A Benefit-Cost Analysis of Private and Semi-Private Hospital Rooms

Anthony E. Boardman, *University of British Columbia*
Diane Forbes, *HEP Consulting*

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Abstract

The design of new hospital inpatient rooms is moving towards private (single occupancy) rooms. These rooms are generally preferred by patients and they may improve patient care, but they are more expensive to build and to staff than semi-private rooms. The question of their societal worth is important because hospitals are expensive, long-term investments and, once built, are prohibitively expensive to change. This paper presents a benefit-cost analysis of private rooms versus semi-private rooms in a proposed new hospital. We estimate that the net social benefit of a bed in a private room is about $70,000 more than a bed in a semi-private room.

KEYWORDS: benefit-cost analysis, acute care hospital room occupancy, health care financing

1. INTRODUCTION

Over time there has been a gradual trend towards private (single-occupancy), acute care hospital rooms in developed countries. In the nineteenth century and early part of the twentieth century, new hospitals had large wards with many beds in each ward. A few private and semi-private rooms were available for those who were willing to pay for them. For the past 50 years or so most hospitals were built with a mixture of 4-bed rooms, 2-bed rooms and single occupancy rooms. Currently, roughly half of the beds in large multi-purpose Canadian hospitals are on wards with 4 or more beds per room. However, private rooms are increasingly considered desirable for a new hospital. In Great Britain new hospitals are required to have at least 50 percent private rooms, while many new hospitals in North America and continental Europe provide private rooms exclusively (Dowdeswell et al., 2004; Jones and Thomas, 2004; Detsky and Etchells, 2008). In Canada, the Kingston General Hospital (2008) redevelopment project has more private rooms than "typical," the Royal Jubilee Hospital redevelopment (British Columbia Ministry of Health, 2007) has 70 percent private rooms, and the Strathcona Community Hospital (Alberta Health Services, 2008) has 80% private rooms.

For a new hospital in a developed country the choice is now limited to private and semi-private rooms. There are some obvious trade-offs between these two types of rooms. Private rooms are generally preferred by patients and they may lessen recovery time, but they take up more space and they are more expensive to build and to staff than semi-private rooms. The purpose of this article is to conduct a comprehensive benefit-cost analysis of private (single occupancy) and semi-private (double occupancy) rooms.

This analysis is important for a number of reasons. First, hospitals are expensive to construct and to operate. In Canada, hospitals account for almost 30 percent of all health care expenditures, which is about 3.5 percent of GDP (CIHI, 2010). In the United States (U.S.) hospitals account for nearly one-third of all health care expenditures, or almost 5 percent of GDP (Hartman et al., 2010). A new hospital often costs billions of dollars. Hospitals usually last 50 years or more and, once they have been built, it is very expensive to change the layout. In practice, the decision is long-term and irreversible.

Second, approximately 80 percent of the space in new urban hospitals is devoted to inpatient rooms. The space allocated to each inpatient bed has more than doubled in the past 30 years and continues to increase (Hosking, 2004). This factor undoubtedly contributes to the increasing cost of hospitals.

Third, there is a growing need for new hospitals. Many existing hospital facilities are outdated and are approaching the end of their useful life (Hosking, 2004). Also, they often occupy valuable land in central urban areas. Developers

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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, the number of inpatients in acute care hospitals is increasing. In the U.S., for example, the number of inpatients increased by almost 10 percent between 2000 and 2008, while the average length of stay has remained constant at around 4.6 days (U.S. Department of Health and Human Services, 2010). With population increases, the baby boomer demographic shift, and increasing wealth and expectations, the demand for hospital services will rise (Shactman et al., 2003). All of these pressures will lead to a significant increase in the number of new hospitals built during the next decade in many developed countries.

Finally, with the exception of the U.S., hospitals are owned directly or indirectly by governments and are funded by taxpayers. They should receive value for money.

To date, there has been no comprehensive quantitative analysis of the social costs and benefits of building private or semi-private acute care hospital rooms. Prior literature has identified some of the impacts of room occupancy on space requirements and cost (BTY Group, 2003; Davis Langdon Adamson, 2003). There has also been research on various factors that relate to patient satisfaction or health outcomes, such as increased satisfaction among nurses, decreased infection rates, reduced need for transfers, reduced medication errors, improved quality of care and higher patient satisfaction (Janssen et al., 2001; Duffin, 2002; Page, 2004; Chaudhury et al., 2005, 2006, 2009; Calkins and Cassella, 2007; van de Glind et al., 2007; Detsky and Etchells, 2008). However, much of this research is based on focus groups, derived from "expert opinion," or is anecdotal. Some authors treat the incremental benefits of private rooms as self-evident. No research has attempted to estimate the social value of these impacts quantitatively—either individually or collectively. And there has been no analysis of the trade-off between the expected benefits and the expected costs.

