A Cost-Benefit Analysis of Private Versus Semi-Private Inpatient Rooms in a New Hospital*

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16 May 2007

*Financial support for this study was provided in part by a contract with Providence Health Care, Legacy Project, Vancouver, BC. The authors wish to Neil MacConnell and Elizabeth Buller, who instigated this research, and Aslam Anis and Habib Chaudhury, who provided helpful suggestions.

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Abstract

The design of new hospital rooms for inpatient stays is moving towards private (single occupancy) rooms. Private rooms are generally preferred by patients, they may minimize the spread of disease and aid recovery times, but they take up more space and they are more expensive to build and to staff than semi-private rooms. From a societal perspective, are they worth it? This question is important because hospitals are long-term investments and, once built, their layout is prohibitively expensive to change. This paper presents a cost-benefit analysis of private rooms versus semi-private rooms in a proposed new hospital in Vancouver, Canada. We find that the present value of the incremental cost of a private room relative to a semi-private room is about $228,000. However, the benefits of a single room are higher, resulting in net social benefits of a private room of a $70,000 per patient bed, on average.

Key words: Cost-benefit Analysis, Hospital Design, Health Care Financing, Economic Evaluation

1. Introduction

Many existing hospital facilities are outdated and occupy valuable land in central urban areas. Developers are eager to obtain the land for building houses or offices and hospital administrators want to reduce costs and provide new facilities. At the same time, population increases, the baby boomer demographic shift, and increasing wealth and expectations raise the demand for hospital services. These pressures will lead to a significant increase in the number of new hospitals built during the next decade in Canada, Britain, the United States and elsewhere.

In Canada and most other countries except the U.S., hospital construction is publicly funded, directly or indirectly. Typically, new urban hospitals cost more than $1 billion to complete and last 50 years or more. As changing the layout is expensive, it is usually avoided. Consequently, it is important to ensure that hospitals are initially designed as well as possible.

One important consideration in new hospital construction is the number of occupants in each inpatient hospital room. Although many Canadian hospitals have inpatient rooms with four patient beds, this is no longer considered to be an option for a new Canadian hospital. Several new hospital projects in North America and Europe provide only private rooms, although Britain requires only 50 per cent private rooms in new constructions (Dowdeswell et al., 2004; Jones et al., 2004). Obviously, there are trade-offs. Private rooms are generally preferred by patients, may minimize the spread of disease and aid recovery times, but they take up more space and they are more expensive to build and to staff than semi-private rooms. Are they worth it? This paper identifies and estimates the costs and benefits of building private (single-occupancy) rooms versus semi-private (double-occupancy) rooms in a new hospital.

Surprisingly, there has been little economic analysis of alternative hospital room designs, and none focuses on the issue of (single versus double) occupancy. The existing literature on hospital design concerns construction costs, identifies some design impacts on patients and

contains qualitative information about benefits and costs; see, for example, the literature review by Chaudhury et al. (2005). However, the estimates consist mainly of "expert opinion" and rarely contain quantitative data. The limited empirical research that does exist applies to specific clinical situations rather than to full institutions. We are not aware of any previous research that attempts to obtain quantitative estimates of the social costs and benefits of building new hospital rooms with different occupancy.

Section 2 provides a comprehensive identification and categorization of the potential costs and benefits of private versus semi-private rooms, and discusses the expected impact of each alternative on each impact dimension. Section 3 presents our main estimates of the incremental costs and benefits of a private room relative to a semi-private room in a new hospital. In this section, benefits are estimated based on patients' willingness to pay derived from current Canadian market prices. Section 4 estimates patients' benefits using an alternative methodology that considers the various impacts that result from being in a single room, values them separately, and then sums them. It also contains some sensitivity analysis. Section 5 provides a brief conclusion.

Our analysis is based on a proposed 537 bed facility that would replace St. Paul's hospital in Vancouver, BC. This hospital occupies a prime piece of urban real estate, opposite the Wall Centre. While the specific quantitative estimates of the benefits and costs of private rooms are location specific, the qualitative conclusion is probably generally applicable to new hospitals in major cities in most developed countries.

2. Qualitative Assessment of the Benefits and Costs of Private Rooms

Since there are only two feasible alternatives, we arbitrarily select the semi-private room as the counterfactual and consider the incremental social costs and benefits of private rooms. Impacts

that would be the same in both room designs are ignored. Table 1 summarises the incremental cost and benefit impacts of private rooms relative to semi-private rooms, and provides a brief discussion of each impact.

