variables with respect to overall contribution to the mode, it is the surgical workload (AVSURG) that is most often associated with waiting times on both the theoretical and policy levels. "Popular" physicians (i.e. those with high levels of surgery) are often assumed to have longer waiting lists and waiting times. Furthermore, while both variables represent workload measures, AVSURG is more narrowly defined in terms of surgical workload versus FTE which includes all services provided to patients billable to MSP; in the later case, it is more difficult to determine whether differences in waiting times are due to differences in the nature of the services provided. AVSURG, therefore, was retained for the regression model.

The total number of operative cases performed within each hospital (OPCASE) was moderately correlated with both the proportion of cases performed on an emergency basis (EMEROP) ($r=.697$) and the length of the hospital waiting list (HOSPWL) ($r=.664$) for cataract surgeries. Separate regression analyses revealed that entering OPCASE versus EMEROP and HOSPWL increased the R^2 from .569 to .572 (see Appendix C:Table C-6). Hence, OPCASE was removed from the model and EMEROP and HOSPWL were retained.

Finally, LOS was highly correlated with proportion of cataract cases performed in each hospital (CATHSP) ($r=.803$). When assessed together and individually in separate regression analyses, it was evident that the inclusion of LOS versus CATHSP resulted in a higher R^2 (.573) (see Appendix C Table C-7). Furthermore, CATHSP was not significantly related to waiting time when placed in the model.

5.4.3 Regression analysis

The results of the AR(1) models are presented in Tables 5.5 – 5.7 for each procedure respectively. The results of Model 1 represent the effect of patient factors on individual waiting time; Model 2 represents the effect of patient and physician factors; and Model 3 represents the effect of patient, physician and hospital factors. The Final Models represent the inclusion of all model variables and significant interaction terms. The results presented include the total variation in waiting time explained by the model (i.e. R^2, Adj R^2), the model constant and the regression coefficients for each variable with level of significance (*p<.05; ** p>.01; ***p<.001). The constants were included in the model since all patients waited a period of time. Furthermore, if removed, the relationship between the dependent and independent variables may be altered.

The model coefficients (β) represent the change in the dependent variable (i.e. lnDAYS) for every unit change in the independent variable. Since the dependent variable represents the natural Log transformation of waiting times, the interpretation of the effect size of the coefficients on waiting time is somewhat abstract. In order to make the results more transparent, the effect size of each independent variable is expressed as the "percent change in waiting time" expected with each unit change in the independent variable; this is calculated as follows:

$$\% \text{ Change} = [(e)^{\beta} - 1] \times 100$$

Overall, the final procedure models explained 61% of the variation in patient waiting time for KR and HR and 58% of the variation for CAT. Regression diagnostics were conducted to assess the stability of the final models. ACF analyses of the residuals clearly indicate no evidence of autocorrelation following the analyses. The AR(1) method, therefore, appears to have

adequately adjusted for the autocorrelation in the SWL data (see Appendix Figs C1-3). The distributions of regression residuals were assessed against all significant variables to ensure a random distribution implying a linear relationship with the dependent variable. The results indicate the residuals were randomly distributed, thus supporting the model.

5.4.3.1 Patient Variables

A preliminary analysis of the amount of variation in waiting time explained (i.e. R^2) by each model clearly demonstrates that for all procedure groups, patient factors explain most of the variation in waiting time: 57% KR and HR and 55% for CAT. In all three cases, patients' experiences on or with the waiting list (i.e. VDTONGR, PRESWL, and MOVE) were significantly associated with patient waiting time compared to variables representing the patients' demographic profile.

Additional analyses revealed that, in all three procedure groups, MOVE explained the greatest amount of variation in patient waiting time. Hence, interaction terms included in the final models were limited to this variable since it represents the most significant individual factor within the most significant group of factors (i.e. patients). It was deemed particularly important to determine if and how MOVE affected waiting time differently for different groups of patients. The interaction terms entered in the final model, therefore, focus on the interactions between this variable and the other significant patient variables. The type and number of interaction terms vary to some extent between procedure groups. Only significant interactions effects are presented.

The results of the individual variables are discussed in the following section as they appear in the final models.

Demographic Variables

Patient demographic characteristics (GENDER, AGEON and LHAGR) were not significantly related to patient waiting time for all procedure groups. While not significantly different, females experienced shorter waiting times compared to their male counterparts for KR (-2.47%) and HR (-1.78%). Conversely, female patients awaiting cataract surgery were more likely to wait longer (2.53%) than their male counterparts; the difference was significant at the $p<.001$ level. Patient age and type of residence were not found to significantly related to patient waiting time. Finally, waiting times differed significantly between those patients who did (COMPR) and did not receive care in another health region for KR cases only; patients receiving care in a health region other than their place of residence experienced waiting times that were 7.04% shorter than those who did not.

Patient Status

As expected, urgent or emergent clinical status was found to significantly ($p<.001$) decrease patient waiting time. The waiting times for urgent/emergent cases compared to elective cases were 43.84% shorter for KR patients, 56.22% shorter for HR cases and 45.28% shorter for CAT cases. The effect of patient status on waiting times was highly significant in Model 1 (i.e. patient factors only) and remained significant in the final models when physician and hospital factors were included. The effects of patient status were interactive with MOVE for HR and CAT cases. These interactions will be discussed below.

Pre-Operative Care

The effect of visiting another specialist (OTHSP) during the course of care had a negative effect on waiting time for all procedures but had a significant effect only for HR. Hip replacement patients who visited another specialist experienced a 9.23% decrease in waiting time compared to those patients who did not.

Table 5.5: Results of AR(1) Models, Knee Replacement

Variables	MODEL 1	MODEL 2	MODEL 3	FINAL MODEL	% Change in WT
R2	.569	.581	.601	.613	
R2 (Adjusted)	.563	.573	.592	.603	
Constant	4.154	3.774	4.140	4.127	
Patient Factors					
MONTHON	.009	.004	.001	.0002	.20%
GENDER	-.029	-.033	-.024	-.025	-2.47%
AGEON	-.00002	.0003	-.00001	.0001	.10%
LHAGR0 (Ref Group)	0	0	0	0	0
LHAGR1	.043	.012	-.011	-.018	-1.78%
LHAGR2	.148***	.152***	.087	.076	7.90%
LHAGR3	.024	.033	.004	-.019	-1.88%
FIRSTPAT	-.144*	-.111	-.138	-.135	-12.63%
COMPHR	.002	.018	-.019	-.014	-1.39%
URGEMER	-.556***	-.540***	-.564***	-.577***	-43.84%
OTHSP1	-.026	-.033	-.035	-.021	-2.08%
VDTONGR0 (Ref Group)	0	0	0	0	0
VDTONGR1	.367***	.358***	.369***	.640***	89.65%
VDTONGR2	.273***	.257***	.273***	.268***	30.73%
VDTONGR3	.090*	.083*	.066	.079	8.22%
VDTONGR4	.404***	.395***	.384***	.359***	43.19%
VDTONGR5	-.069	-.069	-.073	-.078	-.750%
WLADMIN	-.001**	-.001*	-.001*	-.001**	-.10%
PRESWL0 (Ref Group)	0	0	0	0	0
PRESWL1	-.152***	-.160***	-.163***	-.287**	-24.95%
PRESWL2	.168	.170	.008	.031	3.15%
SLOW	.120*	.124**	.136**	.143**	15.37%
MOVEGR1	.908***	.844***	.872***	.868***	138%
MOVEGR2	.619***	.561***	.577***	.610***	84.04%
MOVEGR3	.455***	.434***	.445***	.472***	60.32%
MOVEGR4 (Ref Group)	0	0	0	0	0
MOVEGR5	-.337***	-.357***	-.337***	-.311***	-26.73%
MOVEGR6	-.743***	-.795***	-.770***	-.805***	-55.29%
MOVEGR7	-1.481***	-1.58***	-1.54***	-1.415***	-75.71%
Physician Factors					
NUMHOSP		-.138*	-.083	-.088	-8.42%
FTE		-.017	.062	.053	5.42%
AVSURG		.010***	.006*	.006**	.61%
SURGWL		.016***	.018***	.018***	1.82%
Hospital Factors					
LOS			-.111***	-.110***	-10.42%
OPCASE			.000003	.000003	.003%
EMEROP			.004	.004	.40%
URGOP			.021***	.020***	2.02%
KNEEHSP			.120	.123	13.09%
HOSPWL			-.003	-.003	-.30%
Interaction Terms					
MOVEGR1 x PRESWL				.323	38.13%
MOVEGR2 x PRESWL				.384*	46.81%
MOVEGR3 x PRESWL				.294*	34.18%
(Ref Group)				0	0
MOVEGR5 x PRESWL				.141	15.14%
MOVEGR6 x PRESWL				.324*	38.26%
MOVEGR7 x PRESWL				-.348*	-29.39%
MOVEGR1xVDTONGR1				-.296	-25.62%
MOVEGR2xVDTONGR1				-.417**	-34.10%
MOVEGR3xVDTONGR1				-.443***	-35.80%
(Ref Group)				0	0
MOVEGR5xVDTONGR1				-.361**	-30.30%
MOVEGR6xVDTONGR1				-.124	-11.66%
MOVEGR7xVDTONGR1				.243	27.51%

Legend: * p<.05, **p<.01, ***p<.001

Table 5.6: Results of AR(1) Models, Hip Replacement

Variables	MODEL 1	MODEL 2	MODEL 3	FINAL MODEL	% Change in WT
R^2	.571	.586	.608	.614	
R^2 (Adjusted)	.566	.580	.602	.608	
Constant	4.190	3.695	4.450	4.522	
Patient Factors					
MONTHON	.011*	.004	-.001	-.001	-.10%
GENDER	-.022	-.021	-.014	-.018	-1.78%
AGEON	-.002*	-.002	-.002	-.002	-.20%
LHAGR0 (Ref Group)	0	0	0	0	0
LHAGR1	-.008	-.021	-.041	-.042	-4.11%
LHAGR2	.066	.087*	-.027	-.030	-3.00%
LHAGR3	.008	.054	-.047	-.054	-5.26%
FIRSTPAT	-.293***	-.227**	-.214**	-.201**	-18.20%
COMPHR	-.030	.009	-.072*	-.073*	-7.04%
URGEMER	-.548***	-.521***	-.589***	-.826***	-56.22%
OTHSP1	-.084*	-.106**	-.102**	-.099**	-9.23%
VDTONGR0 (Ref Group)	0	0	0	0	0
VDTONGR1	.330***	.337***	.329***	.332***	39.38%
VDTONGR2	.315***	.330***	.328***	.331***	39.24%
VDTONGR3	.021	.010	.016	.020	2.02%
VDTONGR4	.514***	.545***	.530***	.513***	67.03%
VDTONGR5	-.080	-.098	-.082	-.077	-7.41%
WLADMIN	-.001***	-.001***	-.001***	-.001***	-.10%
PRESWL0 (Ref Group)	0	0	0	0	0
PRESWL1	-.205***	-.202***	-.204***	-.201***	-18.21%
PRESWL2	.148	.182*	-.050	-.053	94.84%
SLOW	.112*	.100*	.087*	.089*	9.31%
MOVEGR1	1.107***	.978***	.994***	.955***	160%
MOVEGR2	.721***	.654***	.679***	.632***	88.14%
MOVEGR3	.515***	.492***	.483***	.435***	54.50%
MOVEGR4 (Ref Group)	0	0	0	0	0
MOVEGR5	-.373***	-.393***	-.387***	-.404***	-33.24%
MOVEGR6	-.908***	-.979***	-.940***	-.888***	-58.85%
MOVEGR7	-1.334***	-1.564***	-1.494***	-1.512***	-77.95%
Physician Factors					
NUMHOSP		-.071	-.067	-.068	-6.57%
FTE		-.182	.026	.031	3.15%
AVSURG		.013***	.005**	.005**	.50%
SURGWL		.023***	.027***	.027***	2.74%
Hospital Factors					
LOS			-.114***	-.118***	-11.13%
OPCASE			-.00002***	-.00002***	-.001%
EMEROP			.011**	.011**	1.11%
URGOP			.022***	.022***	2.22%
HIPHSP			-.096	-.110	-10.42%
Interaction Terms					
MOVEGR1 x URGEMER				1.101***	200%
MOVEGR2 x URGEMER				.934**	154%
MOVEGR3 x URGEMER				.630***	87.76%
(Ref group)				0	0
MOVEGR5 x URGEMER				.218	24.36
MOVEGR6 x URGEMER				-.030	-2.96%
MOVEGR7 x URGEMER				.277	31.92%