Section 2 identifies and categorizes the expected impacts of private versus semi-private rooms, and provides a quantitative assessment of these impacts. Section 3 presents monetized estimates of the incremental social costs and benefits of private versus semi-private rooms on a per bed basis. In this section, patients' benefits are estimated based on their willingness to pay derived from current Canadian and U.S. market prices. Section 4 estimates patients' benefits using an alternative methodology that considers the various impacts that result from being in a private room, values them separately, and then sums them. Section 5 contains some sensitivity analysis. The final section provides a brief conclusion.

Our analysis is based on a proposed new facility to replace St. Paul's hospital in Vancouver, BC, with an estimated capacity of 537 beds. While the specific quantitative estimates of the benefits and costs of private rooms are

location specific, the qualitative conclusions are probably generally applicable to any new, multi-purpose, urban hospital in a developed country.

2. THE IMPACTS OF PRIVATE ROOMS

Since there are only two feasible alternatives, we arbitrarily select semi-private rooms as the counterfactual and consider the incremental social costs and benefits (on a per bed basis) of a private room, relative to a semi-private room. Table 1 lists these impacts and provides a brief discussion of each impact. Impacts that would be the same in both room designs are ignored. For example, we assume that the demolition costs are the same for a private room as for a semi-private room.

Table 1: The Impacts of a Private Hospital Room vs. a Semi-Private Room

Impact Category	Description
LAND, CONSTRUCTION AND OPERATING COSTS	
Land cost	Single-occupancy room requires more land
Construction cost	Single-occupancy room is larger and requires more corridor space
Maintenance	Refinishing and updating of interior fixtures and furniture every 10 years
Housekeeping and operating costs	Based on ward area
Health care provision	Longer distances traveled by nurses and doctors
PATIENT IMPACTS	
Patient Health and Satisfaction	
- Noise and the ability to sleep	Improved ability to rest and sleep
- Privacy	Maintain dignity and engage in personal habits
- Fewer preventable adverse events	Patients are more open and honest, nurses make fewer errors, lower infection rates
GENERAL POPULATION IMPACTS	
Option value	People know that they can have a private room if and when they need one
HOSPITAL IMPACTS	
Patient transfers	Fewer transfers, but slightly longer distances
Patient turnover	Reduced length of hospital stay increases turnover

Private rooms require more space per bed. Consequently, they require more land, have higher construction costs, require more maintenance, and have higher housekeeping and plant operations costs. Also, they decrease the productivity of doctors and nurses who have to walk longer distances between beds or between hospital floors and, therefore, increase the cost of providing health services. However, private rooms may provide important benefits to patients over semi-private rooms. Table 1 contains three potentially key factors identified in the literature: noise and the ability to sleep, privacy and dignity, and the likelihood of an adverse event.

In addition, members of the general public who would like to be in a private room if it were necessary may derive option value from knowing that this would be possible when they needed it. Finally there are potential benefits accruing to the hospital including fewer patient transfers and reduced length of hospital stays.

We now investigate these impacts in more depth and, for most impacts, we provide quantitative estimates. In order to do this it is necessary to consider a specific hospital facility. As mentioned above, our analysis concerns a proposed new 537-bed facility in Vancouver, BC.

Description of Space and Space Requirements

This article assumes that the new hospital will be constructed according to "best practices" design features (Green Guide for Health Care, n.d.; Fisk and Rosenfeld, 1997; Ulrich, 1999; Bilchik, 2002; Ulrich and Zimring, 2004). Professional organizations such as The American Institute of Architects, Hospitals for a Healthy Environment 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 a 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 these best practices in Canada require about 265 sq. ft. per patient bed, say 13.25' x 20'. This is approximately 100 sq. ft. (61 percent) more space than required by a bed in a semi-private room, say 15' x 22', or 165 sq. ft. per patient bed. Recommended sizes of hospital rooms in the U.S. are slightly larger, although the ratio of the size of private to semi-private rooms (including bathroom area) on a per patient bed basis is about the same (BTY Group, 2003; Davis Langdon Adamson, 2003).

Private rooms also require more corridor space, larger nursing areas and more janitorial facilities per patient bed. Suppose that the new hospital has a

triangular floor plan with each exterior wall approximately 120'. Also suppose that patient rooms on the outside, and the corridors and nursing areas are in the middle. This layout could accommodate 42 patients in semi-private rooms or 24 patients in private rooms. Patient rooms would occupy 6,930 sq. ft. on a semi-private ward and 6,360 sq. ft. on a private 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, which implies an overall gross mark-up of 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 private rooms because the size of the nursing area varies more with number of patients than with room size. Our estimated mark-ups are lower than those estimated by Davis Langdon Adamson (2003), although, similar to them, they indicate that a bed in a private room requires about 50 percent more space in aggregate than a bed in a semi-private room.