Insert Table 1 about here

Private rooms require more space. Consequently, they require more land, have higher construction costs, and higher housekeeping and plant operations costs. They decrease the productivity of doctors and nurses who have to walk slightly longer distances or have to travel further between floors. They also increase the cost of transferring patients on a per transfer basis within the hospital, although they reduce the total number of transfers.

However, private rooms provide important benefits over semi-private rooms. In general, patients prefer private rooms. This may be due to a variety of factors. Patients may enjoy greater privacy: they can do what they want when they want. Also, private rooms reduce disruption and increase the ability to rest and sleep. In addition, patients and nurses think that private rooms improve health care, reduce the risk of infection and have result in fewer patient "adverse events". Private rooms improve patient privacy and confidentiality, which may lead to more open and honest discussions with health professionals and to more appropriate treatment with fewer complications. In addition, private rooms may facilitate improved nursing practice and reduce clinical mistakes. Finally, it is also easier for family members to stay in a private room where they can provide additional support for patients (Hendrich and Sorrells, 2004). All of these factors suggest that private rooms may reduce the risk of death, hasten recovery, lessen time in hospital and increase patient satisfaction (Ulrick, 1999; Bilchik, 2002; Duffin, 2002). From a survey of 73 nurses and 4 administrators at four Pacific Northwest hospitals in the United States, Chaudhury et al. (2005) found that private rooms are perceived to offer most of these patient benefits.

There are some potential disadvantages to patients in private rooms. A roommate may provide comfort, companionship, help and security. For example, if one patient falls unobserved by staff, the other can call for help. Kulik et al. (1993) found that the preoperative stress of new patients is reduced if they share a room with a postoperative patient. There are some health benefits to having a roommate. Stelfox et al. (2003) found that patients in isolation rooms for control of MRSA infection in a Toronto Hospital had increased supportive care failures. Some patients may also value companionship.

Another advantage of private rooms is that they reduce the number of patient transfers among rooms, although when transfers do occur, they are likely to be for longer distances. Furthermore as private rooms lead to faster recovery times, hospitals can treat more patients in a period (increase turnover) and reduce waiting times for patients seeking care. Of course, this benefit would be partially offset by increased administrative costs.

3. Quantitative Estimates of the Costs and Benefits of a Private Room

This section estimates the incremental costs and benefits associated with a private room. Costs include the land cost, construction costs, maintenance, operating and housekeeping costs, and increased nursing and physician costs. Patient benefits are estimated based on patients' willingness to pay using market prices.

Architects often consider a hospital's useful life is 40 years although hospitals are frequently in use for longer. Fraumeni (1997) reviews the practices of the Bureau of Economic Analysis (BEA) for measuring the depreciation of assets, and finds that government hospitals typically have a service life of 50 years (private hospitals of 48 years). We assume the new hospital will last 50 years after which it will be demolished. To make all of the impacts commensurable we compute the present value (PV) of all costs and benefits assuming a 50 year

time horizon, and a discount rate of 3.5 percent (Moore et al., 2004). All figures are expressed in 2005 dollars.

Description of Space and Space Requirements

Before estimating the land costs and construction costs it is necessary to provide more information about the hospital space itself and the incremental amount of space required by a private room.

This paper assumes that the hospital will be constructed according to "best practices" design features (Chaudhury et al., 2005; Fisk, 1997; Ulrich and Zimring, 2004; Green Guide for Health Care, 2005). Professional organizations such as The American Institute of Architects (AIA), Hospitals for a Healthy Environment (H2E) and The Center for Health Design have developed guidelines that typically recommend hospitals have as much natural light as building codes allow, airflow at the recommended circulation levels, non-handed (i.e. standardized headboards) rooms adaptable to changing acuity (i.e. illness) levels of patients, and ward unit floor plan that minimizes staff walking and maximizes the ability of nurses to monitor patients from central nursing stations (e.g. triangular or hub and spoke layout).

Private rooms, designed according to best practices in Canada, require about 265 sq. ft. per patient. This is approximately 100 sq. ft. (61 per cent) more space than a double room, which requires (165 sq. ft.) per patient. Although rooms based on these assumptions are smaller than suggested by recent research on single and double occupancy rooms in the United States, the additional space for single-occupancy rooms is similar in percentage terms (David Langdon Adamson, 2005; BTY Group, 2003).