Legend: * p<.05, **p<.01, ***p<.001

Table 5.7: Results of AR(1) Models, Cataract

Variables	MODEL 1	MODEL 2	MODEL 3	FINAL MODEL	% Change in WT
R2	.553	.564	.573	.579	
R2 (Adjusted)	.553	.563	.572	.578	
Constant	3.265	3.655	3.952	3.901	
Patient Factors					
MONTHON	.023***	.005*	.003	.003	.30%
GENDER	.024***	.025***	.025***	.025***	2.53%
AGEON	.0001	.00002	-.0001	-.0001	-.01%
LHAGR0 (Ref Group)	0	0	0	0	0
LHAGR1	-.0009	-.0003	-.008	-.008	-.80%
LHAGR2	.044***	.033**	-.005	-.004	-.40%
LHAGR3	.024	.013	-.007	-.005	-.50%
FIRSTPAT	-.277***	-.278***	-.285***	-.277***	-24.19%
COMPHR	.018*	.016	.001	.001	.10%
URGEMER	-.361***	-.354***	-.360***	-.603***	-45.28%
OTHSP1	-.010	-.013	-.013	-.012	-1.19%
VDTONGR0 (Ref Group)	0	0	0	0	0
VDTONGR1	.160***	.167***	.166***	.265***	30.34%
VDTONGR2	.177***	.177***	.178***	.169***	18.41%
VDTONGR3	.048***	.045***	.048***	.046***	4.71%
VDTONGR4	.218***	.220***	.221***	.204***	22.63%
VDTONGR5	-.003	.002	.002	.005	.50%
WLADMIN	-.0001*	-.0001	-.0001*	-.0001*	-.01%
PRESWL0 (Ref Group)	0	0	0	0	0
PRESWL1	.026*	.026*	.027*	.028**	2.84%
PRESWL2	.101***	.101***	.094***	.081**	8.44%
SLOW	.101***	.096***	.098***	.239***	27.00%
MOVEGR1	.859***	.860***	.876***	.966***	162.74%
MOVEGR2	.537***	.551***	.571***	.631***	87.95%
MOVEGR3	.369***	.385***	.405***	.469***	59.84%
MOVEGR4 (Ref Group)	0	0	0	0	0
MOVEGR5	-.169***	-.149***	-.123***	-.094***	-8.97%
MOVEGR6	-.461***	-.442***	-.414***	-.414***	-33.90%
MOVEGR7	-.924***	-.915***	-.886***	-.875***	-58.31%
Physician Factors					
NUMHOSP		-.211***	-.135***	-.131***	-12.28%
AVSURG		-.001*	.001*	.001*	0.10%
SURGWL		.005***	.003***	.003***	.30%
Hospital Factors					
LOS			-.093***	-.093***	-8.88%
EMEROP			-.003	-.003	-.30%
URGOP			.014***	.014***	1.41%
HOSPWL			.0002**	.0002***	.02%
Interaction Terms					
MOVEGR1 x URGEMER				.497***	64.38%
MOVEGR2 x URGEMER				.549**	73.15%
MOVEGR3 x URGEMER				.695***	100%
(Ref group)				0	0
MOVEGR5 x URGEMER				.579***	78.42%
MOVEGR6 x URGEMER				.457**	57.93%
MOVEGR7 x URGEMER				.093	9.75%
MOVEGR1xVDTONGR1				-.200***	-18.13%
MOVEGR2xVDTONGR1				-.159***	-14.70%
MOVEGR3xVDTONGR1				-.199***	-18.05%
(Ref Group)				0	0
MOVEGR5xVDTONGR1				-.105**	-9.97%
MOVEGR6xVDTONGR1				.002	0.20%
MOVEGR7xVDTONGR1				.067	6.93%
MOVEGR1 x SLOW				-.261***	-22.97%
MOVEGR2 x SLOW				-.185***	-16.89%
MOVEGR3 x SLOW				-.179***	-16.34%
(Ref Group)				0	0
MOVEGR4 x SLOW				-.105*	-9.97%
MOVEGR5 x SLOW				-.071	-6.85%
MOVEGR7 x SLOW				-.109*	-10.33%

Placement on Waiting List

For each type of case, the time at which patients were placed on the waiting list affected waiting times (VDTONGR1-5). When compared to those placed on the waiting list following their final of several pre-surgical consultations (VDTONGR0), patients placed at other times during their course of care waited longer. Patients placed after their first and only visit (VDTONGR3) experienced the smallest increase in patient waiting time in all procedure groups; this group was significantly different from the Reference group only for CAT (4.71%). This result was somewhat expected since they too were placed on the list following their last visit; however, unlike the reference group, they had only one visit. Patients placed on the list during the course of care (VDTONGR1), after their first of several visits (VDTONGR2) or before their first visit (VDTONGR4) experienced waits that were between 30% and 90% longer than the reference group for KR, between 40% and 67% longer than the reference group for HR and between 18% and 30% longer than the reference group for CATS. Patients placed on the waiting list during their course of care (VDTONGR1) experienced the longest waits compared to those placed after the final pre-surgical consultation for KR cases (89.65%) and CAT cases (30.34%). The effect of time of placement on the waiting list was not always independent of other factors; the results of the interactions of this variable with MOVE are presented below.

Waiting List Administration

WLADMIN was significantly associated with patient waiting time for all procedure groups ($p<.05$). With each daily increase in the number of days between the decision to treat (i.e. last visit) and placement on the hospital waiting list, HR and KR patients experienced a 0.1% decrease in waiting and CAT patients experienced a 0.01% decrease. This result is not surprising since the longer physician's wait to place patients on the hospital waiting list, the less time patients appear to be waiting.

Previous SWL experience

A previous experience(s) on the SWL resulted in shorter waiting times for knee and hip replacement patients. Those previously placed on the SWL (PRESWL1) experienced a 24.95% decrease in waiting times for KR and a 18.21% decrease in waiting times for HR. Among cataract patients, however, a previous SWL experience resulted in an increase of 2.84%; while the result was statistically significant ($p<.01$), it does not appear to be clinically significant.

Hospital "Slow" Down

Hospital "slow" downs also have a significant effect on patient waiting time. Patients who were placed on the SWL just prior to or during a slow period (SLOW), could expect longer waiting times compared to patients who were placed the list at other times. The effect was significant ($p<.05$) with increases in waiting times ranging between 9.31% (HR) and 27.00% (CAT).

Waiting List Movement

Waiting list movement (MOVE) significantly affected patient waiting time for all three procedure groups ($p<.011$). The results exhibit a consistent "dose response" effect with patient waiting time increasing (decreasing) as the number of delays (jumps) increases compared to those who did not move (Reference Group). Patients who were delayed (MOVEGR1-3) experienced waits that were between 60% and 138% longer for KR, 55% and 160% longer for HR, and 60% and 160% longer for CAT compared to those who did not move (Reference Group). Conversely, patients who jumped or moved ahead on the waiting list experienced waits that were between 26% and 75% shorter for KR, 33% and 78% shorter for HR, and 9% and 58% shorter for CAT compared to those who did not move (Reference group).

Results of the interaction term effects indicate that movement on the waiting list does not exhibit a consistent effect on waiting times across all groups. The results, however, were mixed and not always easily interpretable. In some cases, movement on the waiting list appeared to have a greater positive effect on the waits of those patients who would otherwise experience a shorter wait. For HR cases, for example, urgent/emergent cases experiencing delays had longer waiting times as a result (87.76% to 200%) compared to urgent/emergent cases that did not move on the list. This effect of delays was greater for this group compared to non-urgent/emergent cases. Urgent/emergent CAT cases, however, experienced increases in waiting times as a result of movement on the waiting list regardless of whether patients moved ahead (MOVEGR4-7) or were delayed (MOVEGR1-3). The interaction of MOVE and URGEMER was not significant for KR.

In other cases, waiting list movement had less of an impact on waiting times for those who would otherwise experience longer waits. KR and CAT cases placed on the waiting list during their course of care (VDTONGR1) experienced decreases in patient waiting times compared to those who did not move as a result of delays. Patients placed on the waiting list at other times experienced longer waits. The same effect was noted among CAT cases placed on the waiting list during or immediately preceding a hospital slow down. These results are often difficult to interpret. They do, however, indicate that specific groups may be affected by waiting list movement differently.

5.4.2.2 Physician Factors

Physician access to hospital services appeared to be consistently inversely related to patient waiting time. The effect, however, was significant only for CAT patients ($p<.001$) with each

additional hospital to which the physician had privileges (NUMHOSP) resulting in a decrease in patient waiting time of 12.28%.

The results of physician workload measures were mixed. FTE measures were not significantly associated with patient waiting time. Surgical workload (AVSURG), however, significantly increased waiting time for all three procedure groups. Patient waiting times increased by between 0.6% (HR) and 0.1% (CAT) as the number of average surgeries performed per month increased. An increase in the average number of surgeries performed per month by 20 cases, for example, results in an increase in waiting time of between 12 (HR) and 2 days (CAT), all other factors remaining equal.

Waiting list size was consistently positively associated with patient waiting time. For each additional patient placed on the waiting list, waiting times increased by 1.82% for KR, 2.74% for HR, and 0.3% for CAT. While the effect size appears small, it is clinically significant for patients placed on a long waiting list. For example, patients awaiting KR surgery on a waiting list with 50 patients, would experience a 54.6% increase in waiting time compared to a KR patient placed on a shorter waiting list with only 20 patients, all other factors remaining equal.

5.4.2.3 Hospital Factors

Several hospital factors were identified as significantly affecting patient waiting time but effect sizes were relatively small except for LOS. Hospital LOS was inversely related to waiting times for all procedures groups; waiting times decreased by 10.42%, 11.13% and 8.88% with a single daily increase in average LOS. The results, however, appear to be somewhat counterintuitive.

Hospital output and availability of services affected waiting times differently across the three procedure groups. The total annual number of operative cases performed in a hospital (OPCASE) was included in the model for KR and HR but was significant only for the latter. The effect size is very small (-0.001%) since it reflects the effect of an increase of a single operative case per year; to achieve a 5% decrease in waiting times, for example, hospitals would have to increase surgical output by 1,000 cases per year. The results of the type of surgery performed (KNEEHSP, HIPHSP) were mixed with a positive effect for KR (13.01%) and a negative effect for HR (-10.42%) but the effects were not significant.

The nature of the hospital output affected waiting times differently across procedure groups. The proportion of operative cases performed on an emergency basis (EMEROP) was significantly related to waiting time for HR only; for every percent increase in emergency operative cases, waiting times increased by 1.11%.

Operative cases conducted on an urgent basis (URGOP) were consistently positively associated with waiting times. A percent increase in the proportion of operative cases performed on a urgent basis resulted in an increase in waiting time of 2.02%, 2.22% and 1.41% for KR, HR, and CAT respectively.

Finally, the size of the hospital waiting list was included in the model for KR and CAT but the effect was significant only for the latter. Each additional patient placed on the hospital waiting list resulted in a 0.02% increase in patient waiting time. While the results may not appear to be clinically significant, they are for patients placed on very long waiting lists.

5.5 DISCUSSION

The results clearly demonstrate that waiting times vary within procedure groups across physicians and hospitals. Box-plot analyses revealed differences in median waiting times and the distribution of waiting times across physicians and hospitals. These findings suggested that physician and hospital factors, in addition to patient factors, may play a role in explaining the variation in waiting time.

The results of the AR(1) confirmed this hypothesis. The collection of factors used in the final models explained between 58% (CAT) and 61% (KR & HR) of the variation in patient waiting times. The method used to construct the final models identified patient factors as the most significant group of factors affecting waiting times. Specifically, patient clinical status, when patients were placed on the waiting list and waiting list experiences were consistently found to be highly significantly associated with waiting time.

As expected, urgent/emergent cases experienced shorter waits compared to elective patients. This finding was consistent across all procedure groups. It provides some evidence that in fact waiting lists are managed to ensure that more urgent cases are being treated first.

The results suggest, however, that other factors also affect patient waiting times. Factors such as movement on the waiting list, when patients are placed on the waiting list, and whether or not patients have had a previous SWL experience were all found to significantly affect patient waiting time.

Perhaps the single most important factor in explaining the variation in patient waiting time is the individual's movement on the waiting list. Whether or not a patient is moved ahead or experiences a delay due to the ascent of others will significantly affect their individual waiting time compared to those who do not move on the list. The results clearly indicate that as patients experience greater delays (jumps) on the waiting list, their waiting times are significantly longer (shorter) compared to those who do not move at all. Although the effects were not always consistent across all patient groups, there does appear to be a consistent and significant pattern across procedure groups.

Given these results, it is important to determine why and under what circumstances patients move on the waiting list. While the movement of urgent/emergent cases appears to be transparent, it is less clear why and under what circumstances elective cases move on the list. There may be several possible explanations. It is conceivable, for example, that a patient's clinical status may deteriorate relative to others waiting on the list, thus increasing the urgency for surgery but perhaps not to the extent that warrants urgent or emergency care and a formal change in patient status. In such cases, patient prioritization among elective cases may appropriately explain some of the movement. Alternatively, patients booked for surgery may choose to postpone care due to personal reasons thus resulting in possible delays.

Conversely, evidence is emerging that suggests that patient access to services may be affected by non-clinical factors (see Chapter 2). It may be the case that elective patients in the SWL are also moving on the waiting list for reasons that are not related to their clinical status (e.g. social status, personal relationships with physicians). Unlike movement due to changes in clinical status, these situations could compromise equitable access to care.

As expected, patients placed on the waiting list earlier in the course of care (i.e. after the first of several visits or during the course of care) appeared from the data to experience longer waits compared to those who were placed on the list immediately after their final pre-surgical consultation. Furthermore, the time when patients are placed on the hospital waiting list, relative to the decision to treat, also affects waiting times. These results have significant implications for calculating and comparing waiting times both within and across procedure groups. Waiting times may appear to be longer or shorter depending on the procedures and practices of physicians and hospitals. Differences in waiting times may be in part due to differences in waiting list management practices as opposed to actual differences in the amount of time patients wait for care.

Patients placed on the waiting list during or immediately preceding a hospital slow down experience longer waits compared to those who are placed on the list at other times. There are several factors that may explain this result. First, patients may choose not to undergo surgery during traditional holiday times; postponing surgery would likely lead to increased waiting times. Second, while this factor was measured at the individual level, it represents the organization and management of resources at the physician and hospital level. For similar reasons, operating capacity is reduced during these times thus, prolonging the waits for patients who would have been scheduled for surgery during this time.

The effects of surgical workload and waiting list size were consistent across procedure groups. The average number of surgeries performed on a monthly basis was consistently positively associated with patient waiting time. While the effect size was small, this essentially implies that the more surgery an individual physician performs, the longer his/her patients may wait. This result contradicts the commonly held belief that increasing surgical output will decrease patient

waiting time, at least at the physician level. The results also indicate that patients waiting on longer waiting lists experience longer waits compared to those placed on shorter lists. While the association between waiting times and waiting list size has often been assumed to be positive, there has been little empirical evidence to confirm this. This result indicates that there may be implications for placing patients on longer waiting lists. Information regarding shorter versus longer physician waiting lists may be best provided via a centralized waiting list system operating at the regional or provincial level such as the SWL registry.

Finally, the effects of hospital variables on patient waiting times were mixed and/or difficult to interpret. Hospital LOS, for example, was consistently negatively associated with patient waiting time; that is, patients receiving care at hospitals with lower average LOS demonstrated longer waiting times. The result is the opposite of what was expected. It was hypothesized that LOS would be positively associated with waiting times; longer (shorter) LOS was assumed to result in lower (higher) surgical outputs due to lower (higher) availability of beds resulting in longer waits for inpatient cases. However, surgical throughputs at the hospital level was not consistently associated with waiting times. The total number of operative cases was positively (but not significantly) associated with waiting times for KR and was negatively (and significantly) associated with waiting times for HR. Furthermore, the type of surgery performed (knee replacements and hip replacements) were also not significant. Hence, there does not appear to be a consistent negative association between surgical volume and waiting time as is often assumed.

However, the nature of the operative cases appears to matter. As the proportion of operative cases performed on an urgent basis increases, so to do waiting times. Hence, if operating resources are being used on an ever-increasing number of urgent cases, there will likely be fewer

resources available for predominantly elective procedures such as knee and hip replacements and cataract surgeries. Based on these results, the issue of the effect of hospital resources on waiting times appears to focus on the use or distribution of resources across the spectrum of services offered within hospitals.

The policy implications of these and previous results will be discussed in the final chapter.