Impacts on Nurses' and Doctors' Time

The number of beds in each room affects the provision of heath care because nurses and doctors spend more time walking between patients in private rooms than between patients in semi-private rooms. Typically, patients receive about 5 hours of nursing support per day (nurse to patient ratios are about 1:4 (days), 1:6 (evenings) and 1:8 (over-night)). Assuming a 7.5 hr work shift, each patient bed requires about 0.66 nurses per day. Shepley and Davies (2003) indicate that, on average, each nurse walks 5,490 linear feet (just over a mile or 1.67 kms.) in 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. Therefore, given that private rooms require 52 percent more space per patient, nurses on wards with private rooms spend about half an hour more time walking per shift. This amount is equivalent to about 20 minutes (0.66 x 30 minutes) per patient per day. Note that the impact on time is calculated on a per patient basis and is, therefore, independent of the occupancy rate.

Impacts on Patients

The literature on the impact of hospital room design on patients considers many different aspects. Based on our review of this literature there are three potentially important impacts on patients: noise, privacy, and the risk of an adverse event.
　　Noise: Noise is high in hospitals, predominantly due to the movement of equipment and interpersonal communications of staff, patients, and visitors. Sick patients have a low tolerance for noise (Duffin, 2002). Private rooms are quieter:

patients suffer fewer disruptions from staff and other patients, thereby increasing their ability to rest and sleep (Hilton, 1985).

Privacy: Patients enjoy greater privacy in a private room: they can do what they want when they want. They can engage in their personal habits without embarrassment or offending another party. They can maintain their dignity, they do not have to pay attention to someone they may not like, and they do not have to endure another patient's suffering or their irritating habits.

Risk of an Adverse Event: Unfortunately, adverse events, such as injury and infections, are not uncommon in hospitals. Many patients probably think that the greatest risk is that of infection from antibiotic resistant pathogens (e.g., Methicillin-Resistant Staphylococcus Aureus (MRSA)), airborne pathogens (e.g., tuberculosis) or potentially highly virulent and transmissible pathogens (e.g., avian influenza). On average, nosocomial (hospital acquired) infection rates affect between 7 and 10 percent of all inpatients, with rates in an intensive care unit (ICU) approaching 50 percent (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 had well-designed protocols. Unfortunately, many of these studies were confounded by alterations in staffing ratios, increases in sanitary facilities or other factors. In general hospital settings, a change from a five-person ward to a four-person ward was found to be the breakpoint in reducing MRSA infections, not from semi-private rooms to private rooms. Most well designed studies demonstrating effective infection control pertain to specialised wards, not general wards where the risk of cross infection is likely to be much lower (Lorenz, 2003; Dettenkofer, 2004; Premier Safety Institute, n.d.). At present, therefore, there is not strong or consistent evidence that there is less risk of infection from being in a private room rather than in a semi-private room when considering the hospital as a whole.

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 (Ulrich and Zimring, 2004). Roughly 5 percent 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 consultations/examinations are improved in private rooms and they may employ better nursing practices (e.g. hand washing) in such rooms (Chaudhury et al., 2003).

Also, it is easier for friends and family to stay with patients in private rooms. Consequently, patients in private rooms may receive more assistance and support from family members (Hendrich et al., 2004).

On the other hand, there are a number of potential disadvantages of private rooms. Despite nurses' stated belief in the superiority of private rooms, these rooms require nurses to walk longer distances to attend to patients, which might increase fatigue or cause nurses to hurry. Also, patients in private rooms do not have a roommate. A roommate can provide comfort, companionship, help and security. For example, if one patient falls unobserved by staff, the other patient can call for help. This assistance may be particularly important for seniors (Lorenz 2009). Stelfox et al. (2003) report that supportive care failures are increased in private, isolation rooms. Also, Kulik et al. (1993) found that the preoperative stress of new patients is reduced if they share a room with a postoperative patient.

Unfortunately, there is little quantitative data on the aggregate impact of private rooms on preventable adverse events (Chaudhury et al. 2009). However, good work environments that lessen staff fatigue and unhappiness can reduce medical errors leading to mortality by about 5 percent (Lundstrom et al., 2002). Suppose, therefore, that private rooms provide 20 percent of this benefit and, therefore, reduce the incidence of preventable adverse events by 1 percentage point. The Canadian Adverse Events Study estimates that, on average, there are 7.5 adverse events per 100 patients of which over 40 percent (3.1 in 100) are preventable (Baker et al., 2004). At St. Paul's Hospital each acute inpatient stays 9.1 days on average. Consequently, there are 32 (0.8 x 365/9.1) patients per bed per year, assuming an 80 percent occupancy rate, which implies there are approximately 0.992 (32 x 0.031) preventable adverse events per bed year. Roughly 20 percent of individuals with an adverse event die, while the remainder suffers serious illness. Thus, there is approximately one preventable adverse event per bed year, of which 0.2 cause death and 0.8 result in a serious illness. If a private room reduced these events by one percentage point, it would avoid 0.002 deaths and 0.008 serious illnesses per bed year.