Private rooms also require more corridor space per patient, as the distance between beds is further. To compute the total incremental space required for a private room (including

corridors and nursing areas) we begin with the assumption that the dimensions of a private room would be 13.25' x 20' and the dimensions of a semi-private room would be 15' x 22', both with windows on the shorter side. Suppose each ward has a triangular floor plan with each wall approximately 120', patient rooms on the outside, and with corridors and nursing area are in the middle. This area could accommodate 42 patients in semi-private rooms or 24 patients in private rooms. Patient rooms would occupy 6930 sq. ft. of a double-occupancy ward and 6360 sq. ft. of a single-occupancy ward. The total ward floor space would be 10,464 sq. ft. (436 sq. ft. per bed) on a ward with private rooms and 12,060 sq. ft. (287 sq. ft. per bed) on a ward with semi-private rooms, implying that private rooms require 52 per cent more space than semi-private rooms in aggregate. This estimate is very similar to that obtained by Davis Langdon Adamson (2003) who suggested 49 percent more space. The overall gross mark-up of total space per patient to room space per patient is 1.74 (i.e. 287/165) for double-occupancy patient beds and 1.65 (i.e. 436/265) for single-occupancy patient beds. The mark-up is smaller for single-occupancy rooms because the size of the nursing area varies with number of patients more than room size.

Land Cost

As discussed above a private room requires 436 sq. ft. per bed versus 287 sq. ft. per bed for a semi-private room. To accommodate the extra space, the hospital would have to be taller or occupy more ground space. Either way, there is an opportunity cost. This cost is most appropriately and most easily estimated by the amount developers currently pay per buildable square foot of land. Currently, developers pay between $100 to $110 per buildable sq. ft. on the west side of Vancouver and from $30 to $35 per buildable sq. ft. on the east side in Vancouver. Given the proposed location of the new hospital, $80 per buildable sq. ft. is appropriate.

Consequently, the land cost for each semi-private bed would be $22,960, and for a private bed it would be $34,880, a difference of $11,920 per patient bed.

At the end of the 50-year discounting period, the hospital authority would own more land if it adopted the private room alternative. The present value of possessing this additional land in 50 years time should be subtracted from the initial cost of the land so that, in effect, the resultant land cost figure reflects the present value of renting the land for 50 years. Assuming no change in the relative price of land over 50 years, the PV of owning the land in 50 years is $4,111 per semi-private room, $6,245 per private room, a difference of $2,134. Thus, the net incremental land cost of a private patient bed over 50 years is $9,786.

Construction Cost

Recently, Davis Langdon Adamson (2004) estimated U.S. construction costs for ten new hospital ward designs. They break construction costs down into several component parts including, for example, the shell, the interior, the functional equipment, and mechanical/ electrical costs. Excluding the cost of site preparation, landscaping or onsite utilities, which would not vary with room types, they estimate the cost of construction is $410 per sq. ft. in 2005 Canadian dollars. This cost does not vary with bed occupancy, but would vary with attributes of the room, such as the number and size of the windows, and the materials used for floors, walls and ceilings. Using this construction cost estimate implies the cost of constructing the total space (hospital room, corridors and nursing area) associated with a patient bed in a semi-private room is $410x287 = $117,670, the cost associated with a private room is $410 x 436 = $178,760, for a difference of $61,090 per patient bed.

Maintenance

Hospital rooms are rarely subject to major refurbishing due to the significant pipefitting (gas and pluming) costs required. However, rooms receive new fixtures, flooring, wall coverings and furniture every 10 years or so. Typically, such updates cost approximately 10 percent of construction costs. Thus, we assume that maintaining wards and nursing areas costs one percent of construction per annum--$1,177 per annum for a semi-private patient bed, $1,788 per annum for a private patient bed, a difference of $611 per year. The present value of this amount for 50 years discounted at 3.5 percent equals $14,329.

Housekeeping and Operating Costs

Currently, housekeeping costs at St. Paul's are $7.26 per sq. ft. per annum and plant operations cost $9.62 per sq. ft. per annum (Anis, 2005). A new hospital design with a "Green Building" whole systems approach for responding to changing heating and cooling loads would reduce plant operations costs by $1.56 per sq. ft. (Harvard Green Campus Initiative, 2005). Assuming such an energy efficient design, the annual housekeeping and costs would be $4,397 for a semi-private room, $6,680 for a private room, a difference of $2,283 per annum, equivalent to $53,542 over the life of the project.