CHAPTER VI

POLICY IMPLICATIONS

The primary objective of this study was to contribute to our understanding of the nature of waiting lists and waiting times. It attempted to do so by critically reviewing the existing literature, assessing the accuracy of the waiting list data and developing a conceptual framework, to guide the study of factors that affect patient waiting time for knee and hip replacement and cataract surgery. Several of the key findings of the study may have policy and research implications for waiting lists and waiting times in BC and elsewhere. Overall, the results of this study, along with emerging evidence of effective policy options tried to date, point toward the use of policies that focus on managing waiting lists in an attempt to standardize and improve the accuracy of waiting list data, prioritize patients and manage patients awaiting care.

6.1 POLICY IMPLICATIONS

6.1.2 Standardization of Waiting List Data

The results of the literature review revealed several key insights regarding the state of our collective understanding of waiting lists and waiting times, and highlighted several key problems. Specifically, the review pointed to the need to ensure the consistent use of accurate measures and high quality waiting list data. The range of definitions and methods used to define and calculate waiting time points to the need to ensure that such indicators are valid and are defined and measured consistently across physicians and hospitals and, where appropriate, across

procedure groups. To achieve this goal, consensus must be reached in two key areas: a standard definition of waiting time and standard measures of date-on and date-off the waiting list.

Standard Definition of Waiting Time

The literature offers a range of definitions of waiting times used to date in various jurisdictions. These range from the broadest of definitions, "total waiting time" representing patients' wait for care beginning with a visit to the GP to treatment, to a more specific definition of hospital waiting time. There is currently no universally accepted definition of waiting time in Canada. In BC, the SWL data compiled by the Ministry of Health clearly represents the waiting time for hospital services. While this definition was consistently used by the Ministry, it is not universally accepted in BC by all stakeholder groups. The BCMA, for example, argues that this waiting time does not accurately reflect the "total" amount of time patients must wait for care. This disagreement has led the Association to collect their own data to provide a "more accurate" picture of waits for care in BC and it is no surprise that these estimates do not agree.

Before we can begin to develop policy options to address the issue of waiting list and waiting times, we need to have an accurate assessment of the current state of patient waits. While there will always be disagreement regarding the extent of the problem, there must be a degree of consensus regarding the nature and accuracy of the data used to provide this information. If there are disagreements regarding the definition of waiting times and numerous sources of information, then it becomes difficult, if not impossible, to reach consensus among key stakeholder groups regarding the current state of affairs. The standardization of waiting time data, therefore, must begin by building consensus around the basic definition of waiting time, specifically, what waiting period should be captured by the data.

Standard Measure of Waiting Time

The second step in the standardization of waiting list data must focus on the development of standard measures of waiting time and overall data quality. The lack of standard definitions and methodologies to guide the collection of waiting time data has been and continues to be a problem in Canada. There are currently no universally applied guidelines or criteria regarding patient placement on waiting lists for most surgical procedures. Cardiac care is perhaps the only exception where, in Ontario, standardized criteria developed by the Cardiac Care Network (CCN) are used to determine precisely when patient waiting time begins for coronary revascularization and angiography.

A thorough assessment of the SWL data was conducted to ensure the quality and accuracy of the data. These results have implications for the collection and analysis of waiting time data in BC and in other jurisdictions. The results of the analysis confirmed the accuracy of the patient, physician and hospital information provided for those patients identified in the SWL. These results were consistent across hospitals. The use of additional administrative data sets allowed for a thorough analysis of the construct validity of waiting time (i.e. date-on and date-off the waiting lists). As expected, the majority of patients (>90%) were removed from the waiting list on the day of surgery, a finding that was consistent across hospitals. There was, however, a degree of variation regarding when patients were placed on the waiting list. Approximately two-thirds of knee replacement (63.7%) and hip replacement (68.4%) patients and over 75% of cardiac surgery cases, with one or more pre-surgical consultation(s), were placed on the waiting list following their last or only consultation; just over half of the cataract cases (54.7%) were placed on the list at this time. The remaining cases across all procedure groups were placed on the list either before their first visit, after their first of several visits or during the course of care. Once again, the findings were fairly consistent across hospitals.

Results of the regression analyses indicate that when patients are placed on the waiting list matters for patient waiting times. The point during the course of care when patients are placed on the list as well as when, following the decision to treat, they are placed on the hospital list appears to affect patient waiting times. The analysis clearly demonstrated that patients placed on the list earlier in their course of care experience longer apparent waits compared to those placed later. As well, patients placed immediately following the decision to treat have longer reported waiting times compared to those placed some time after. These factors were demonstrated in the regression analyses to significantly affect patient waiting time.

Despite the lack of guidelines in BC, the results of this study, as noted above, indicate that there is varying levels of agreement regarding when patients are put on and taken off the waiting list in all four procedure groups. Efforts to standardize the indicators used to measure waiting times should build on this information. In the case of procedure groups with higher levels of agreement, the process may begin by making more explicit the implicit practices of physicians and hospitals when placing patients on the waiting list. For knee and hip replacement, therefore, date-on the waiting list may be defined as the last visit prior to surgery since this is likely when the decision to treat is made. For procedures lacking certain levels of agreement, the work must begin by building consensus among practitioners and hospital representatives regarding the most appropriate time to place patients on the list. Standard methods would certainly work to increase the consistency of waiting time reports both across different levels (i.e. regional, hospital, physician) and different specialty groups in jurisdictions across the country.

6.1.2 Completeness of Waiting List Data

Perhaps the only source of concern regarding the SWL data was the accuracy of the waiting list size. The results of the validity assessment of waiting list size revealed that in fact the SWL does

not represent all non-urgent/emergent knee and hip replacement, CABG and cataract surgeries performed in the participating hospitals during the study period. The accuracy of the counts varied across physicians and hospitals. As discussed in Chapter 4, there may be cases in which patients require services on an emergent basis and, therefore, were not placed on a waiting list at all. However, there were also urgent and elective cases identified in the hospital data that in fact were not identified in the SWL data. One would expect that these cases should have been placed on the waiting list, even if for a short period of time in the case of urgent patients. These omissions may have implications for the interpretation of waiting list data and management of waiting lists.

While much emphasis is appropriately placed on waiting times rather than waiting list size, it remains important to ensure that the data accurately represent all cases waiting for surgery. The SWL data are currently used by the BC Ministry of Health to provide up-to-date information on the status of waiting lists in the province. The data are used to generate bi-annual "Waiting List Reports" and are also available via the Internet. The data, therefore, may be used by physicians and hospitals to set policies and make decisions, such as allocating resources, to address perceived problems with waiting lists and waiting times. Patients may also use this information to make informed decisions about their course of care. It is important, therefore, that the information be as accurate as possible and reflect the true state of waiting lists as they exist in the province.

Second, the results of the literature review indicated that waiting lists are often interpreted as a measure of "need" or "demand" for services or as a measure of inadequate resources although the concepts of need and demand are often vague. In many provinces, resource allocations within the health care sector have been made to directly address the issue of waiting lists and

waiting times (Manitoba Health, 1995 (a) (b); Alberta Health, 1996; Ontario Ministry of Health, 1997). The Ministry of Health in BC, for example, has allocated millions of dollars of targeted funding to reduce waiting lists for specific procedures. Between 1991 and 1997, the Ministry reportedly spent $120 million to reduce waiting lists for procedures such as cardiac care, dialysis, cancer and other services (BC Ministry of Health 1997 (a) (b)). Whether or not this is the most effective long-term policy response to waiting lists can be debated. The fact is that decisions such as these are being made in BC and across the country and it is imperative that they be based on accurate and reliable information. Furthermore, any attempt to determine the effects of such policies (e.g. actual reductions in waiting list size) will be seriously threatened without accurate data.

Finally, if the data continue to be used for research purposes, any further problems regarding the completeness of the data could compromise the quality of the research. For these reasons, efforts should continue to ensure that the SWL data be as complete and accurate as possible.

6.1.3 Managing Waiting Lists

The emerging evidence appears to support policy efforts aimed at managing waiting lists, specifically practices that promote standardized patient prioritization and active management once patients have been placed on the waiting list. Intra-procedure variation in waiting times across different levels has been demonstrated in various studies, including this one, across a range of procedures. While the evidence is still at a nascent stage, patient factors, both clinical and non-clinical, have been shown to play a role in explaining the variation. Patient prioritization and management practices may effectively reduce the variation in patient waiting times and may reduce waits for specific groups of patients, particularly when this strategy is

coupled with the establishment of expected or acceptable waiting times of each priority grouping.

Patient Prioritization

Patient prioritization has been identified as one of the key steps in effectively managing waiting lists. Priority ranking of patients has been instituted at the regional and national level in various jurisdictions. Faced with increasing waiting times in the late 1980s, health departments in selected regions of Australia and New Zealand adopted similar approaches developing priority criteria to manage hospital waiting lists for a broad range of procedures. In Australia, patients were classified as either urgent, semi-urgent or non-urgent, requiring admission within 30 days, within 12 weeks and after 12 weeks respectively. Although the evidence is somewhat limited, there are clear indications that these strategies worked to appropriately prioritize patients as well as identify those patients who may be waiting too long (Beaumont, 1993; Agnew et al., 1994; Duckett, 1995; Street & Duckett, 1996; Hadorn & Holmes, 1997(a) (b); Doogue et al., 1997).

The situation regarding prioritization and waiting list management is less clear in Canada. A recent national survey of hospitals, Regional Health Authorities and cancer agencies revealed that, with few exceptions, standardized criteria are not being used to prioritize patients (McDonald et al, 1998). Once again, the best known example of patient prioritization is in Ontario for cardiac care. Patients entering the CCN are assigned an urgency rating score used to prioritize patients based on clinical need and an expected waiting times to ensure timely access to care.

In BC, the SWL data indicate that patients are assigned a priority ranking identifying them as either elective, urgent or emergent. Results of the regression analyses, indicate that these

rankings do explain some of the variation in patient waiting times remaining consistently highly significant ($p<.001$) during the model development process (i.e. Model 1 – Final Model) for all three procedure groups. Furthermore, evidence that urgent and emergent cases experience waits that are between 44% and 56% shorter compared to elective cases confirms that these rankings to are used to prioritize patients and seem to be doing so effectively. However, there was no information available regarding the criteria used to assign patients nor with which to assess consistency of application across hospitals and physicians. This appears to be the situation in many other jurisdictions in Canada, where patients may well be prioritized for care, but most likely at the physician level with implicit criteria. There is virtually no information available to determine the nature and extent of more comprehensive prioritization efforts or how consistent they might be.

Prioritizing patients, therefore, must begin with the identification of the factors and weightings currently used by physicians to classify patients as elective versus urgent/emergent. This process would essentially make explicit the implicit decisions physicians are making every day. This information in addition to available clinical information regarding patient clinical status and outcomes can be used to standardize patient prioritization. This process has begun in Canada through the work of the Western Canada Waiting List Project. This initiative represents a partnership of regional health authorities, medical associations, provincial Ministries of Health and academics in the four western provinces. The primary objective of the project is to develop priority tools to rank patients in a standardized manner based on the best available evidence and clinical practices. The tools essentially provide a priority score based on the patient's clinical, functional and social conditions. This work is currently being conducted for selected procedures including knee and hip replacement and cataract. This work may be expanded to include the establishment of expected or reasonable waits in the future but do not do so at this point

(WCWL, 2000). If proven valid and reliable, this type of tool can be used to ensure that patients are prioritized in a standardized manner both in BC and across Canada.

Managing Patients on Waiting Lists

Once patients are prioritized, active management of the waiting list can be used to follow patients throughout their wait, track patient movement on the list and ensure that patients receive care in a timely manner. Once again, there is very little evidence regarding the active management of waiting lists for hospital services in Canada. The best known example of systematic and coordinated waiting list management is the CCN in Ontario used to manage patients awaiting cardiac surgery. The Network was established to manage and coordinate care for patients awaiting cardiac surgery or catheterization. The Network includes all patients in Ontario awaiting care in one of the 8 participating surgical centers and 4 catheterization laboratories. Patient information is entered into a provincial registry managed by nurse coordinators at each site; the data are used to manage cases and provide information to physician and patients. The experience to date indicates that the system has effectively prioritized patients, reduced waiting times and minimized adverse critical events (CCN, 1997).

The results of this study clearly indicate that patient movement on the waiting list explains a significant amount of the variation in patient waiting time for selected procedures in BC. This study represents one of the first attempts to measure the effects of patient movement on a waiting list. The results indicate that patients who move ahead can experience waits that are up to 75% shorter compared to patients who do not move. Conversely, patients who are delayed can experience waits up to 150% longer than those who do not move. The information available in the SWL data does not permit a thorough analysis of this phenomenon to determine why patients move and to what extent the movement is due to clinical versus non-clinical factors. Some of this

movement may in fact occur due to prioritization of cases once patients have been placed on the list. Patients who may experience declines in clinical status relative to those around them may be moved ahead in order to access care in a more timely manner. Some of the movement, however, may be due to non-clinical factors. Emerging evidence suggests that factors such as personal relationships or position in one's community may in fact result in queue jumping (Atler,1998). Additional information such as changes in clinical status, patient decision-making regarding timing of surgery, socio-economic status, previous experience with waiting lists and nature of the patient's relationships with both the surgeon and hospital, can be used to conduct a more in-depth analysis of this phenomenon.

This raises several issues regarding the management of patient waiting lists. First, the possibilities as outlined above, raise concerns regarding the fairness of waiting lists and the need to manage patients on the list to ensure that those with greater clinical need are the first to receive care (Daniels, 1984; Naylor, 1991; Doyal, 1995). Thus, if a patient does move ahead of others on the list, it must be for reasons that are justifiable and acceptable.

Second, while patient movement on the waiting list may bring shorter waits for some, it will inevitably result in longer waits for those who are delayed. Not surprisingly, evidence is emerging regarding the adverse effects of lengthy waits for care. Several studies have been conducted in the UK to assess the physical, social and economic problems among patients awaiting surgery. The results reveal that many patients suffer high levels of pain (Freeland & Curley, 1987; West et al., 1991; Rigg, 1994; Roy & Hunter, 1996; Williams et al., 1997), stress and anxiety (Bishop, 1990; Underwood et al., 1993; Bengston et al., 1994; Martin, 1995; Petrie et al., 1996) and other problems including reduced employment and dissatisfaction with the quality of their lives (i.e. social life) (Mulgan, 1990; West et al., 1991; Rigg, 1994; Hall & Hall,

1996). It is important, therefore, to ensure that movement on the waiting list is appropriate and does not lead to excessive delays for other patients that may ultimately lead to adverse health effects.