Reprise Concerning Impacts on Patients: Patients may or may not be aware of these impacts and they may hold different opinions about the value of them. Some patients may value one aspect, such as privacy, while other patients may value another aspect, such as reduced risk of infection. For this study, however, it is not necessary for patients to know the effects or to value them separately, although we do perform this analysis in a later section. What matters is the incremental amount of money that patients are willing to pay for a private room over a semi-private room, which we discuss in the next section.

It is possible that private rooms have benefits (or costs) that we have not identified above. For example, there might be benefits post-discharge, although our literature review has not identified any other impacts. As mentioned above, if patients think these effects exist, they will be incorporated into their willingness to pay for a private room.

Impacts on the General Population

Some "option value" benefit may accrue to non-patients. Suppose that you are currently healthy. Also suppose that if you were in a hospital, then you would prefer a private room. It seems reasonable to suppose that you would be better off now if you knew that a private room would be available if and when you needed one.

Impacts on Patient Transfers

In rooms with multiple occupants, patient transfers occur most often due to patient requests for privacy, to avoid disruptive, misbehaving patients or to control infection. Consequently, private rooms reduce within-hospital transfers, thereby reducing orderly time. 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). We assume that a private room reduces the probability of being transferred within a ward during a week from 0.167 to zero but has no effect on moves to ICU wards as these moves are not closely related to room occupancy.

Higher Turnover and Reduced Waiting Time

Possibly due to better consultations and treatment, better sleep and fewer adverse events, private rooms probably reduce patients' length of stay in hospital (Duffin, 2002). This saving could be "spent" in two ways or a combination thereof. One option would hold the total number of patients in a year constant, but would reduce the occupancy rate. In turn, this might reduce crowding and the "boarding" of patients in the emergency department until a bed becomes available. Diercks et al. (2007) and others have found that boarding has a negative impact on patients' quality of care. Thus, there could be an additional positive effect on patient outcomes. In our view, however, Canadian hospital administrators would be more likely to treat more patients in a period (increase turnover) and reduce waiting times for patients seeking care. Earlier we suggested that private rooms reduce the number of preventable adverse events by about one percentage point per year. Baker et al. (2004) estimate that each adverse event increases the length of hospitalization by about 16 days. Thus, private rooms could reduce the usage of each patient bed by about 0.16 days per year. Of course, this benefit would be partially offset by slightly increased administrative costs, which we ignore.

3. QUANTITATIVE ESTIMATES OF THE COSTS AND BENEFITS OF A PRIVATE ROOM

This section monetizes the estimated impacts discussed above and computes the present value (PV) of the benefits, costs and net social benefits of a bed in a private room relative to a bed in a semi-private room. In order to compute specific numbers we need to make some assumptions about the longevity of hospitals and the social discount rate.

Architects often consider a hospital's useful life is 40 years although they are frequently in use longer. Fraumeni (1997) reviews the practices of the Bureau of Economic Analysis 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 rooms will last 50 years after which they will be demolished.

Table 2: The Social Costs and Benefits of a Bed in a Private Hospital Room Relative to a Semi-Private Room

Costs and Benefits	Semi-Private Room	Private Room	Total or Annual Difference	PV of Difference (with Adjustments)
Up-Front Costs				
Land Cost	24,748	37,596	12,848	10,714
Construction Cost	126,854	192,712	65,858	65,858
On-going Annual Costs				
Maintenance	1,269	1,927	659	15,447
Housekeeping and Operating	4,741	7,203	2,461	57,736
Additional Nursing Costs			3,726	92,181
Additional Cost to Doctors			165	3,870
Total Costs				**245,806**
Annual Benefits				
Patients' Willingness to Pay			13,140	308,207
Reduced Transfers			269	6,314
Reduced Waiting Time			43	1,011
Option Value				+
Total Benefits				**315,532**
Net Social Benefits				**69,726**

The choice of the social discount rate (SDR) is often an important issue. Drawing on a recent article by Boardman et al. (2010) we use a SDR of 3.5 percent. The results, which are summarized in Table 2, are expressed in Canadian 2008 dollars.

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 obtain 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 $105 to $120 per buildable sq. ft. on the west side of Vancouver and from $30 to $40 per buildable sq. ft. on the east side in Vancouver. Given the proposed location of the new hospital, $86.23 per buildable sq. ft. is appropriate. Consequently, the land cost would be $24,748 for each semi-private bed, and $37,596 for each private bed, a difference of $12,848 per patient bed.