Patient Care Costs

Nursing wage costs make up approximately 45 per cent of a hospital's annual operating expenditures (Pedersen, 1997). On a general medical ward, the number of nurses is generally determined by maintaining a nurse to patient ratio of about 1:4 (days), 1:6 (evenings) and 1:8 (over-night) to provide 4.5 to 5 hours of nursing care per patient bed over 24 hours. The number of beds in each room can affect nursing costs in two ways. First, wards with private rooms have

fewer patients per ward and, consequently, they may require a higher nurse to patient ratio in order to maintain minimum staffing levels. Second, private rooms require more space per bed, increasing the distance between patients. Here, we focus on the latter impact.

An AIA (2005) study indicates that, on average, nurses travel 5,490 linear feet (just over a mile or 1.67 kms.) on a well-designed unit each day. Given that walking requires many changes in direction, this is roughly equivalent to one hour per shift. Trites et al. (1970) obtain a similar estimate. Given that private rooms require 52 percent more space per patient, nurses on such wards spend about half an hour more time walking per shift. Assuming 5 hours of nursing support per patient per day and a 7.5 hr work shift, each patient bed would require 0.66 nurses per day. Thus, each private patient would require about 20 minutes more nursing time per day (0.66x30 minutes), which is equivalent to 122 additional nursing hours per year per patient bed.

Registered nurses perform approximately 75 per cent of nursing duties; licensed practical nurses perform the remainder. Given that these nurses earn roughly $60,000 and $41,000 per annum, respectively, in Vancouver, each hour of patient care costs $28.34. Consequently, the additional nursing cost from having private patients would be $3,457 per bed per year (122 hours per patient bed x $28.34 per hour), which has a PV equal to $81,086.

Similar to many jurisdictions throughout Canada and the U.S., the lower mainland of British Columbia faces a severe and worsening shortage of nurses (Duffield and O'Brien-Pallas, 2002). When faced recently with a shortage of doctors, the provincial government raised their salaries significantly. Nurses' salaries will undoubtedly rise too. Assuming that the real relative wages of nurses increase at 2 percent per annum for the next ten years and then remain unchanged, the PV of the increased nursing time for a private room would equal $85,522.

Private rooms similarly increase physicians' costs. The average Canadian physician's salary is $187,951 per year, or $96.39 per hour, based on 1950 hours per year (George et al.,

2002). Pedersen (1997) estimates that nurses spend 1.3 percent of their time in rounds with physicians and care teams. Assuming that physicians spend the same percentage of their time making rounds, the cost of the additional time that physicians would spend traveling on private-room wards is $153 per patient bed per year (0.013x122 hours x $96.39 per hour), which has a PV equal to $3,589.

Patient Benefits

Patients are the main beneficiaries of private rooms. As discussed earlier, they may receive better care, they may suffer fewer adverse events and they may sleep better. This reduces their time in hospital and may increase their quality of life, both while they are in hospital and subsequently.

With well-informed consumers and well functioning markets, the difference in price between two goods or services provides an estimate of the difference in the value of these two goods for the average consumer (Boardman et al., 2006). Thus, a natural estimate of the incremental benefit of a private room is the difference in price between these rooms and semi-private rooms.

A survey of seven regional hospitals in two health regions in the lower mainland of British Columbia (Vancouver Coastal Health and the Fraser Health Authority) shows that hospitals charge different prices for rooms with different occupancy levels. Wards (with 4 or more patients) are typically free while patients often have to pay extra for private or semi-private rooms. As shown in Table 2, the price of a semi-private room ranges from $60 to $110 per day, while the price of a private room ranges from $100 to $150 per day. These prices suggest that, on average, patients are willing to pay about $33 per day to have a private room rather than a semi-private room.

Insert Table 2 about here

The market for private rooms in the lower mainland of BC appears to be reasonably competitive. Anecdotal evidence indicates that there is some excess demand for both double-occupancy and single-occupancy rooms, suggesting that the market prices under-estimate what patients are willing to pay for these rooms. For the most part, higher prices reflect the hospital location, newer age and larger size. Taking account of these factors and recognizing that the proposed hospital would be the most modern in the region, suggests that the average user would be willing to pay about $40 per day more for a private room than a semi-private room in the new hospital.

To compute an annual figure requires an estimate of the occupancy rate. Patient beds cannot be and should not be occupied 100 percent of the time. Target occupancy rates tend to be higher in units with predictable utilisation, such as medical/surgical units, than in units with less predictable utilisation, such as maternity or an intensive care unit (ICU). However, beds may be "closed" due to renovations, seasonal short staffing, and budgetary restrictions. Such beds are typically excluded from consideration when calculating administrative occupancy rates (for open beds), thereby over-stating the actual occupancy rate. While the proposed new hospital will probably set an overall occupancy rate goal of 85 per cent *for all open beds*, this would be approximately equivalent to a goal of about 80 per cent *of the total beds*.