Finally, managing patient waiting lists also provides the opportunity for regular list audits in which patient are routinely monitored to ensure that those on waiting lists in fact need and want to receive treatment. The evidence presented in the literature review, strongly suggests that list audits (most in the UK) can result in reductions in waiting list size; in some cases, between 30% and 50% of cases were removed as a result of auditing. While many have argued that the focus should be placed on the length of the waiting times rather than waiting list size, the findings of this study suggest that there may be a positive association between patient waiting time and the length of a physician's waiting list; patients can experience up to a 3% increase in waiting time for every additional person placed on the waiting list (Chapter 5). Waiting on a lengthy queue may have adverse effects for individual patients. In addition to contributing to the accuracy and validity of waiting list information, list audits may also have a positive effect on waiting times as noted above. The removal of patients who no longer require or want care may have a positive effect on aggregate measures of patient waiting times, and may result in more timely access to care for those patients remaining on the list. This type of monitoring is possible through waiting list management.

Waiting lists will almost certainly continue to exist in Canada and will undoubtedly continue to be used as indicators of problems with access to care (Buske, 1997). It is imperative, therefore, that lists be properly managed and monitored to protect patients and ensure equitable access to health care services. Waiting list can technically be managed at various levels ranging from the level of the individual physician to the provincial level. This process is likely to be most

effective if lists are maintained centrally including all patients or all physicians in a particular hospital or region for a given procedure (Bell, 1988). Alternatively, the catchment area can be defined as those who are going to access common resources such as diagnostic facilities or operating suites.

6.1.4 Increasing Resources

A discussion regarding policy options for dealing with waiting lists and waiting times would not be complete with out addressing those policies that support increasing resources. Over the past several years, the issue of waiting lists and waiting times has become key in the debate about health care funding and access to health care services. Many have and continue to argue that the most effective course of action is to increase funding to hospitals and other sectors experiencing long waits. In a recent survey of government officials, hospital administrators and members of various health care organizations, respondents were most likely to point to increased funding as the solution to the waiting list problem (Shortt & Ford, 1998; Shortt et al., 1998). As previously mentioned, many provincial Ministries of Health have adopted policies of targeted funding to address lengthy lists and waits for selected procedures. In many cases, governments have declared victory arguing that increased funding resulted in shorter lists and shorter waits (CNN, 1997; BC Ministry of Health 1997 (a)(b); Ontario Ministry of Health, 1997; Fayerman, 1997). There have not been, however, any formal evaluations of these policies to assess the short and long term effects.

The international experiences indicate that increased funding at the global or targeted levels does not result in sustained decreases in waiting list size and times over the long-term. The UK has struggled with waiting lists since the inception of the National Health Service. Since the late 1980's, when waiting lists gained significant political attention, the Department of Health has

introduced a series of policies to reduce waiting lists and times. In 1987, the Waiting List Initiative represented the first national waiting list policy aimed to eliminate waits of more than 2 years. Funding was available to Regional Health Authorities and hospitals to implement strategies approved by the Department of Health to reduce waiting lists and times (Drake, 1991; Department of Health, 1998). In 1992, Waiting Time Guarantees were introduced as part of the Patient's Charter guaranteeing patients admission to hospital within 2 years of placement on a waiting list. The Charter was revised in 1995 reducing the guaranteed time to 18 months (NHS, 1995). Despite the availability of national waiting list data, there has been little formal evaluation of these policies. Several independent studies, however, conducted in selected regions and/or hospitals concluded that, in many cases, targeted funding provided as a result of the Initiative reduced waiting lists in the short-term (Thomas et al., 1989; Lee et al., 1992; Mills et al., 1991; Mackinnon et al., 1992; Parmar, 1993; Harvey et al., 1993; Mobb et al., 1994). A single national study conducted using waiting list and hospital admission data concluded that the provision of additional funding was followed by a period of increased admissions to hospitals; however, this was followed by increases in the number of patients placed on the waiting list (Newton et al., 1995). There is little information regarding the effect of the Waiting Time Guarantees. National reports indicated that there were decreases in the number of patients waiting more than 2 years but these decreases were not sustained over the long-term. Furthermore, there were substantial increases in the number of patients waiting less than 2 years. Some argued that while the targeted funds may have benefited those waiting longer, the benefits may have come at the expense of those waiting less than 2 years or 18 months. Concerns were raised that funding targeted to reduce lengthy waits benefited patients waiting at the expense of others (Yates, 1991; Appleby, 1993; Umeh et al., 1994).

A similar policy was adopted in Sweden in 1992 for selected surgical procedures. The policy was multi-pronged combining targeted funding with waiting time guarantees. Patients placed on hospital waiting list were guaranteed admission to hospital within 3 months. If the hospital could not provide services within the guaranteed time, patients had the right to request treatment by another hospital or within a private clinic at the expense of the resident hospital. Additional funding was provided to help hospitals meet their targets. Initially the policy was to be implemented for one year but was later extended from 1993 to 1995. Additional resources, however, were not provided during the extension. Once again, the evidence regarding the effectiveness of the policies is limited but suggests that waiting list size and waiting times were reduced but not for long; two years following the introduction of the policy, waiting lists and waiting times had increased and hospitals were not able to honor the waiting time guarantees. Waiting times increased in part because patients chose to wait instead of being transferred to another hospital (Hanning et al., 1996; Lundstrom et al., 1996; Hanning et al., 1998).

Proponents of increased funding have also argued that private health care can solve the waiting list problems in the public system (Kennedy, 1997; Mulawka, 1997). The introduction or expansion of or private sector health care will relieve the pressures on the public system by diverting patients to the private system thus freeing up more resources in the public system. This could be achieved by introducing a public system where it currently does not exist or provide subsidies to public sector patients to use in the private sector (Cullis & Jones, 1983, 1985). While there is limited evidence regarding the effectiveness of this approach, that which is available does not appear to support this argument. Evidence from the UK where private and public systems coexist suggests that private sector health care actually has adverse effects on public sector waiting times (Richmond, 1996; Light, 1997; Iversen, 1997). Regions with higher levels of private hospital beds demonstrated higher public sector waiting times (Yates, 1995).

Furthermore, when the public sector waiting times of physicians working exclusively in the public sector compared those working in both the private and public sectors were compared, the latter group demonstrated higher waiting times for public patients (Harvey, 1993). Similar conclusions were reached in studies conducted in Manitoba and Alberta among ophthalmologists performing cataract surgery. Physicians performing surgery in both the public system and private clinics demonstrated higher public sector waiting times compared to their colleagues working exclusively in the public system (CAC, 1994; DeCoster et al., 1999).

While this study did not directly address the effects of increased resources on waiting lists and waiting times, various physician and hospital factors representing surgical outputs were used to proxy resource use. The results of this study, therefore, may in fact help shed some light regarding the effectiveness of these types of policies. Results of the regression analyses presented in Chapter 5, indicate that hospital factors do not play as major a role in determining individual patient waiting time compared to individual patient factors. Furthermore, the results regarding hospital output were mixed and did not demonstrate a consistent inverse association with waiting times at the individual as is often hypothesized. It is possible, as has been demonstrated, that increased resources may reduce waiting lists and times over the short period. However, other factors such as those representing patients experiences and to some extent, use of resources (i.e. type of admissions) may be more important in affecting waiting times over the long term.

6.2 STUDY LIMITATIONS

Despite all attempts to be as comprehensive as possible, there are several limitations to this study. The generalizability of the study results is limited for several reasons. First, the study is

based on data representing only one province, BC. It is not clear whether or not these results apply to other jurisdictions across Canada. Second, the analyses are limited to selected surgical procedures. However, given the consistency in most of the results of both the data assessment and regression analyses across the four procedure groups, the results of this study can be generalized to other similar surgical procedures. Given the availability of data, the methods used in this study can be applied to procedures that significantly differ from those in this study (e.g. diagnostic procedures) to determine if the results are generalizable to a broader range of procedure groups. Finally, concerns regarding the validity of waiting list size may restrict the generalizability of the results to patients who have been placed on the SWL as opposed to the universe of cases awaiting care in BC. A more detailed analysis comparing patients who have and have not been placed on the waiting list by procedure group is required to determine if there are any systematic differences and to determine whether these differences may affect the waiting experiences of patients.

Waiting times as defined for the purposes of this study included only the waiting period between placement on the hospital waiting list and the date of surgery. As is outlined in Chapter 3, patients may have to wait at several points during their course of care, including before and after GP visits, initial consultations and diagnostic tests, if required. The study did not consider other potential waiting periods.

Given data availability, only a limited number of patient, physician, and hospital variables could be considered in the model. The model variables were selected to represent various factors identified in the literature and represented in the theoretical framework as potentially affecting patient waiting time. This framework guided much of the work conducted on the factors affecting patient waiting times. Despite attempts to be as comprehensive as possible, there were

several factors identified in the framework but not considered in the regression models such as information on patient preferences, waiting list management practices of both physicians and hospitals and the effects of broader health policies. Furthermore, the variables used may not fully represent the impact of a specific factor. For example, physician access to hospital services was represented by the number of hospitals to which physicians admitted patients. More precise information regarding physician access to operating suite time within hospitals may provide additional information regarding this particular factor. Similarly, the variables used to represent hospital resource availability, including human resource availability, and use may not have fully captured the overall effect of hospital resources on patient waiting time. More specific information regarding the allocation of resources across competing departments and specialties within hospitals would contribute to this type of analysis.

Finally, the analyses were based on waiting times measured at the individual patient level. While this was the most appropriate level at which to assess the validity of the data, the results of the regression analyses may not be directly applicable to waiting times measured at the physician or hospital levels. It is not clear at this time to what extent factors affecting individual patient waiting times also affect waiting times measured at the physician or hospital level. For example, patient movement (MOVE) on the waiting list was found to significantly affect patient waiting time. However, the effect of patient movement on waits measured at the physician or hospital level may not be significant since the effect of patients who move ahead (i.e. decreased waiting times) would be countered by the effects of those who are delayed (i.e. increased waiting times). Hence, the aggregate effect of patient movement on physician level waiting times may be negligible. Conversely, the effect of physician and hospital level factors on aggregated measures of waiting times may differ compared to their effects on individual patient waiting times. For example, the effect of physician surgical workload patterns (AVSURG) may be more directly

evident at the physician level if there is a clear pattern among physicians such that those with higher rates of surgery have longer median (mean) waiting times compared to those performing less surgery. This pattern may be masked at the patient level due to the high variance in waiting time across patients at the physician level.

Several methods are available to test these and other hypotheses regarding the effects of various factors on patient and hospital level waiting times. Regression analyses can be conducted on aggregated measures (i.e. median or mean) of physician and/or hospital waiting times after adjusting for the effects of patient factors. Alternatively, multi-level models may be used to assess the variation in patient waiting times at each level of aggregation (i.e. patient, physician, hospital) simultaneously. This more sophisticated analysis was not possible at the time of this study but is certainly worth considering for future analyses. Regardless of the type of choice of methods, regression based analysis must address the issue of autocorrelation as was done in this study.

6.3 NEXT STEPS

The evidence regarding the nature of waiting lists and waiting times and the factors affecting them remains rather rudimentary. Research efforts should continue to be supported in order to build a critical mass of evidence in this field of study. Future research efforts, however, must be based on valid and reliable data and must inform the policy debate regarding waiting lists and waiting times. This requires several key steps.

First, efforts to collect standardized and accurate waiting list data should be supported and promoted at the hospital, provincial and national levels. Waiting list data should include the

patient, physician and hospital information currently being collected by the SWL with additional information regarding patient experiences while on the waiting list. The availability of waiting list data at the provincial level can provide valuable information regarding the state of waiting lists and waiting times for a broad range of procedures across various levels. Furthermore, these data can be used as is or in conjunction with other data sources by researchers to investigate various aspects of waiting lists and waiting times. The availability of such data in BC was critical for this particular study.

Second, efforts to further investigate the nature of waiting lists and waiting times should be supported and promoted. The research should proceed in several directions. For examples, the methods used in this study could be applied to other procedures represented in the SWL (and other sources of data) to determine if the results are generalizable to a broader range of procedure groups. The analyses could also be expanded to include a broader range of factors. This may require additional sources of information beyond what is available in administrative data sets. Qualitative data may be used to investigate the effects of decisions made by patients regarding their care or the effects of decisions made at the hospital level regarding the allocation of resources on waiting lists and waiting times.

These research efforts, however, should not stop at simply the identification of factors affecting waiting lists and waiting times, but must also seek to uncover the nature of their associations to these phenomena. This may involve more in-depth analyses of those factors identified as significantly affecting waiting lists and waiting times such as, patient movement on the waiting list. Alternative analytical models, such as those provide in economics and queuing theory, may also contribute to exploration of these relationships (George et al., 1983; McQuarrie, 1983; Worthington, 1987; Iversen, 1993).

Finally, future research efforts should continue to contribute to and inform the policy debate surrounding waiting lists and waiting times that is likely to continue in this country. Relevant research findings from studies such as these should continue to be made available to those who are currently faced with the difficult decisions that must be made regarding waiting lists and waiting time in an environment often characterized by competing sources of information and interests. Hopefully, this study has contributed in some way to a more comprehensive understanding of waiting lists and waiting times.