At the end of the hospital's 50-year life, the hospital authority would own more land if it adopted the private room alternative. The present value of owning 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 $4,431 per semi-private room, $6,731 per private room, a difference of $2,134. Thus, the net incremental PV of the land cost of a private patient bed over 50 years is $10,714.

Construction Cost

Davis Langdon Adamson (2003) estimate U.S. construction costs for ten new hospital ward designs. They break construction costs down into several component parts including, for example, the exterior shell, the interior, the functional equipment, and mechanical, electrical and plumbing costs. Excluding the cost of site preparation, landscaping or onsite utilities, which would not vary with room type, they estimate the cost of construction is approximately U.S. $285 per sq. ft. It is not clear whether this figure is in November 2003 dollars or March 2005 dollars. Assuming it is in Nov 2003 dollars, converting it to Canadian dollars at an exchange rate of 1.31, adding inflation in the interim to mid 2008 (9.12%) and then adding 10 percent due to the relatively high construction costs in Vancouver at that time yields an estimated construction cost of $442 per sq. ft. in 2008 Canadian dollars. (If we assumed the figure was in March 2005 U.S. $ this would yield a lower figure in 2008 Canadian $ mainly because the Canadian

dollar was higher in March 2005.) This cost does not vary with room occupancy, that is, it is independent of the number of beds in a room. One might think that the cost per square foot of a private room would be higher than for a semi-private room because it would have relatively more bathroom space. In practice the difference is negligible (Davis Langdon and Adamson, 2003) or less than 4 percent (BTY Group, 2003). Costs 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 a construction cost estimate of $442 per sq. ft. implies that the PV of the cost of constructing the total space (hospital room, corridors and nursing area) associated with a patient bed in a semi-private room is $126,854, while the PV of the cost associated with a private room is $192,712, a difference of $65,858 per patient bed.

Maintenance

Hospital rooms are rarely subject to major refurbishing due to the significant pipefitting (gas and plumbing) costs required. However, patient 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—$1,269 per annum for a semi-private patient bed, $1,927 per annum for a private patient bed, a difference of $659 per year. The PV of this amount for 50 years discounted at 3.5 percent equals $15,447.

Housekeeping and Operating Costs

Housekeeping costs at St. Paul's Hospital are $7.83 per sq. ft. per annum and plant operations cost are $10.37 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 about $1.68 per sq. ft. (Harvard Green Campus Initiative, n.d.). Therefore, the annual housekeeping and plant operating costs for an energy efficient design would be about $16.52 ($7.83+10.37-1.68) per sq. ft. Multiplying this amount by the space required for each bed (287 sq ft. per bed in a semi-private room and 436 sq ft. per bed in a private room) implies that the annual housekeeping and maintenance costs would be $4,741 for a semi-private room bed and $7,203 for a private room bed, a difference of $2,461 per annum, equivalent to a PV of $57,736 over the life of the hospital.

Patients' Care Costs

The previous section suggested that, due to longer distances travelled, beds in private rooms require, on average, 20 more minutes of nursing time per day. It is not clear who will bear these costs. Nurses may keep patient care constant and take the time out of their breaks, the hospital may hire more staff or nurses will spend less time with patients. Either way, nurses' salaries would provide a reasonable estimate of the social cost.

Registered nurses perform approximately 75 percent of nursing duties; licensed practical nurses perform the remainder. In Vancouver these nurses earn roughly $64,670 and $44,190 per annum, respectively. Consequently, each hour of patient care costs $30.54 in nursing time. Assuming full occupancy or, equivalently, that the additional walking distance is independent of the actual occupancy rate, the additional nursing cost from having private rooms would be $3,726 per bed per year (1/3 hours per day x 365 days/year x $30.54 per hour), which has a PV equal to $87,396.

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 $92,181.

Private rooms also increase physicians' costs because they have to walk further too. The average Canadian physician's income is $202,585 per year, or $103.88 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 $165 per patient bed per year (0.013x.33 hours x365 days x $103.88 per hour), which has a PV equal to $3,870. This may be an underestimate, as physicians' incomes may be better estimated on a per patient or per procedure basis rather than on an hourly basis.

Patients' Benefits

Patients are the main beneficiaries of private rooms. As we discussed above, patients in private rooms may sleep better, enjoy more privacy, receive better care, and suffer fewer adverse events. These impacts may hasten recovery, reduce the risk of death, reduce time in hospital and may even have post-discharge benefits. Previous research indicates that, in general, patients are "more satisfied" with private rooms (Ulrich and Zimring, 2004; Chaudhury et al., 2005). Benefit-

cost analysis, however, requires an estimate of willingness to pay. With well-informed consumers and well-functioning markets, the difference in price between two goods or services provides an estimate of the incremental willingness to pay for one good over the other (Boardman et al., 2011). A natural estimate of the incremental benefit of a private room, therefore, is the difference in price between beds in private 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. Beds on wards (with 4 or more patients) are typically fully paid under the public health care plans while patients often have to pay extra for private or semi-private rooms. As shown in Table 3, the price of a bed in a semi-private room in Canadian hospitals ranges from $65 to $119 per day, while the price of a bed in a private room ranges from $108 to $162 per day. On average, a private room costs $36 more per day.