Assuming that each bed is occupied 80 per cent of the time implies that the average person's incremental benefit of a single room is $32 ($40x0.80) per night or $12,439 per year, which has a PV of $291,769.

Fewer Patient Transfers

Single occupancy rooms reduce within-hospital transfers thereby reducing orderly time and disruption for patients. In existing hospitals with 30 patients per ward, there are approximately 5 transfers per week on average, although there are over 20 moves per week on some wards (Chaudhury et al., 2003). The most frequently sited reason for transferring a patient is a request for privacy (greater than 50 per cent), followed by patient (mis)behavior and infection control issues. Other reasons include extended stays in hospital, visitor considerations, and a needed move to an ICU setting. We assume that private rooms will reduce the number of within-ward transfers from 0.167 (5 out of 30) per week per bed to zero but will have no effect on moves to ICU wards as these moves are not closely related to room occupancy.

Most transfers require less than 30 minutes in time and cost between C$28.76 and C$165.39 depending on the nature of the facility and the location of the move (Chaudhury et al., 2003). We use the lower figure of $28.76 for moves within a ward or between similar wards as this cost is associated with The University of Washington Medical Center, which is of similar size and has a similar case mix to the proposed new hospital. Thus, we estimate that private rooms would save $249.75 per bed per year compared to semi-private rooms due to reduced transfers. This amount has a PV of $5,858.

Faster Turnover and Reduced Waiting Time

Private rooms may reduce length of stay and increase patient turnover due better diagnosis, better treatment, better sleep, and fewer adverse events. Consequently, patients who are waiting to enter hospital may be able to enter sooner than otherwise. In a subsequent section, we estimate that private rooms reduce the number of preventable adverse events by about one event per bed year. Baker et al. (2004) estimated that an adverse event increases the length of

hospitalization by about 16 days. Thus, each private room could reduce the usage of each patient bed by 0.16 days per year.

There are two ways to value this benefit. One way would determine how much patients would be willing to pay to obtain earlier treatment (and to experience less pain and suffering). This is not easy. An easier way is to compute the cost savings to the hospital. The incremental cost of a day in an acute care room is about $250 per bed per day. Based on this figure, the estimated benefit of reduced waiting times would equal approximately $40 per bed per year (PV= $938). This amount would clearly under-estimate the amount that patients would be willing to pay, even after subtracting incremental administrative costs, if any.

Net Social Benefits

The total incremental cost of a private room relative to a semi-private room amounts to $227,857, as shown in Table 3. The main determinants of cost are nursing costs, construction costs, and operating and housekeeping costs. The PV of the benefits equals $298,565, which is largely composed of patients' willingness-to-pay. A private room has a net social benefit (NSB) of $70,978 relative to a semi-private room. For the average patient, the social benefits of a private room exceed the social costs.

Insert Table 3 about here

4. Alternative Benefit Estimation and Sensitivity Analysis

The estimated NSB depends importantly on the estimate of patients' willingness-to-pay. As there is some uncertainty about this estimate, this section presents and discusses two alternative estimates, one based on U.S. data and another based on adding the benefit components. It also contains a short sensitivity analysis.

Patients' Benefits Estimated Using U.S. Hospital Prices Data

In addition to examining Canadian hospital room prices, we surveyed the prices of private and semi-private hospital rooms in the U.S.-- four large Pacific Northwest hospitals and one Eastern hospital. These results are shown in the bottom portion of Table 2. It clearly shows that the U.S. has much higher prices and much greater price variability than does the lower mainland of BC. Semi-private room rates varied between $847 per day to $7246 (Canadian dollars) per day. The incremental cost of a private room ranged from $0.00 to $410 per day, with an average of $141 per day, or $41,172 per year, assuming 80 per cent occupancy, which has a PV of $965,715.

Patients' Benefits Estimated by Summing Components

Using market prices to estimate patient benefits is appropriate if patients are informed consumers, that is, if they are knowledgeable about the benefits and costs of being in private versus semi-private rooms. It presumes patients have a reasonable estimate of the net effects of the expected consequences of being in a private room, including how much quieter it is, and the reduced chance of experiencing an adverse event, infection, etc. But do they? Gathering information is difficult. Patients may not consider all of the potential incremental benefits of single rooms or they may over-estimate them (Grant, 2005). If patients underestimate the health benefits of single-occupancy rooms then the market price differential will underestimate patient benefits, and vice versa.