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APPENDIX A

Table A-1: Date of first submission to the SWL and number of cases by hospital (No. of Physicians)

Hospital	Date of First Submission	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/ LensSurgery
1	Aug 92	395 (7)	805 (12)	1100 (12)	4033 (22)
2	Jan 93	493 (7)	480 (9)	1678 (17)	1963 (20)
3	June 92	47 (2)	56 (3)	0 (0)	3533 (9)
4	May 92	0 (0)	0 (0)	0 (0)	1360 (7)
5	Mar 92	329 (6)	323 (6)	658 (7)	1 (1)
6	Mar 92	259 (2)	185 (2)	0 (0)	4349 (17)
7	June 92	411 (4)	461 (5)	0 (0)	4007 (6)
8	Jan 95	107 (5)	115 (5)	0 (0)	916 (2)
9	Apr 96	12 (1)	62 (5)	0 (0)	372 (3)
10	May 93	23 (1)	3 (1)	87 (3)	963 (4)
11	July 93	200 (5)	294 (6)	17 (3)	2431 (11)
12	Mar 93	71 (3)	115 (3)	0 (0)	1252 (3)
13	June 93	0 (0)	1 (1)	0 (0)	16 (2)
14	Oct 91	275 (9)	429 (10)	483 (6)	4795 (13)
15	Apr 92	104 (3)	113 (4)	0 (0)	848 (8)
16	June 93	0 (0)	4 (1)	0 (0)	581 (4)
17	Sept 93	158 (3)	170 (3)	0 (0)	670 (3)
18	Jan 93	532 (7)	423 (7)	1 (1)	617 (9)
19	July 93	81 (4)	183 (4)	0 (0)	1533 (4)
20	July 92	185 (7)	235 (8)	0 (0)	2328 (3)
21	Apr 92	336 (5)	290 (5)	0 (0)	3011 (4)
22	June 95	95 (2)	88 (2)	2 (1)	575 (3)
23	Mar 93	99 (2)	125 (2)	0 (0)	0 (0)
24	Aug 95	41 (2)	0 (0)	0 (0)	396 (2)
25	Oct 95	17 (4)	12 (3)	0 (0)	28 (3)
26	May 93	214 (4)	161 (4)	1 (1)	1577 (4)
27	Apr 93	24 (3)	48 (3)	0 (0)	384 (2)
28	Aug 95	2 (1)	2 (1)	0 (0)	41 (2)
29	Feb 93	8 (1)	8 (1)	0 (0)	153 (2)
30	July 93	0 (0)	17 (3)	0 (0)	49 (3)
31	May 93	0 (0)	0 (0)	0 (0)	364 (3)
Total		**4518**	**5208**	**4027**	**43,146**

Table A-2: Number of physicians and number of patients per physician by procedure

	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/ LensSurgery
No. of Procedures				
0-49	63	74	32	58
50-99	21	26	2	10
100+	10	10	15	82
Total	94	110	49	150
Min/Max	1/370	1/484	1/489	1/1962
Median	27	32	12	154
Mean	48	47	82	287
Median Percentile*	15	17	6	21

Note: *Median Percentile: number of physicians providing 50% of procedures

APPENDIX B

Table B-1: Results of validity assessment of hospital number by hospital (% of matched cases within hospital)

Hospital	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1	285 (100%)	639 (100%)	844 (99.8%)	3369 (100%)
2	333 (100%)	354 (100%)	1054 (99.9%)	1517 (99.9%)
3	41 (100%)	54 (100%)	n/a	3284 (99.9%)
4	n/a	n/a	n/a	1140 (99.9%)
5	213 (100%)	222 (98.2%)	523 (100%)	n/a
6	159 (100%)	126 (100%)	n/a	3414 (99.9%)
7	183 (99.5%)	243 (99.6%)	n/a	2411 (99.9%)
8	69 (100%)	87 (100%)	n/a	729 (100%)
9	3 (100%)	34 (100%)	n/a	175 (100%)
10	18 (100%)	3 (100%)	n/a	663 (100%)
11	143 (100%)	209 (100%)	n/a	1981 (99.9%)
12	40 (100%)	83 (100%)	n/a	1064 (100%)
13	n/a	n/a	n/a	13 (100%)
14	23 (13.7%)	51 (16.4%)	14 (3.5%)	1394 (46.6%)
15	57 (100%)	82 (100%)	n/a	632 (99.8%)
16	n/a	2 (100%)	n/a	462 (100%)
17	n/a	n/a	n/a	n/a
18	304 (100%)	265 (100%)	n/a	323 (100%)
19	29 (100%)	141 (100%)	n/a	1092 (99.9%)
20	117 (100%)	169 (100%)	n/a	1882 (100%)
21	204 (100%)	174 (100%)	n/a	1670 (100%)
22	60 (100%)	63 (100%)	n/a	462 (100%)
23	62 (100%)	73 (100%)	n/a	n/a
24	7 (100%)	n/a	n/a	99 (100%)
25	12 (100%)	9 (100%)	n/a	20 (100%)
26	134 (100%)	118 (100%)	n/a	1013 (100%)
27	16 (100%)	41 (100%)	n/a	331 (100%)
28	1 (100%)	n/a	n/a	20 (100%)
29	n/a	n/a	n/a	106 (100%)
30	n/a	9 (100%)	n/a	34 (100%)
31	n/a	n/a	n/a	233 (100%)
Total	**2513 (94.5%)**	**3251 (92.5%)**	**2435 (86.2%)**	**29,533 (94.8%)**

Table B-2: Results of validity assessment of procedure information by hospital (% of matched cases within hospital)

Hospital	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1	285 (100%)	637 (99.7%)	830 (98.1%)	3362 (99.8%)
2	331 (99.4%)	353 (99.7%)	970 (91.9%)	1462 (96.3%)
3	41 (100%)	54 (100%)	n/a	3279 (99.8%)
4	n/a	n/a	n/a	1132 (99.2%)
5	213 (100%)	226 (100%)	478 (91.4%)	n/a
6	158 (99.4%)	126 (100%)	n/a	3410 (99.9%)
7	183 (99.5%)	243 (99.6%)	n/a	2404 (99.6%)
8	69 (100%)	87 (100%)	n/a	729 (100%)
9	3 (100%)	34 (100%)	n/a	175 (100%)
10	18 (100%)	3 (100%)	n/a	661 (99.7%)
11	140 (97.9%)	205 (98.1%)	n/a	1972 (99.5%)
12	40 (100%)	83 (100%)	n/a	1063 (99.9%)
13	n/a	n/a	n/a	13 (100%)
14	168 (100%)	309 (99.4%)	397 (99.3%)	2984 (99.7%)
15	57 (100%)	80 (97.6%)	n/a	610 (96.4%)
16	n/a	2 (100%)	n/a	448 (97.0%)
17	n/a	n/a	n/a	n/a
18	302 (99.3%)	264 (99.6%)	n/a	321 (99.4%)
19	29 (100%)	141 (100%)	n/a	1084 (99.2%)
20	117 (100%)	168 (99.4%)	n/a	1878 (99.8%)
21	204 (100%)	174 (100%)	n/a	1665 (99.7%)
22	60 (100%)	63 (100%)	n/a	461 (99.8%)
23	62 (100%)	73 (100%)	n/a	n/a
24	7 (100%)	n/a	n/a	99 (100%)
25	12 (100%)	9 (100%)	n/a	20 (100%)
26	134 (100%)	118 (100%)	n/a	1012 (99.9%)
27	16 (100%)	41 (100%)	n/a	328 (99.1%)
28	1 (100%)	n/a	n/a	20 (100%)
29	n/a	n/a	n/a	106 (100%)
30	n/a	9 (100%)	n/a	33 (97.1%)
31	n/a	n/a	n/a	233 (100%)
Total	**2650 (99.7%)**	**3502 (99.6%)**	**2675 (94.7%)**	**30,964 (99.4%)**

Table B-3: Results of validity assessment of physician identifier by hospital (% of matched cases within hospital)

Hospital	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1	269 (94.4%)	596 (93.3%)	819 (96.8%)	3326 (98.7%)
2	333 (100%)	352 (99.4%)	1097 (98.3%)	1511 (99.5%)
3	41 (100%)	53 (98.1%)	n/a	3238 (98.6%)
4	n/a	n/a	n/a	1130 (99.0%)
5	213 (100%)	223 (98.7%)	505 (96.6%)	n/a
6	159 (100%)	126 (100%)	n/a	3404 (99.7%)
7	180 (97.8%)	243 (99.6%)	n/a	2399 (99.4%)
8	69 (100%)	87 (100%)	n/a	728 (99.9%)
9	3 (100%)	33 (97.1%)	n/a	174 (99.4%)
10	18 (100%)	3 (100%)	n/a	661 (99.7%)
11	135 (94.4)	197 (94.3%)	n/a	1838 (92.7%)
12	40 (100%)	83 (100%)	n/a	1059 (99.5%)
13	n/a	n/a	n/a	13 (100%)
14	164 (97.6%)	310 (99.7%)	369 (99.0%)	2979 (99.5%)
15	57 (100%)	81 (98.8%)	n/a	621 (98.1%)
16	n/a	2 (100%)	n/a	458 (99.1%)
17	n/a	n/a	n/a	n/a
18	299 (98.4%)	256 (96.6%)	n/a	320 (99.1%)
19	29 (100%)	141 (100%)	n/a	1091 (99.8%)
20	113 (96.6%)	167 (98.8%)	n/a	1882 (100%)
21	204 (100%)	173 (99.4%)	n/a	1663 (99.6%)
22	59 (98.3%)	62 (98.4%)	n/a	459 (99.4%)
23	62 (100%)	72 (98.6%)	n/a	n/a
24	7 (100%)	n/a	n/a	99 (100%)
25	10 (93.3%)	9 (100%)	n/a	20 (100%)
26	133 (99.3%)	118 (100%)	n/a	1009 (99.6%)
27	15 (93.8%)	41 (100%)	N/a	331 (100%)
28	1 (100%)	n/a	N/a	20 (100%)
29	n/a	n/a	n/a	106 (100%)
30	n/a	9 (100%)	N/a	5 (14.7%)
31	n/a	n/a	N/a	222 (95.3%)
Total	**2613 (98.3%)**	**3437 (97.8%)**	**2757 (97.6%)**	**30,766 (98.8%)**

Table B-4: Results of validity assessment of patient type by hospital (% of matched cases within hospital)

Hospital	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1	285 (100%)	639 (100%)	840 (99.3%)	2137 (63.4%)
2	328 (98.5%)	353 (99.7%)	1051 (99.6%)	987 (65.0%)
3	41 (100%)	50 (92.6%)	n/a	1621 (49.3%)
4	n/a	n/a	n/a	604 (52.9%)
5	213 (100%)	226 (100%)	519 (99.2%)	n/a
6	156 (98.1%)	125 (99.2%)	n/a	1784 (52.2%)
7	184 (100%)	244 (100%)	n/a	1441 (59.7%)
8	69 (100%)	87 (100%)	n/a	604 (82.9%)
9	0 (0%)	1 (2.9%)	n/a	175 (100%)
10	18 (100%)	3 (100%)	n/a	496 (70.7%)
11	143 (100%)	209 (100%)	n/a	1153 (58.2%)
12	39 (97.5%)	81 (97.6%)	n/a	619 (58.2%)
13	n/a	n/a	n/a	4 (30.8%)
14	168 (100%)	311 (100%)	400 (100%)	2257 (75.4%)
15	52 (91.2%)	81 (98.8%)	n/a	403 (63.7%)
16	n/a	2 (100%)	n/a	312 (67.5%)
17	n/a	n/a	n/a	n/a
18	301 (99.0%)	265 (100%)	n/a	250 (77.4%)
19	29 (100%)	141 (100%)	n/a	634 (58.0%)
20	115 (98.3%)	169 (100%)	n/a	981 (52.1%)
21	204 (100%)	174 (100%)	n/a	1070 (64.1%)
22	60 (100%)	63 (100%)	n/a	459 (99.4%)
23	62 (100%)	72 (98.6%)	n/a	n/a
24	7 (100%)	n/a	n/a	99 (100%)
25	12 (100%)	9 (100%)	n/a	19 (95.0%)
26	128 (95.5%)	117 (99.2%)	n/a	507 (50.0%)
27	15 (93.8%)	41 (100%)	n/a	185 (55.9%)
28	1 (100%)	n/a	n/a	18 (90.0%)
29	N/a	n/a	n/a	54 (50.9%)
30	N/a	4 (44.4%)	n/a	18 (52.9%)
31	N/a	n/a	n/a	128 (54.9%)
Total	**2630 (98.9%)**	**3467 (98.6%)**	**2810 (99.5%)**	**18,992 (61.0%)**

Table B-5: Results of validity assessment of patient status by hospital (% of matched cases within hospital)

Hospital	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1	283 (99.3%)	636 (99.5%)	825 (97.5%)	3356 (99.6%)
2	331 (99.3%)	339 (95.8%)	694 (65.8%)	1505 (99.1%)
3	40 (97.6%)	53 (98.1%)	n/a	3285 (100%)
4	n/a	n/a	n/a	1129 (98.9%)
5	212 (99.5%)	209 (92.5%)	38 (7.3%)	n/a
6	158 (99.4%)	126 (100%)	n/a	3394 (99.4%)
7	175 (95.1%)	198 (81.1%)	n/a	2352 (97.4%)
8	69 (100%)	85 (97.7%)	n/a	726 (99.6%)
9	3 (100%)	33 (97.1%)	n/a	175 (100%)
10	16 (88.9%)	3 (100%)	n/a	628 (94.7%)
11	130 (74.1%)	144 (68.9%)	n/a	1899 (95.8%)
12	39 (97.5%)	79 (95.2%)	n/a	1062 (99.8%)
13	n/a	n/a	n/a	13 (100%)
14	145 (86.3%)	357 (82.6%)	311 (77.8%)	2941 (98.3%)
15	55 (96.5%)	79 (96.3%)	n/a	624 (98.6%)
16	n/a	2 (100%)	n/a	416 (99.8%)
17	n/a	n/a	n/a	n/a
18	301 (99.0%)	261 (98.5%)	n/a	322 (99.7%)
19	27 (93.1%)	131 (92.9%)	n/a	990 (90.6%)
20	109 (93.2%)	148 (87.6%)	n/a	1865 (98.6%)
21	176 (86.3%)	132 (75.9%)	n/a	1634 (97.8%)
22	57 (95.0%)	59 (93.7%)	n/a	458 (99.1%)
23	61 (98.4%)	66 (90.4%)	n/a	n/a
24	7 (100%)	n/a	n/a	98 (99.0%)
25	12 (100%)	9 (100%)	n/a	19 (95.0%)
26	131 (97.8%)	115 (97.5%)	n/a	1008 (99.5%)
27	13 (81.3%)	32 (78.0%)	n/a	328 (99.1%)
28	1 (100%)	n/a	n/a	18 (90.0%)
29	n/a	n/a	n/a	105 (99.1%)
30	n/a	5 (55.6%)	n/a	25 (73.5%)
31	n/a	n/a	n/a	232 (99.6%)
Total	**2527 (95.0%)**	**3201 (91.0%)**	**1868 (66.1%)**	**30,643 (98.4%)**

Table B-6: Results of validity assessment of patient birth date by hospital (% of matched cases within hospital)