For the most part, price differences between these hospitals reflect the hospital's location, age and size. There are more private rooms on maternity wards than on other wards. Generally, though, patients can choose the type of room they prefer and are not assigned rooms based on their condition unless they have a communicable disease considered to be a risk to other patients. (Patients who want elective surgery and have a communicable disease are often not admitted.) Anecdotal evidence at St. Paul's Hospital indicates that there is some excess demand for private rooms, which suggests that the market price differentials under-estimate the premiums that most patients are willing to pay for a private room. On the other hand, the additional cost of a private room may be covered by insurance for some patients. On balance, we think that they $36 per day price difference is a reasonable estimate of patients' willingness to pay for a private room in the currently available hospital facilities.

One might think that U.S. data would provide a better estimate of willingness to pay due to more competition. However, while patients have more choice about which hospital to attend, many local U.S. markets are dominated by a few hospital systems and they are affected by the presence of vertically integrated HMOs (e.g. Kaiser), Medicare, Medicaid and private insurance (Gaynor and Vogt, 2003). Overall prices are much higher in the U.S. Some hospitals may provide more expensive "hotel services" (Mukamel et al., 2002) as a means of differentiating their services in a private health care system. While the average price premium for a single room is much higher in the U.S. than in Canada ($152 versus $36, both in 2008 Canadian $), this premium is a much smaller percentage mark-up over the price of a semi-private room (109% versus 140%, on average).

Table 3: Prices (Per Day) of a Bed in a Semi-Private and Private Room

Hospitals	Semi-Private ($)	Private ($)	Difference ($)	Difference (%)
Canadian Hospitals				
Burnaby General	108	140	32	130
Surrey Memorial	97	129	32	133
Lions Gate Hospital	97	119	22	123
Richmond General	65	108	43	166
Vancouver Hospital and Health Science Centre	119	162	43	136
University of British Columbia Hospital	81	124	43	153
St. Paul's Hospital	92	129	37	140
Average Canadian Sample	94	130	36	140
U.S. Hospitals				
Bronson Medical Center	n/a	2177	n/a	n/a
Hackensack Medical Center	7,810	8,081	271	103
Southwest Medical Center	987	1,035	48	105
Swedish Medical Center	1,741	1,741	0	100
Sacred Heart Hospital	913	913	0	100
University of Washington Medical Center	1,181	1,623	442	137
Average U.S. sample	2,526	2,595	152	109

Taking account of these factors, and recognizing that the proposed hospital would be the most modern in the region, suggests that the average patient would be willing to pay about $45 per day for a private room than a semi-private room in the new hospital.

Estimation of the annual patient benefits also requires an estimate of the occupancy rate. Beds cannot 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 ICU. In practice, 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 (i.e., 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 percent *for all open beds*, this would be approximately equivalent to about 80 percent *of the total beds*. Assuming that each bed is occupied 80 percent of the time implies that the incremental benefit of a private room is, on average, $13,140 per year, which has a PV of $308,207.

Fewer Transfers

Most transfers require less than 30 minutes in time and cost between $31 and $178, depending on the nature of the facility and the location of the move (Chaudhury et al., 2003). We use the lower figure of $31.00 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. Assuming, as we argued above, that private rooms reduce the number of transfers by .167 per week (8.68 per year), we estimate that private rooms would save $269.20 per bed per year compared to semi-private rooms due to reduced transfers. This amount has a PV of $6,314.

Faster Turnover and Reduced Waiting Time

One way to value this benefit is to suppose that, as a result of increased turnover, the hospital requires fewer beds and compute the cost savings. The incremental cost of a day in an acute care room is about $269 per bed per day. Therefore reducing the usage of each bed by 0.16 days per year would save $43 per bed per year, which has a PV of $1,011 per bed. Alternatively the hospital could maintain the same number of beds but reduce waiting times. For a 537-bed hospital this would mean that, on average, one patient would be able to enter hospital about 86 days earlier than otherwise. If a patient valued this benefit at about $15,500 this would be equivalent to $43 per bed per year.