One way to partially check the validity of our estimate of the benefits of being in a single room is to estimate the magnitude of the various impacts that result from being in a single room, value each of them separately, and then sum them. We focus first on privacy and noise, and then on health benefits.

Privacy and Noise. Part of the reason people are willing to pay for privacy is reduced noise. Noise is high in hospitals, predominantly due to the movement of equipment and interpersonal communications of staff, patients, and visitors. Quieter (i.e. private) rooms may improve patient satisfaction and reduce recovery times. Wibe (1997) studied the cost of noise in Sweden and found that persons were willing to pay roughly 6.5 per cent of mean monthly rental charge per household to decrease noise to a "quiet" or non-disruptive level. Given that the average rent for a two-bedroom apartment in Vancouver is $984 per month, the cost of noise reduction would be $63.96 per month or $2.12 per day. Saelendminde (1999) found the willingness to pay for road traffic noise reduction by an "annoyed" person is between $645 and $1291 per year in Norway, i.e. approximately $2.65 per day. Intuition suggests that these numbers are lower than an in-patient would pay for reduced noise, but even assuming patients would be willing to pay the average of these amounts for the reduced noise in a private room, $2.38 per day, this amounts to $695 per year, which has a PV of $16,300.

In a private room, patients can engage in their personal habits without embarrassment or offending another party and they do not have to endure another patient's suffering or their irritating habits. One potential shadow price for privacy is the incremental amount single people are willing to pay for a private cabin on a cruise ship. A survey of eight advertised singles cruises of 3-night to 12-night durations that originated in different parts of the world found that the average cost differential for private accommodation for an inside cabin is $121.75 per day. Of course, people may be willing to pay more for privacy on a singles holiday than in hospital due to higher disposable income and personal preferences. Also, there is some evidence that privacy is less valued with increasing illness (Spork, 1990). Nonetheless, the results do suggest that our earlier $40 per day estimate for a private hospital room is likely to be on the low side.

Patient Treatment, Patient Health and Adverse Events. Single rooms may result in better treatment, fewer medical errors and reduced chance of hospital-acquired infection or other adverse events. Single rooms are better suited to the maintenance of patient confidentiality, which impacts patients' rights and has health care implications. Roughly 5 per cent of patients in multi-bed rooms withhold portions of their medical history and/or refuse components of their physical examinations (Barlas et al., 2001). Nurses overwhelmingly consider patient consultation/examination is improved in single patient rooms (Chaudhury et al., 2003). Improved communication may lead to better treatment and fewer adverse events.

Inpatients may worry about hospital-acquired infections from antibiotic resistant pathogens (MRSA, VRE), the presence of airborne pathogens (tuberculosis, varicella-zoster) and potentially highly virulent and transmissible pathogens (SARS, avian influenza). On average, nosocomial infection rates range between 7 and 10 per cent of all inpatients, with rates in the ICU approaching 50 per cent (Filetoth, 2003). Such infections may lead to serious illness, permanent disability and death. The reduction in risk of nosocomial infection associated with private rooms is regarded as a major reason for providing them (Ulrich and Zimring, 2004). However, reliable statistical evidence is weak. In a systematic review of 178 studies Dettenkofer et al. (2004) found only 17 studies that had well-conducted designs. Unfortunately, many of these studies were confounded by alterations in staffing ratios, increases in sanitary facilities or other factors. Most studies pertained to specialised wards, not general wards where the risk of cross infection is likely to be much lower (Premier Safety Institute, 2005). In general hospital settings, a change from a five-person to a four-person ward was the breakpoint in reducing MRSA infections. Moving from a semi-private room to a private room appears to have negligible impact on reducing infections.

The incremental effect of single-occupancy rooms relative to double-occupancy rooms on patients' health and the likelihood of adverse events in a new, best-practice design is up for debate. Good work environments that lessen staff fatigue and unhappiness can reduce medical errors leading to mortality by about 5 per cent (Lundstrom et al., 2002). Suppose, for illustrative purposes, private rooms reduce the incidence of preventable adverse events by 1 percent.