Hospital	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1	285 (100%)	630 (98.6%)	833 (98.5%)	3188 (94.6%)
2	328 (98.5%)	350 (98.9%)	1044 (99.0%)	1507 (99.3%)
3	39 (95.1%)	54 (100%)	n/a	2970 (90.4%)
4	n/a	n/a	n/a	1080 (94.7%)
5	208 (97.7%)	223 (98.7%)	515 (98.5%)	n/a
6	152 (95.6%)	122 (96.8%)	n/a	3152 (92.3%)
7	183 (99.5%)	243 (99.6%)	n/a	2393 (99.1%)
8	69 (100%)	85 (97.7%)	n/a	714 (97.9%)
9	3 (100%)	32 (94.1%)	n/a	169 (96.6%)
10	14 (77.8%)	3 (100%)	n/a	630 (95.0%)
11	141 (98.6%)	205 (98.1%)	n/a	1941 (97.9%)
12	35 (97.5%)	77 (92.8%)	n/a	971 (91.3%)
13	n/a	n/a	n/a	12 (92.3%)
14	168 (100%)	310 (99.7%)	399 (99.8%)	2974 (99.4%)
15	56 (98.2%)	77 (93.9%)	n/a	599 (94.6%)
16	n/a	2 (100%)	n/a	437 (94.6%)
17	n/a	n/a	n/a	n/a
18	275 (90.5%)	249 (94.0%)	n/a	290 (89.8%)
19	27 (93.1%)	134 (95.0%)	n/a	1037 (94.9%)
20	113 (96.6%)	162 (95.6%)	n/a	1777 (94.4%)
21	204 (100%)	174 (100%)	n/a	1663 (99.6%)
22	60 (100%)	58 (92.1%)	n/a	448 (97.0%)
23	62 (100%)	72 (98.6%)	n/a	n/a
24	4 (57.1%)	n/a	n/a	62 (62.6%)
25	11 (91.7%)	8 (88.9%)	n/a	19 (95.0%)
26	121 (90.3%)	104 (88.1%)	n/a	935 (92.3%)
27	14 (87.5%)	38 (92.7%)	n/a	301 (90.9%)
28	1 (100%)	n/a	n/a	20 (100%)
29	n/a	n/a	n/a	88 (83.0%)
30	n/a	9 (100%)	n/a	29 (85.3%)
31	n/a	n/a	n/a	204 (87.6%)
Total	**2573 (96.8%)**	**3421 (97.3%)**	**2791 (98.8%)**	**29,610 (95.1%)**

Table B-7: Results of validity assessment of patient gender by hospital (% of matched cases within hospital)

Hospital	Knee Replacement	Hip Replacement	Cardiac Surgery	Cataract/Lens Surgery
1	285 (100%)	639 (100%)	846 (100%)	3339 (99.1%)
2	333 (100%)	354 (100%)	1052 (99.7%)	1515 (99.8%)
3	40 (97.6%)	53 (98.1%)	n/a	3250 (98.9%)
4	n/a	n/a	n/a	1130 (99.0%)
5	213 (100%)	226 (100%)	520 (99.4%)	n/a
6	158 (99.4%)	124 (98.4%)	n/a	3370 (98.7%)
7	184 (100%)	244 (100%)	n/a	2414 (100%)
8	69 (100%)	86 (98.6%)	n/a	719 (98.6%)
9	3 (100%)	34 (100%)	n/a	173 (98.9%)
10	18 (100%)	3 (100%)	n/a	658 (99.2%)
11	143 (100%)	208 (99.5%)	n/a	1973 (99.5%)
12	40 (100%)	81 (97.6%)	n/a	1058 (99.4%)
13	n/a	n/a	n/a	13 (100%)
14	168 (100%)	311 (100%)	398 (99.5%)	2991 (99.9%)
15	57 (100%)	82 (100%)	n/a	626 (98.9%)
16	n/a	2 (100%)	n/a	452 (97.8%)
17	n/a	n/a	n/a	n/a
18	300 (98.7%)	264 (99.6%)	n/a	318 (98.5%)
19	29 (100%)	140 (99.3%)	n/a	1081 (98.9%)
20	117 (100%)	169 (100%)	n/a	1866 (99.1%)
21	204 (100%)	174 (100%)	n/a	1669 (99.9%)
22	59 (98.3%)	63 (100%)	n/a	461 (99.8%)
23	62 (100%)	72 (98.6%)	n/a	n/a
24	6 (85.7%)	n/a	n/a	91 (91.9%)
25	12 (100%)	9 (100%)	n/a	20 (100%)
26	131 (97.8%)	118 (100%)	n/a	1005 (99.2%)
27	16 (100%)	41 (100%)	n/a	327 (98.8%)
28	1 (100%)	n/a	n/a	20 (100%)
29	n/a	n/a	n/a	105 (99.1%)
30	n/a	9 (100%)	n/a	34 (100%)
31	n/a	n/a	n/a	231 (99.1%)
Total	**2648 (99.6%)**	**3506 (99.7%)**	**2816 (99.7%)**	**30,909 (99.3%)**

Table B-8: Results of the validity of DATEON by hospital, Knee Replacement

Hospital	Before 1st Visit	After 1st Visit (Only 1 visit)	After 1st Visit (>1 visit	After nth Visit (>1 visit)	After Last Visit (>1 visit)	Total
1	13	66	19	45	109	252
	5.2%	26.2%	7.5%	17.9%	43.3%	100.0%
2	2	108	22	19	148	299
	.7%	36.1%	7.4%	6.4%	49.5%	100.0%
3	0	13	4	2	20	39
	0	33.3%	10.3%	5.1%	51.3%	100.0%
5	9	64	22	22	80	197
	4.6%	32.5%	11.2%	11.2%	40.6%	100.0%
6	4	24	54	43	22	147
	2.7%	16.3%	36.7%	29.3%	15.0%	100.0%
7	4	34	38	26	61	163
	2.5%	20.9%	23.3%	16.0%	37.4%	100.0%
8	5	6	6	19	23	59
	8.5%	10.2%	10.2%	32.2%	39.0%	100.0%
9	0	1	0	0	1	2
	0	50.0%	0	0	50.0%	100.0%
10	0	2	2	0	14	18
	0	11.1%	11.1%	0	77.8%	100.0%
11	3	34	31	37	32	137
	2.2%	24.8%	22.6%	27.0%	23.4%	100.0%
12	0	11	3	3	24	41
	0	26.8%	7.3%	7.3%	58.5%	100.0%
14	14	43	27	31	34	149
	9.4%	28.9%	18.1%	20.8%	22.8%	100.0%
15	7	14	7	11	20	59
	11.9%	23.7%	11.9%	18.6%	33.9%	100.0%
18	17	68	51	42	117	295
	5.8%	23.1%	17.3%	14.2%	39.7%	100.0%
19	1	7	2	2	13	25
	4.0%	28.0%	8.0%	8.0%	52.0%	100.0%
20	7	27	11	13	50	108
	6.5%	25.0%	10.2%	12.0%	46.3%	100.0%
21	14	78	25	14	48	179
	7.8%	43.6%	14.0%	7.8%	26.8%	100.0%
22	21	4	12	12	8	57
	36.8%	7.0%	21.1%	21.1%	14.0%	100.0%
23	2	8	5	9	36	60
	3.3%	13.3%	8.3%	15.0%	60.0%	100.0%
24	0	3	0	0	4	7
	0	42.9%	0	0	57.1%	100.0%
25	1	1	4	2	4	12
	8.3%	8.3%	33.3%	16.7%	33.3%	100.0%
26	5	19	37	26	40	127
	3.9%	15.0%	29.1%	20.5%	31.5%	100.0%
27	0	3	1	0	14	18
	0	16.7%	5.6%	0	77.8%	100.0%
28	0	0	0	0	1	1
	0	0	0	0	100.0%	100.0%
Total	129	638	383	378	923	2451
	5.3%	26.0%	15.6%	15.4%	37.7%	100.0%

Table B-9: Results of the validity of DATEON by hospital, Hip Replacement

Hospital	Before 1st Visit	After 1st Visit (Only 1 visit)	After 1st Visit (>1 visit	After nth Visit (>1 visit)	After Last Visit (>1 visit)	Total
1	25	151	54	64	276	570
	4.4%	26.5%	9.5%	11.2%	48.4%	100.0%
2	3	124	20	21	163	331
	.9%	37.5%	6.0%	6.3%	49.2%	100.0%
3	0	18	2	2	30	52
	0	34.6%	3.8%	3.8%	57.7%	100.0%
5	6	58	18	32	105	219
	2.7%	26.5%	8.2%	14.6%	47.9%	100.0%
6	4	27	46	24	25	126
	3.2%	21.4%	36.5%	19.0%	19.8%	100.0%
7	3	98	18	32	83	234
	1.3%	41.9%	7.7%	13.7%	35.5%	100.0%
8	5	10	19	20	28	82
	6.1%	12.2%	23.2%	24.4%	34.1%	100.0%
9	0	9	1	2	14	26
	0	34.6%	3.8%	7.7%	53.8%	100.0%
10	0	3	0	0	0	3
	0	100.0%	0	0	0	100.0%
11	2	55	28	45	64	194
	1.0%	28.4%	14.4%	23.2%	33.0%	100.0%
12		23	2	5	47	77
		29.9%	2.6%	6.5%	61.0%	100.0%
14	15	72	74	67	77	305
	4.9%	23.6%	24.3%	22.0%	25.2%	100.0%
15	3	25	9	16	27	80
	3.8%	31.3%	11.3%	20.0%	33.8%	100.0%
16	0	0	0	0	2	2
	0	0	0	0	100.0%	100.0%
18	8	85	33	33	93	252
	3.2%	33.7%	13.1%	13.1%	36.9%	100.0%
19	11	34	15	21	52	133
	8.3%	25.6%	11.3%	15.8%	39.1%	100.0%
20	7	56	19	14	67	163
	4.3%	34.4%	11.7%	8.6%	41.1%	100.0%
21	4	61	29	18	55	167
	2.4%	36.5%	17.4%	10.8%	32.9%	100.0%
22	6	10	11	17	11	55
	10.9%	18.2%	20.0%	30.9%	20.0%	100.0%
23	2	25	2	12	31	72
	2.8%	34.7%	2.8%	16.7%	43.1%	100.0%
25	1	2	0	1	5	9
	11.1%	22.2%	0	11.1%	55.6%	100.0%
26	6	22	31	28	31	118
	5.1%	18.6%	26.3%	23.7%	26.3%	100.0%
27	0	15	0	4	22	41
	0	36.6%	0	9.8%	53.7%	100.0%
30	0	6	0	0	3	9
	0	66.7%	0	0	33.3%	100.0%
Total	111	989	431	478	1311	3320
	3.3%	29.8%	13.0%	14.4%	39.5%	100.0%

Table B-10: Results of the validity of DATEON by hospital, CABG

Hospital	Before 1st Visit	After 1st Visit (Only 1 visit)	After 1st Visit (>1 visit)	After nth Visit (>1 visit)	After LastVisit (>1 visit)	Total
1	7	177	172	58	400	814
	.9%	21.7%	21.1%	7.1%	49.1%	100.0%
2	10	380	141	43	356	930
	1.1%	40.9%	15.2%	4.6%	38.3%	100.0%
5	1	26	66	25	354	472
	.2%	5.5%	14.0%	5.3%	75.0%	100.0%
14	2	72	45	6	268	393
	.5%	18.3%	11.5%	1.5%	68.2%	100.0%
Total	20	655	424	132	1378	2609
	.8%	25.1%	16.3%	5.1%	52.8%	100.0%

Table B-11: Results of the validity of DATEON by hospital, Cataract

Hospital	Before 1st Visit	After 1st Visit (Only 1 visit)	After 1st Visit (>1 visit)	After nth Visit (>1 visit)	After LastVisit (>1 visit)	Total
1	103	223	546	670	1166	2708
	3.8%	8.2%	20.2%	24.7%	43.1%	100.0%
2	8	158	42	114	773	1095
	.7%	14.4%	3.8%	10.4%	70.6%	100.0%
3	44	479	263	361	1281	2428
	1.8%	19.7%	10.8%	14.9%	52.8%	100.0%
4	37	66	149	260	336	848
	4.4%	7.8%	17.6%	30.7%	39.6%	100.0%
6	95	279	417	714	1133	2638
	3.6%	10.6%	15.8%	27.1%	42.9%	100.0%
7	15	336	55	145	1257	1808
	.8%	18.6%	3.0%	8.0%	69.5%	100.0%
8	7	36	44	148	322	557
	1.3%	6.5%	7.9%	26.6%	57.8%	100.0%
9	2	44	0	5	81	132
	1.5%	33.3%	0	3.8%	61.4%	100.0%
10	15	67	37	101	279	499
	3.0%	13.4%	7.4%	20.2%	55.9%	100.0%
11	25	83	187	542	736	1573
	1.6%	5.3%	11.9%	34.5%	46.8%	100.0%
12	37	15	151	462	129	794
	4.7%	1.9%	19.0%	58.2%	16.2%	100.0%
13	0	2	0	0	10	12
	0	16.7%	0	0	83.3%	100.0%
14	97	279	212	770	1195	2553
	3.8%	10.9%	8.3%	30.2%	46.8%	100.0%
15	32	10	43	348	72	505
	6.3%	2.0%	8.5%	68.9%	14.3%	100.0%
16	20	3	74	195	107	399
	5.0%	.8%	18.5%	48.9%	26.8%	100.0%
18	9	25	34	89	149	306
	2.9%	8.2%	11.1%	29.1%	48.7%	100.0%
19	51	40	195	366	238	890
	5.7%	4.5%	21.9%	41.1%	26.7%	100.0%
20	62	232	355	284	275	1208
	5.1%	19.2%	29.4%	23.5%	22.8%	100.0%
21	73	78	435	608	177	1371
	5.3%	5.7%	31.7%	44.3%	12.9%	100.0%
22	10	2	96	157	118	383
	2.6%	.5%	25.1%	41.0%	30.8%	100.0%
24	0	32	0	0	40	72
	0	44.4%	0	0	55.6%	100.0%
25	0	3	0	1	13	17
	0	17.6%	0	5.9%	76.5%	100.0%
26	56	76	88	318	358	896
	6.3%	8.5%	9.8%	35.5%	40.0%	100.0%
27	2	67	3	7	193	272
	.7%	24.6%	1.1%	2.6%	71.0%	100.0%
28	0	7	0	1	11	19
	0	36.8%	0	5.3%	57.9%	100.0%
29	0	23	3	13	35	74
	0	31.1%	4.1%	17.6%	47.3%	100.0%
30	0	17	2	2	10	31
	0	54.8%	6.5%	6.5%	32.3%	100.0%
31	5	31	40	38	70	184
	2.7%	16.8%	21.7%	20.7%	38.0%	100.0%
Total	805	2713	3471	6719	10564	24272
	3.3%	11.2%	14.3%	27.7%	43.5%	100.0%

Table B-12: Results of the validity of DATEOFF by hospital, Knee Replacement (SWL and Hospital Data Linkage)