Net Social Benefits

The PV of the total incremental cost of a bed in a private room relative to a semi-private room amounts to $245,806, as shown in Table 2. The largest component is increased nursing costs due to walking greater distances between patients. The second and third largest incremental costs are construction costs, and operating and housekeeping costs. We estimate that the PV of the benefits of a private room equals $315,532 (plus option value benefits), which consists primarily of patient benefits. Consequently, private rooms have a net social benefit of about $70,000 per bed relative to semi-private rooms, at the margin.

4. ALTERNATIVE PATIENT BENEFIT ESTIMATION

The estimated benefits and costs depend on a number of important assumptions. The most crucial is patients' willingness to pay for a private room. Using market prices to estimate benefits is appropriate if patients have choice and are informed

consumers, that is, if they are knowledgeable about the incremental benefits and costs of being in a private versus semi-private room. But, do patients know this? Patients may not consider all of the potential benefits of private rooms or may over-estimate them.

This section presents and discusses an alternative benefit estimation process that values each of the three aspects identified earlier (noise, privacy, the risk of an adverse event) and then adds them. Some of these impacts are both final goods and intermediate goods. For example, privacy has consumption value and may also lead to improved health outcomes. The causal relationships are complicated and are not well understood. Here, however, we value noise and privacy for their own sake, ignoring their effects on health outcomes. Thus, the impacts can be regarded as mutually exclusive. They cover all of the important impacts discussed in the literature and are therefore collectively exhaustive.

Noise

Wibe (1997) studied noise in Sweden and found that people were willing to pay roughly 6.5 percent of their 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 $1,060 per month, the cost of noise reduction would be $68.94 per month or $2.29 per day. Saelendminde (1999) found the willingness to pay for road traffic noise reduction by an "annoyed" person is between $695 and $1392 per year in Norway, i.e. approximately $2.85 per day. Intuition suggests that these numbers are lower than an inpatient 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, $2.57 per day, this would amount to $749 per year (assuming 80% occupancy), which has a PV of $17,570.

Privacy

Privacy is another important aspect of private rooms. One potential shadow price for privacy is the incremental amount 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 $131 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 estimate of $45 per day for a private hospital room is likely to be on the low side.

Patient Treatment, Human Errors and Adverse Events

Earlier we suggested that private rooms might avoid 0.002 deaths and 0.008 serious illnesses per bed year. Recent reliable estimates of the value of a statistical life (VSL) in the U.S. range between $3 million and $7 million, which suggests a reasonable point estimate is $5 million (Miller, 2000; Mrozek and Taylor, 2002; Viscusi and Aldy, 2003; Kochi et al., 2006). Using the mid-2008 U.S. $ to Cdn $ exchange rate of 1.0225 implies that this VSL equals Cdn $5.11 million. We next adjust for income differences between Canada and the U.S. using the formula:

$$V_{CAN} = V_{US} + e_I V_{US}(I_{CAN} - I_{US})/I_{US} \qquad (1)$$

where, V_{CAN} and V_{US} denote the VSL in Canada and the U.S. in Canadian dollars, respectively, I_{CAN} and I_{US} denote the average income in Canada and the U.S. in Canadian dollars, respectively, and e_I is the income elasticity of the VSL. Given that Canadian incomes have historically been about 15 percent lower than U.S. incomes and that estimates of e_I range between 0.5 and 1.0 (Mrozek and Taylor, 2002; Viscusi and Aldy, 2003), it is reasonable to use a VSL in Canada of about $4.54 million.

Most of the research on estimating the value of avoiding a serious illness comes from the transportation literature 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. (2002) estimate the cost of a serious crash injury requiring hospitalization is $390,576 (AIS 3). Subtracting the cost of medical and emergency services, insurance administrative costs, legal costs, property damage and travel delay costs yields an estimated value of $279,567 for a serious injury avoided. Using an alternative approach, Helliwell (2005) estimates the income equivalent to a change in happiness associated with enduring a serious illness is $344,916. Suppose then that the value of a serious illness avoided is $300,000.

This discussion suggests that private rooms might avoid 0.002 deaths and 0.008 serious illnesses per bed year. Using a VSL of $4.54 million and a value of serious injury avoided of $300,000 implies that private rooms might have incremental health benefits of approximately $11,475 per bed per year, which has a PV of $269,146. Due to the high VSL, very slight reductions in the number of adverse events resulting in death can have a large impact on the estimated benefits.

Summing Up the Components

This section has argued that there are three separate but potentially beneficial aspects associated with private rooms: less noise, more privacy, and fewer adverse events. The estimated benefit of reduced noise is quite small. In contrast, the value of privacy is very large. We did not compute a number but observed that in some situations individuals are willing to pay far more for privacy than $45 per day—the amount we used in our earlier analysis in Section 3. The PV of reduced adverse events is also very large: we estimate approximately $270,000 per bed. This result is "driven" by the estimated VSL ($4.54 million) and the estimated reduction in adverse events leading to a fatality (0.002 lives saved per bed year) due to reduced medical errors. Contrary to the beliefs of many advocates of private rooms, current research does not show clearly that private rooms have a benefit over semi-private rooms in terms of infection rates. If one were sure that they actually did provided this benefit, then this would be another reason for private rooms. In summary this section suggests that our earlier analysis provides a fairly conservative estimate of the incremental value of a private room.