At St. Paul's Hospital each acute inpatient stay is 9.1 days on average. Consequently, there are approximately 32 (0.8x365/9.1) patients per bed per year, assuming an 80 per cent occupancy rate. The Canadian Adverse Events Study (Baker et al., 2004) estimates that, on average, there are 7.5 adverse events (unintended injury, including unintended infections) per 100 patients of which over 40 per cent (3.1 in 100) are preventable. Roughly 20 per cent of individuals with an adverse event die, the remainder suffer serious illness. Thus, there are approximately 0.992 (32x0.031) preventable adverse events per bed year, of which 0.2 die and 0.8 suffer a serious illness. Assuming that single occupancy beds reduce mortality and morbidity by 1 per cent implies a reduction of 0.002 deaths per bed year and a reduction of 0.008 serious illnesses.

Based on a thorough evaluation of the literature, Zhang et al. (2004) recently concluded that the best point estimate of the value of a statistical life (VSL) in Canada equals $4.25 million (2002 Canadian Dollars). Using the CPI to convert this amount into 2005 Canadian dollars, suggests the VSL equals $4.48 million. Most of the research on estimating the value of avoiding a serious illness is in the transportation area and focuses on the social cost of road crashes of different levels of severity from minor (AIS 1) to fatal (AIS 6). Using a willingness-to-pay approach, Blincoe et al. (2000) estimate the cost of a serious crash injury requiring hospitalization is $325,480 (AIS 3), while the cost of a severe crash injury is $757,837 (AIS 4). Subtracting the cost of medical and emergency services, insurance administrative costs, legal

costs, property damage and travel delay costs yields an estimated value of $228,554 for a serious injury avoided and $536,482 for a severe injury avoided. Helliwell (2005) proposes an alternative approach and estimates the income equivalent to a change in happiness associated with enduring a serious illness is $320,000. We use this estimate as it is within the bounds of the estimates from the transportation literature and it is likely to be a lower bound on the willingness-to-pay for avoiding a severe adverse event in a hospital. Using a VSL of $4.48 million and the value of a serious illness avoided of $320,000 implies a saving of $8,960 for deaths avoided per bed year and a saving of $2,560 for serious illness avoided per bed year for a total of $11,520 per bed per year, which has an NPV of $270,209. Thus, very slight reductions in the number of adverse events can have a large impact on the net benefits.

Sensitivity Analysis

The actual cost of construction might be lower than $410 per sq. ft. suggested by Davis Langdon Adamson (2003). Discussions with local architects and developers suggest that hospitals can be constructed for as little as $250 per sq. ft., which would increase net social benefits (NSB) by $23,840 per patient bed to $94,818.

On the other hand we may have under-estimated some costs. The estimate of incremental nursing costs was based only on the increased walking distance—about half an hour per day. It ignores the fact that wards with private rooms might have more nurses per patient on average due to the need to maintain minimum nursing levels (numbers) on each shift. Also, the implicit assumption that nurses spend the same amount of time per patient may be incorrect. Patients in private rooms may have a greater need to talk with nurses as they do not have a roommate. The incremental cost estimate of physicians' time may be low for two reasons. First, the opportunity cost of their time may be greater than $96 per hour. Many cardiac surgeons, for example, earn

more than $400,000 per year. Second, a hospital with more single occupancy rooms would have more wards and would therefore require more physician travel time between wards.

The main conclusion is not very sensitive to the choice of the discount rate. If we use a lower discount rate of 2 per cent, the PV of the net social benefits increases by $53,721 to $124,429 per patient bed. If we use a higher discount rate of 5 percent, the PV of the net social benefits decreases by $27,727 to $42,981 per patient bed.

5. Conclusion

This study estimates the costs and benefits of private rooms versus semi-private rooms in a new hospital, build according to best practices in Canada. As far as we know, this is the first study to conduct a comprehensive examination, quantification and monetization of such benefits and costs. The main conclusion is that the estimated benefits of a private room exceed the estimated costs for the average patient.

We are reasonably confident about our cost estimates, although the incremental construction cost might be lower than our figure. Estimating the benefits is less certain. This study estimates benefits based on patients' willingness-to-pay, derived from market prices. It assumes markets are reasonably competitive and that patients are well informed. However, this may not be the case. Consequently, we also estimated patient benefits by examining the specific components and adding them up. This additional analysis suggested that our benefits estimates are fairly conservative.

Patients may over-estimate the health benefits of being in a private room, especially the reduced risk of infection leading to an adverse event. However, we show that small improvements in adverse events can have a large impact on the estimated net benefits of private rooms.