Hospital	Same as Procedure Date	Between admission & separation	Between 1 wk before adm & 1 wk after sep	Admission & separation between dateon and dateoff	Total
1	256	27	2	0	285
	89.8%	9.5%	.7%	0	100.0%
2	320	13	0	0	333
	96.1%	3.9%	0	0	100.0%
3	40	1	0	0	41
	97.6%	2.4%	0	0	100.0%
5	201	11	0	1	213
	94.4%	5.2%	0	.5%	100.0%
6	151	8	0	0	159
	95.0%	5.0%	0	0	100.0%
7	67	116	0	1	184
	36.4%	63.0%	0	.5%	100.0%
8	69	0	0	0	69
	100.0%	0	0	0	100.0%
9	3	0	0	0	3
	100.0%	0	0	0	100.0%
10	18	0	0	0	18
	100.0%	0	0	0	100.0%
11	128	14	1	0	143
	89.5%	9.8%	.7%	0	100.0%
12	38	2	0	0	40
	95.0%	5.0%	0	0	100.0%
14	164	3	0	1	168
	97.6%	1.8%	0	.6%	100.0%
15	46	8	0	3	57
	80.7%	14.0%	0	5.3%	100.0%
18	290	14	0	0	304
	95.4%	4.6%	0	0	100.0%
19	28	1	0	0	29
	96.6%	3.4%	0	0	100.0%
20	113	4	0	0	117
	96.6%	3.4%	0	0	100.0%
21	193	11	0	0	204
	94.6%	5.4%	0	0	100.0%
22	43	16	0	1	60
	71.7%	26.7%	0	1.7%	100.0%
23	61	0	1	0	62
	98.4%	0	1.6%	0	100.0%
24	7	0	0	0	7
	100.0%	0	0	0	100.0%
25	12	0	0	0	12
	100.0%	0	0	0	100.0%
26	129	5	0	0	134
	96.3%	3.7%	0	0	100.0%
27	14	2	0	0	16
	87.5%	12.5%	0	0	100.0%
28	1	0	0	0	1
	100.0%	0	0	0	100.0%
Total	2392	256	4	7	2659
	90.0%	9.6%	.2%	.3%	100.0%

Table B-13: Results of the validity of DATEOFF by hospital, Hip Replacement (SWL and Hospital Data Linkage)

Hospital	Same as Procedure Date	Between admission & separation	Between 1 wk before adm & 1 wk after sep	Admission & separation between dateon and dateoff	Total
1	589	29	2	19	639
	92.2%	4.5%	.3%	3.0%	100.0%
2	339	15	0	0	354
	95.8%	4.2%	0	0	100.0%
3	50	4	0	0	54
	92.6%	7.4%	0	0	100.0%
5	211	10	0	5	226
	93.4%	4.4%	0	2.2%	100.0%
6	118	8	0	0	126
	93.7%	6.3%	0	0	100.0%
7	77	163	2	2	244
	31.6%	66.8%	.8%	.8%	100.0%
8	87	0	0	0	87
	100.0%	0	0	0	100.0%
9	34	0	0	0	34
	100.0%	0	0	0	100.0%
10	2	1	0	0	3
	66.7%	33.3%	0	0	100.0%
11	199	10	0	0	209
	95.2%	4.8%	0	0	100.0%
12	76	7	0	0	83
	91.6%	8.4%	0	0	100.0%
14	304	7	0	0	311
	97.7%	2.3%	0	0	100.0%
15	66	9	2	5	82
	80.5%	11.0%	2.4%	6.1%	100.0%
16	2	0	0	0	2
	100.0%	0	0	0	100.0%
18	250	15	0	0	265
	94.3%	5.7%	0	0	100.0%
19	135	6	0	0	141
	95.7%	4.3%	0	0	100.0%
20	161	8	0	0	169
	95.3%	4.7%	0	0	100.0%
21	167	7	0	0	174
	96.0%	4.0%	0	0	100.0%
22	51	12	0	0	63
	81.0%	19.0%	0	0	100.0%
23	69	3	1	0	73
	94.5%	4.1%	1.4%	0	100.0%
25	8	0	0	1	9
	88.9%	0	0	11.1%	100.0%
26	112	6	0	0	118
	94.9%	5.1%	0	0	100.0%
27	40	1	0	0	41
	97.6%	2.4%	0	0	100.0%
30	4	5	0	0	9
	44.4%	55.6%	0	0	100.0%
Total	3151	326	7	32	3516
	89.6%	9.3%	.2%	.9%	100.0%

Table B-14: Results of the validity of DATEOFF by hospital, Cardiac Surgery (SWL and Hospital Data Linkage)

Hospital	Same as Procedure Date	Between adm & 1 wk after adm	Between 1 wk before adm & 1 wk after adm	Admission between dateon and dateoff	Total
1	742	64	29	11	846
	87.7%	7.6%	3.4%	1.3%	100.0%
2	1008	47	0	0	1055
	95.5%	4.5%	0	0	100.0%
5	468	50	0	5	523
	89.5%	9.6%	0	1.0%	100.0%
14	393	7	0	0	400
	98.3%	1.8%	0	0	100.0%
Total	2611	168	29	16	2824
	92.5%	5.9%	1.0%	.6%	100.0%

Table B-15: Results of the validity of DATEOFF by hospital, Cataract Surgery (SWL and Hospital Data Linkage)

Hospital	Same as Procedure Date	Between adm & 1 wk after adm	Between 1 wk before adm & 1 wk after adm	Admission between dateon and dateoff	Total
1	3301	30	9	29	3369
	98.0%	.9%	.3%	.9%	100.0%
2	1511	2	4	1	1518
	99.5%	.1%	.3%	.1%	100.0%
3	3254	8	6	17	3285
	99.1%	.2%	.2%	.5%	100.0%
4	1133	8	0	0	1141
	99.3%	.7%	0	0	100.0%
6	3363	35	9	8	3415
	98.5%	1.0%	.3%	.2%	100.0%
7	2366	43	2	3	2414
	98.0%	1.8%	.1%	.1%	100.0%
8	728	1	0	0	729
	99.9%	.1%	0	0	100.0%
9	175	0	0	0	175
	100.0%	0	0	0	100.0%
10	653	9	1	0	663
	98.5%	1.4%	.2%	0	100.0%
11	1967	13	0	2	1982
	99.2%	.7%	0	.1%	100.0%
12	1061	2	0	1	1064
	99.7%	.2%	0	.1%	100.0%
13	13	0	0	0	13
	100.0%	0	0	0	100.0%
14	2962	10	2	19	2993
	99.0%	.3%	.1%	.6%	100.0%
15	515	39	14	65	633
	81.4%	6.2%	2.2%	10.3%	100.0%
16	436	18	1	7	462
	94.4%	3.9%	.2%	1.5%	100.0%
18	316	4	0	3	323
	97.8%	1.2%	0	.9%	100.0%
19	1084	8	0	1	1093
	99.2%	.7%	0	.1%	100.0%
20	1875	6	0	1	1882
	99.6%	.3%	0	.1%	100.0%
21	1667	3	0		1670
	99.8%	.2%	0		100.0%
22	397	64	0	1	462
	85.9%	13.9%	0	.2%	100.0%
24	99	0	0	0	99
	100.0%	0	0	0	100.0%
25	20	0	0	0	20
	100.0%	0	0	0	100.0%
26	978	23	12	0	1013
	96.5%	2.3%	1.2%	0	100.0%
27	328	3	0	0	331
	99.1%	.9%	0	0	100.0%
28	19	1	0	0	20
	95.0%	5.0%	0	0	100.0%
29	105	1	0	0	106
	99.1%	.9%	0	0	100.0%
30	26	4	0	4	34
	76.5%	11.8%	0	11.8%	100.0%
31	228	4	1	0	233
	97.9%	1.7%	.4%	0	100.0%
Total	30580	339	61	162	31142
	98.2%	1.1%	.2%	.5%	100.0%

APPENDIX C

Table C-1a: Correlation Matrix, Patient Variables (Knee Replacement n=1841)

	MONTHON	GENDER	AGEON	LHAGR	FIRSTPAT	COMPHR	URGEMER	OTHSP	VDTONGR	WLADMIN	PRESWL	MOVE	SLOW
MONTHON	1.000	-.005	.014	-.004	-.231	.067	-.034	.013	-.087	.027	.122	.173	-.028
p-value	.	.835	.543	.865	.000	.004	.148	.578	.000	.250	.000	.000	.224
GENDER	-.005	1.000	.057	-.078	.011	.012	.018	-.072	-.070	.001	-.024	-.002	-.039
p-value	.835	.	.014	.001	.630	.619	.443	.002	.002	.976	.323	.943	.097
AGEON	.014	.057	1.000	-.030	-.026	.192	.031	-.126	-.062	-.003	-.026	-.014	.009
p-value	.543	.014	.	.203	.269	.000	.178	.000	.007	.914	.287	.541	.703
LHAGR	-.004	-.078	-.030	1.000	-.006	-.166	.019	.140	.126	.004	.012	.001	-.038
p-value	.865	.001	.203	.	.786	.000	.421	.000	.000	.848	.629	.951	.104
FIRSTPAT	-.231	.011	-.026	-.006	1.000	-.007	.026	.002	-.004	-.016	-.053	-.054	-.073
p-value	.000	.630	.269	.786	.	.780	.265	.940	.851	.486	.027	.021	.002
COMPHR	.067	.012	.192	-.166	-.007	1.000	-.006	-.085	-.019	.005	-.037	.005	.056
p-value	.004	.619	.000	.000	.780	.	.785	.000	.407	.830	.120	.818	.017
URGEMER	-.034	.018	.031	.019	.026	-.006	1.000	.071	.043	-.062	.043	.118	-.043
p-value	.148	.443	.178	.421	.265	.785	.	.002	.067	.007	.076	.000	.063
OTHSP	.013	-.072	-.126	.140	.002	-.085	.071	1.000	.435	-.177	.004	.011	-.037
p-value	.578	.002	.000	.000	.940	.000	.002	.	.000	.000	.880	.639	.116
VDTONGR	-.087	-.070	-.062	.126	-.004	-.019	.043	.435	1.000	-.007	.040	-.066	.028
p-value	.000	.002	.007	.000	.851	.407	.067	.000	.	.771	.092	.004	.225
WLADMIN	.027	.001	-.003	.004	-.016	.005	-.062	-.177	-.007	1.000	.116	.047	.009
p-value	.250	.976	.914	.848	.486	.830	.007	.000	.771	.	.000	.042	.704
PRESWL	.122	-.024	-.026	.012	-.053	-.037	.043	.004	.040	.116	1.000	.128	-.019
p-value	.000	.323	.287	.629	.027	.120	.076	.880	.092	.000	.	.000	.435
MOVE	.173	-.002	-.014	.001	-.054	.005	.118	.011	-.066	.047	.128	1.000	-.013
p-value	.000	.943	.541	.951	.021	.818	.000	.639	.004	.042	.000	.	.584
SLOW	-.028	-.039	.009	-.038	-.073	.056	-.043	-.037	.028	.009	-.019	-.013	1.000
p-value	.224	.097	.703	.104	.002	.017	.063	.116	.225	.704	.435	.584	.

Table C-1b: Correlation Matrix, Patient Variables (Hip Replacement n=2491)

	MONTHON	GENDER	AGEON	LHAGR	FIRSTPAT	COMPHR	URGEMER	OTHSP	VDTONGR	WLADMIN	PRESWL	MOVE	SLOW
MONTH	1.000	-.008	.012	-.011	-.233	.051	-.013	-.009	-.065	.020	.069	.158	-.026
p-value	.	.699	.543	.569	.000	.011	.530	.665	.001	.325	.001	.000	.197
GENDER	-.008	1.000	.124	-.040	.011	.025	.033	-.016	-.017	-.008	-.007	.016	-.023
p-value	.699	.	.000	.045	.575	.214	.101	.436	.384	.695	.733	.436	.260
AGEON	.012	.124	1.000	-.026	.015	.176	.091	-.062	.030	-.099	-.030	.077	-.002
p-value	.543	.000	.	.199	.443	.000	.000	.002	.134	.000	.140	.000	.908
LHAGR	-.011	-.040	-.026	1.000	.005	-.244	-.031	.052	.083	.014	.020	-.004	.028
p-value	.569	.045	.199	.	.819	.000	.127	.010	.000	.479	.329	.829	.162
FIRSTPAT	-.233	.011	.015	.005	1.000	.012	.033	-.018	.009	.001	-.046	-.011	-.064
p-value	.000	.575	.443	.819	.	.537	.103	.365	.651	.952	.025	.568	.001
COMPHR	.051	.025	.176	-.244	.012	1.000	.069	-.092	.030	-.083	-.029	.037	.014
p-value	.011	.214	.000	.000	.537	.	.001	.000	.131	.000	.152	.063	.474
URGEMER	-.013	.033	.091	-.031	.033	.069	1.000	.086	.070	-.079	.025	.103	-.030
p-value	.530	.101	.000	.127	.103	.001	.	.000	.000	.000	.221	.000	.138
OTHSP	-.009	-.016	-.062	.052	-.018	-.092	.086	1.000	.406	-.149	-.017	-.004	-.010
p-value	.665	.436	.002	.010	.365	.000	.000	.	.000	.000	.413	.838	.604
VDTONGR	-.065	-.017	.030	.083	.009	.030	.070	.406	1.000	-.033	.020	-.063	.037
p-value	.001	.384	.134	.000	.651	.131	.000	.000	.	.103	.321	.002	.064
WLADMIN	.020	-.008	-.099	.014	.001	-.083	-.079	-.149	-.033	1.000	.084	-.042	.016
p-value	.325	.695	.000	.479	.952	.000	.000	.000	.103	.	.000	.034	.429
PRESWL	.069	-.007	-.030	.020	-.046	-.029	.025	-.017	.020	.084	1.000	.061	-.046
p-value	.001	.733	.140	.329	.025	.152	.221	.413	.321	.000	.	.003	.027
MOVE	.158	.016	.077	-.004	-.011	.037	.103	-.004	-.063	-.042	.061	1.000	-.023
p-value	.000	.436	.000	.829	.568	.063	.000	.838	.002	.034	.003	.	.244
SLOW	-.026	-.023	-.002	.028	-.064	.014	-.030	-.010	.037	.016	-.046	-.023	1.000
p-value	.197	.260	.908	.162	.001	.474	.138	.604	.064	.429	.027	.244	.