5. SENSITIVITY ANALYSIS

Our results are "driven" by one benefit (patients' willingness to pay) and three costs (construction, housekeeping and operations, and additional nursing costs). Consider first construction costs. Construction costs in Vancouver were and are higher than in most parts of the U.S. Discussions with local architects and developers suggest that hospitals can currently be constructed for about $550 per sq. ft., which is about $530 in 2008 Canadian dollars. Using this figure would increase construction costs by about 20 percent and would reduce the net benefits of private rooms by $16,188 to $53,602.

Davis Langdon Adamson (2003) computed higher gross mark-up factors (total required floor space per bed to patient room floor space per bed): 2.41 for a patient bed in a single-occupancy room (versus our estimate of 1.65), and 2.71 for a patient bed on a mixed ward with half single occupancy and half double occupancy beds (versus our estimate of 1.74 for a patient bed in a double-occupancy room). Using their mark-up factors would increase the incremental cost of a private room by $39,659 in total (construction costs by $18,785, maintenance costs by $4,406, and housekeeping and operating costs by $16,468), which would reduce the net social benefits of a private room to about $30,000, which is still positive.

We may have under-estimated incremental nursing costs, which were based only on the increased walking distance—about half an hour per day. In

practice, however, wards with private rooms might have more nurses per patient due to the need to maintain minimum nursing levels (numbers) on each shift, which would further increase nursing costs. 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 desire to talk with nurses as they do not have a roommate.

In addition, the incremental cost estimate of physicians' time may be low for two reasons. First, the opportunity cost of their time may be greater than $103.88 per hour. Specialists, for example cardiac surgeons, may 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.

Patients' benefits for a private room were calculated in two ways. One was based on willingness to pay derived from current market prices. The alternative method was based on noise, privacy and the probability of an adverse event (and the VSL and the value of a serious illness avoided). Slight variations in the reduction in the probability of an adverse event due to single-occupancy rooms have a large impact on the estimated benefits of those rooms. A +/- 0.5 percentage point variation around our estimated 1 percentage point reduction in adverse events affects our estimated net benefits by +/- $134,573.

Any long-term project is naturally somewhat sensitive to the choice of the discount rate. The PV of the net benefits of private rooms decreases as the SDR increases. Under the assumptions in Section 3, the net social benefits of single-occupancy rooms are equal to those of double-occupancy rooms if the real SDR is just above 5.6 percent.

6. CONCLUSION

This study estimates the costs and benefits of a bed in private room versus a semi-private room in a proposed new multi-purpose hospital, built according to best practices in Canada. Private rooms are more expensive to build and operate but patients are willing to pay more for them. Are they worth it? This is an important question because many new hospitals will be built in the next few years, they are expensive to build and, once built, they are expensive to change.

Previous research on hospital design is largely qualitative, often based on expert opinions. This article is the first to undertake a comprehensive identification and assessment of the relative benefits and costs of private rooms. Also it is the first attempt to derive quantitative estimates of the value of the different benefits and costs, individually and collectively. The main conclusion is

that the PV of the estimated net social benefits of a private room exceeds that of a semi-private room for the average patient by about $70,000.

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. Section 3 estimates the incremental benefit based on patients' willingness-to-pay, derived from differences in market prices. It assumes markets are reasonably competitive and that patients are well informed. However, this may not be the case. Consequently, Section 3 provides an alternative method: we postulated three mutually exclusive benefits (noise, privacy, and the risk of an adverse event), estimated the value of each one and added them up. This method suggests that the benefits of private rooms are much higher than our original estimates, implying that our initial benefits estimates are fairly conservative. The main benefit of private rooms comes from patients' desire for privacy, and from fewer adverse events.

Our study does not imply that new hospitals should be built with only private rooms. Our research suggests that, on average, people are willing to pay $45 more for a private room in a new Canadian hospital and this premium is sufficient to justify construction of private rooms over semi-private rooms at the margin. However, some patients prefer semi-private rooms, although we do not know how many. For example, orthopedic patients may think that the benefit of a roommate exceeds the costs. Given such preferences and the fact that semi-private rooms cost about $245,000 less per bed, some of them should be built in a new hospital.

Hospitals may also wish to have some semi-private rooms for strategic purposes: it may not be possible to charge a premium for a private room if there is no alternative. However, for this reason, semi-private rooms may become politically unacceptable in Canada, despite the fact that, as we have mentioned, each one costs less and many people prefer them.

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