Our study does not imply that one should necessarily build the new hospital with only private rooms. Private rooms are more expensive to construct and require more nursing time under conditions of resource restrictions. The main benefit of private rooms comes from patients' desire for privacy, despite evidence that roommates reduce anxiety among newly admitted patients and provide companionship. Under these circumstances it seems appropriate to offer single rooms only to those who are willing to pay for them. Of course, patients at high risk of nosocomial infection, or who are carriers of infectious diseases need to be isolated. Also, particularly difficult patients with disruptive behaviours will never make good roommates.

Some patients prefer semi-private rooms. Given this preference, and the fact that semi-private rooms cost less, it seem reasonable to include some semi-private rooms in a new hospital. Also, providing some semi-private rooms may help the hospital internalize the willingness to pay of patients who prefer single rooms through differential pricing strategies. In Canada, hospitals may not be able to charge extra for private rooms if no alternate accommodation is available.

In the lower mainland of BC, approximately 53 percent of the rooms accomodate more than two people (wards), 30 percent are semi-private and 17 percent are private; see Table 2. To make policy suggestions concerning the ratios in new hospitals requires further analysis. We would recommend increasing the proportion of private rooms, but not to 100 percent.

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Table 1: The Costs and Benefits of a Private Inpatient Room Relative to a Semi-Private Room

Impact Category	Cost	Benefit	Description
COSTS			
Land cost	X		Larger room requires more land
Construction cost	X		Single-occupancy room requires more space per patient
Maintenance	X		Refinishing and updating of interior fixtures and furniture every 10 years. Larger area per patient costs more.
Housekeeping and operating costs	X		Based on ward area
Health provision	X		Longer distances traveled by nurses and doctors takes more time
PATIENT IMPACTS			
Patient Health and Satisfaction		X	
- Privacy and ability to sleep		X	Preference for privacy. Also, improved ability to rest increases recovery times
- Patient care, reduced infection and fewer adverse events		X	Patients are more open and honest, reduced infection, nurses make fewer errors
- No help or companionship from roommate	X		Roommate could help with surveillance, falls, reassurance
OTHER IMPACTS			
Patient transfers (orderlies)		X	Fewer transfers, but slightly longer distances
Patient turnover	X	X	Reduced patient waiting time; slight increase in administrative costs

Table 2: Market Daily Prices of Semi-Private Rooms and Private Rooms and the Distribution of Rooms in Selected Canadian and United States Hospitals

	Semi-Private ($)	Private ($)	Difference ($)	Wards (%)	Semi-Private (%)	Private (%)
Canada						
Burnaby General	100	130	30			
Surrey Memorial	90	120	30	54	36	9
Lions Gate Hospital	90	110	20	46	39	16
Richmond General	60	100	40	82	9	9
Vancouver Hospital and Health Science Centre	110	150	40			
University of British Columbia Hospital	75	115	40	33	33	33
St. Pauls Hospital	85	120	34	48	32	20
Average Canadian Sample	87	121	33	53	30	17
U.S. (In Canadian $)						
Bronson Medical Center	n/a	2020	n/a			
Hackensack Medical Center	7246	7497	251			
Southwest Medical Center	916	960	44			
Swedish Medical Center	1615	1615	0			
Sacred Heart Hospital	847	847	0			
University of Washington Medical Center	1096	1506	410			
Average U.S. sample	2344	2408	141			

U.S. Prices Converted to Canadian dollars at 1 C$ = U.S.$0.797, based on http://money.mytelus.com/sub/tlsForex.asp (May 3, 2005)

Table 3: The Costs and Benefits of a Private Inpatient Hospital Room Relative to a Semi-Private Room

Impact	Semi-Private Room	Private Room	Difference	PV of Difference[1]
Up-Front Costs				
Land Cost (per patient bed)	18,849	28,635	9,786	9,786
Construction Cost (per patient bed)	117,670	178,760	61,090	61,090
On-going Annual Costs				
Maintenance	1,177	1,788	611	14,329
Housekeeping and Operating	4,397	6,680	2,283	53,542
Cost of Nurses Care			3,457	85,522
Cost of Doctors			153	3,589
Total costs				227,857
Annual Benefits				
Patients' Willingness to Pay	22,864	35,303	12,439	291,769
Fewer Patient Transfers			250	5,858
Reduced Waiting Time				938
Total benefits				298,565
Net Social Benefits				70,708

[1] The present values (PV) are based on an expected hospital life of 50 years and assuming a discount rate of 3.5 percent.