Table C-1c: Correlation Matrix, Patient Variables (Cataract Surgery n=21,655)

	MONTH ON	GENDER	AGEON	LHAGR	FIRST PAT	COM PHR	URG EMER	OTHSP	VDT ONGR	WL ADMIN	PRE SWL	MOVE	SLOW
MONTH	1.000	.015	-.007	-.010	-.087	-.003	-.015	-.010	-.011	.102	.106	.133	-.042
p-value	.	.033	.296	.143	.000	.621	.026	.130	.104	.000	.000	.000	.000
GENDER	.015	1.000	.092	-.028	-.013	.017	-.002	-.027	-.012	.030	.016	-.041	-.008
p-value	.033	.	.000	.000	.049	.013	.768	.000	.080	.000	.021	.000	.260
AGEON	-.007	.092	1.000	-.039	-.028	.129	-.013	-.076	-.066	.043	.027	-.026	.001
p-value	.296	.000	.	.000	.000	.000	.059	.000	.000	.000	.000	.000	.939
LHAGR	-.010	-.028	-.039	1.000	-.004	-.208	.068	.080	.105	.000	-.009	.001	-.003
p-value	.143	.000	.000	.	.533	.000	.000	.000	.000	.942	.185	.854	.657
FIRSTPAT	-.087	-.013	-.028	-.004	1.000	.004	.014	.034	.003	-.008	-.034	-.007	-.023
p-value	.000	.049	.000	.533	.	.561	.035	.000	.620	.257	.000	.313	.001
COMPHR	-.003	.017	.129	-.208	.004	1.000	.041	-.052	-.043	.022	.004	-.003	.002
p-value	.621	.013	.000	.000	.561	.	.000	.000	.000	.001	.536	.671	.765
URGEMER	-.015	-.002	-.013	.068	.014	.041	1.000	.083	.007	-.009	-.003	.152	.001
p-value	.026	.768	.059	.000	.035	.000	.	.000	.327	.202	.683	.000	.909
OTHSP	-.010	-.027	-.076	.080	.034	-.052	.083	1.000	.255	-.201	-.144	.032	.007
p-value	.130	.000	.000	.000	.000	.000	.000	.	.000	.000	.000	.000	.325
VDTONGR	-.011	-.012	-.066	.105	.003	-.043	.007	.255	1.000	.063	.370	-.043	.010
p-value	.104	.080	.000	.000	.620	.000	.327	.000	.	.000	.000	.000	.155
WLADMIN	.102	.030	.043	.000	-.008	.022	-.009	-.201	.063	1.000	.353	.038	-.014
p-value	.000	.000	.000	.942	.257	.001	.202	.000	.000	.	.000	.000	.034
PRESWL	.106	.016	.027	-.009	-.034	.004	-.003	-.144	.370	.353	1.000	.059	.001
p-value	.000	.021	.000	.185	.000	.536	.683	.000	.000	.000	.	.000	.868
MOVE	.133	-.041	-.026	.001	-.007	-.003	.152	.032	-.043	.038	.059	1.000	.025
p-value	.000	.000	.000	.854	.313	.671	.000	.000	.000	.000	.000	.	.000
SLOW	-.042	-.008	.001	-.003	-.023	.002	.001	.007	.010	-.014	.001	.025	1.000
p-value	.000	.260	.939	.657	.001	.765	.909	.325	.155	.034	.868	.000	.

Tables C-2a-c: Correlation Matrices, Physician Variables

a) Knee Replacement

	NUMHOSP	FTE	AVSURG	SURGWL
NUMHOSP	1.000	.259	.139	.324
p-value	.	.000	.000	.000
FTE	.259	1.000	.597	.408
p-value	.000	.	.000	.000
AVSURG	.139	.597	1.000	.012
p-value	.000	.000	.	.612
SURGWL	.324	.408	.012	1.000
p-value	.000	.000	.612	.

b) Hip Replacement

	NUMHOSP	FTE	AVSURG	SURGWL
NUMHOSP	1.000	.175	.173	-.035
p-value	.	.000	.000	.083
FTE	.175	1.000	.508	.380
p-value	.000	.	.000	.000
AVSURG	.173	.508	1.000	-.282
p-value	.000	.000	.	.000
SURGWL	-.035	.380	-.282	1.000
p-value	.083	.000	.000	.

c) Cataract

	NUMHOSP	FTE	AVSURG	SURGWL
NUMHOSP	1.000	.491	.538	.085
p-value	.	.000	.000	.000
FTE	.491	1.000	**.884**	.464
p-value	.000	.	.000	.000
AVSURG	.538	**.884**	1.000	.504
p-value	.000	.000	.	.000
SURGWL	.085	.464	.504	1.000
p-value	.000	.000	.000	.

Tables C-3a-c: Correlation Matrices, Hospital Variables

a) Knee Replacement

	LOS	OPCASE	EMEROP	URGOP	KNEEHSP	HOSPWL
LOS	1.000	.359	.046	-.253	-.130	.131
p-value	.	.000	.047	.000	.000	.000
OPCASE	.359	1.000	.444	.070	-.404	.317
p-value	.000	.	.000	.003	.000	.000
EMEROP	.046	.444	1.000	-.290	.025	.082
p-value	.047	.000	.	.000	.290	.000
URGOP	-.253	.070	-.290	1.000	-.021	.283
p-value	.000	.003	.000	.	.371	.000
KNEEHSP	-.130	-.404	.025	-.021	1.000	.375
p-value	.000	.000	.290	.371	.	.000
HOSPWL	.131	.317	.082	.283	.375	1.000
p-value	.000	.000	.000	.000	.000	.

b) Hip Replacement

	LOS	OPCASE	EMEROP	URGOP	HIPHSP	HOSPWL
LOS	1.000	.432	.079	-.262	.185	.421
p-value	.	.000	.000	.000	.000	.000
OPCASE	.432	1.000	.476	.050	.031	.736
p-value	.000	.	.000	.012	.116	.000
EMEROP	.079	.476	1.000	-.242	.117	.229
p-value	.000	.000	.	.000	.000	.000
URGOP	-.262	.050	-.242	1.000	-.048	.114
p-value	.000	.012	.000	.	.016	.000
HIPHSP	.185	.031	.117	-.048	1.000	.269
p-value	.000	.116	.000	.016	.	.000
HOSPWL	.421	.736	.229	.114	.269	1.000
p-value	.000	.000	.000	.000	.000	.

c) Cataract

	LOS	OPCASE	EMEROP	URGOP	CATHSP	HOSPWL
LOS	1.000	-.043	.029	-.482	.803	.095
p-value	.	.000	.000	.000	.000	.000
OPCASE	-.043	1.000	.697	.330	-.387	.662
p-value	.000	.	.000	.000	.000	.000
EMEROP	.029	.697	1.000	.227	-.321	.288
p-value	.000	.000	.	.000	.000	.000
URGOP	-.482	.330	.227	1.000	-.514	.275
p-value	.000	.000	.000	.	.000	.000
CATHSP	.803	-.387	-.321	-.514	1.000	-.002
p-value	.000	.000	.000	.000	.	.743
HOSPWL	.095	.662	.288	.275	-.002	1.000
p-value	.000	.000	.000	.000	.743	.

Table C-4: Variable selection, OPCASE vs HOSPWL (Hip Replacement)

Variable(s) entered in AR(1) model	R^2 (Adj R^2)	β (p-value)	S.E.	BETA
OPCASE and HOSPWL	.609 (.602)	-.00001 (p<.01) -.004 (p<.05)	.000004 .00159	-.0711 -.0574
OPCASE	.608 (.602)	-.00002 (p<.001)	.000003	-.10
HOSPWL	.607 (.602)	-.006 (p<.001)	.0014	-.10

Table C-5: Variable selection, FTE vs AVSURG (Cataract Surgery)

Variable(s) entered in AR(1) model	R^2 (Adj R^2)	β (p-value)	S.E.	BETA
AVSURG and FTE	.563 (.563)	-.005 (p>.05) -.068 (p>.05)	.0006 .070	-.009 -.007
AVSURG	.563 (.563)	-.001 (p<.05)	.0004	-.014
FTE	.563 (.563)	-.106 (p<.05)	.044	-.014

Table C-6: Variable selection, OPCASE vs EMEROP and HOSPWL (Cataract Surgery)

Variable(s) entered in AR(1) model	R^2 (Adj R^2)	β (p-value)	S.E.	BETA
OPCASE, EMEROP and HOSPWL	.572 (.572)	-.00001 (p<.001) .006 (p<.01) .0005 (p<.001)	.000002 .002 .00008	-.048 .018 .045
OPCASE	.569 (.569)	-.000002 (p>.05)	.000001	-.007
EMEROP and HOSPWL	.572 (.572)	-.003 (p>.05) .0002 (p<.01)	.002 .00007	-.008 .019

Table C-7: Variable selection, CATHSP vs LOS (Cataract Surgery)

Variable(s) entered in AR(1) model	R^2 (Adj R^2)	β (p-value)	S.E.	BETA
LOS and CATHSP	.576 (.575)	-.208 (p<.001) .0002 (p<.01)	.012 .00006	-.159 .0159
LOS	.573 (.572)	.0933 (p<.01)	.008	-.069
CATHSP	.570 (.569)	-.001 (p>.05)	.001	-.004

Figure C-1: ACF analysis of regression residuals, Knee Replacement

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Autocorrelations:   Error for LNDAYS from AREG, Final Model

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                  +----+----+----+----+----+----+----+----+
  1  -.078   .023                    *.I.                        11.178   .001
  2   .095   .023                     .I.*                       27.487   .000
  3   .102   .023                     .I.*                       46.274   .000
  4   .083   .023                     .I.*                       58.740   .000
  5   .077   .023                     .I.*                       69.481   .000
  6   .075   .023                     .I*                        79.600   .000
  7   .096   .023                     .I.*                       96.376   .000
  8   .084   .023                     .I.*                      109.376   .000
  9   .091   .023                     .I.*                      124.481   .000
 10   .048   .023                     .I*                       128.698   .000
 11   .014   .023                     .*.                       129.081   .000
 12   .070   .023                     .I*                       138.054   .000
 13   .016   .023                     .*.                       138.550   .000
 14   .095   .023                     .I.*                      155.088   .000
 15   .013   .023                     .*.                       155.414   .000
 16   .054   .023                     .I*                       160.810   .000

Partial Autocorrelations:
   Pr-Aut- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1
                  +----+----+----+----+----+----+----+----+
  1  -.078   .023                    *.I.
  2  -.089   .023                     .I.*
  3   .117   .023                     .I.*
  4   .094   .023                     .I.*
  5   .074   .023                     .I*
  6   .062   .023                     .I*
  7   .080   .023                     .I.*
  8   .071   .023                     .I*
  9   .070   .023                     .I*
 10   .021   .023                     .*.
 11  -.030   .023                     *I.
 12   .020   .023                     .*.
 13  -.014   .023                     .*.
 14   .060   .023                     .I*
 15  -.006   .023                     .*.
 16   .016   .023                     .*.

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  1814     Computable first lags:  1813
```

Figure C-2: ACF analysis of regression residuals, Hip Replacement

Autocorrelations: Error for LNDAYS from AREG, Final Model

Lag	Auto-Corr.	Stand. Err.	-1 -.75 -.5 -.25 0 .25 .5 .75 1	Box-Ljung	Prob.
1	-.058	.020	*I.	8.159	.004
2	.120	.020	.I.*	43.236	.000
3	.090	.020	.I.*	62.647	.000
4	.043	.020	.I*	67.092	.000
5	.093	.020	.I.*	88.090	.000
6	.044	.020	.I*	92.828	.000
7	.097	.020	.I.*	115.690	.000
8	.068	.020	.I*	127.019	.000
9	.019	.020	.*.	127.929	.000
10	.067	.020	.I*	138.884	.000
11	.073	.020	.I*	151.879	.000
12	.033	.020	.I*	154.570	.000
13	.060	.020	.I*	163.215	.000
14	.030	.020	.I*	165.472	.000
15	.042	.020	.I*	169.765	.000
16	.022	.020	.*.	170.909	.000

Partial Autocorrelations: ERR_6 Error for LNDAYS from AREG, MOD_4

Lag	Pr-Aut-Corr.	Stand. Err.	-1 -.75 -.5 -.25 0 .25 .5 .75 1
1	-.058	.020	*I.
2	.117	.020	.I.*
3	.104	.020	.I.*
4	.041	.020	.I*
5	.077	.020	.I.*
6	.038	.020	.I*
7	.078	.020	.I.*
8	.057	.020	.I*
9	-.005	.020	.*.
10	.031	.020	.I*
11	.058	.020	.I*
12	.013	.020	.*.
13	.026	.020	.I*
14	.006	.020	.*.
15	.011	.020	.*.
16	-.003	.020	.*.

Plot Symbols: Autocorrelations * Two Standard Error Limits .

Total cases: 2416 Computable first lags: 2415

Figure C-3: ACF analysis of regression residuals, Cataract

Autocorrelations: Error for LNDAYS from AREG, Final Model

Lag	Auto-Corr.	Stand. Err.	-1 -.75 -.5 -.25 0 .25 .5 .75 1	Box-Ljung	Prob.
1	-.161	.007	***I	553.392	.000
2	.063	.007	I*	637.629	.000
3	.082	.007	I**	782.180	.000
4	.099	.007	I**	991.273	.000
5	.087	.007	I**	1151.041	.000
6	.098	.007	I**	1354.244	.000
7	.084	.007	I**	1505.791	.000
8	.087	.007	I**	1668.870	.000
9	.097	.007	I**	1870.886	.000
10	.077	.007	I**	1996.000	.000
11	.090	.007	I**	2167.473	.000
12	.087	.007	I**	2330.550	.000
13	.079	.007	I**	2462.331	.000
14	.081	.007	I**	2604.162	.000
15	.088	.007	I**	2768.955	.000
16	.076	.007	I**	2891.159	.000

Partial Autocorrelations: ERR_8 Error for LNDAYS from AREG, MOD_6

Lag	Pr-Aut-Corr.	Stand. Err.	-1 -.75 -.5 -.25 0 .25 .5 .75 1
1	-.161	.007	***I
2	.038	.007	I*
3	.101	.007	I**
4	.130	.007	I***
5	.119	.007	I**
6	.119	.007	I**
7	.099	.007	I**
8	.088	.007	I**
9	.090	.007	I**
10	.066	.007	I*
11	.066	.007	I*
12	.062	.007	I*
13	.049	.007	I*
14	.044	.007	I*
15	.048	.007	I*
16	.037	.007	I*

Plot Symbols: Autocorrelations * Two Standard Error Limits .

Total cases: 21341 Computable first lags: 21340