Cost-Benefit Analysis in Healthcare

Creating investment incentives to drive adoption of a technical innovation

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Gesture Control, i.e. controlling computers using hand and body gestures in the air, is a popular utility in the gaming sector, but can also add significant benefits in Healthcare as an alternative to mice/keyboards. This as it would allow staff to interact with the increasing amount of computers without frequently touching a physical surface, thus risking infection transmission. Even though the benefits might seem evident, motivating the investment towards hospital management has proven to be difficult. This is derived from the fact that hospitals are becoming increasingly cost-aware, while the benefits harvested from decreased infection transmission and potential efficiency gains are indirect and thus difficult to estimate.

Purpose

This paper is based of a master thesis that investigates where in hospitals gesture control can be applied favorably as an alternative to mice/keyboards, and to estimate the monetary benefit of doing so in one such area. The results can be used to further drive the adoption of gesture control in healthcare by providing insights into potentially new use cases, as well as a suitable pricing benchmark. Further on, the results also convey a better understanding for the cost burden of using mice/keyboards in clean environments; which may appeal to hospital management and infection prevention staff.

The thesis is based on four research questions:

RQ 1 - Is transmission of Hospital-Acquired Infections a problem in modern Healthcare and if so, what areas in the hospital are most affected?

RQ 2 - How is the use of mice and keyboards related to HAI transmission?

RQ 3 - Where in hospitals can the utilization of gesture control add large benefit?

RQ 4 - What is the monetary value of the Cost-Benefit in one setting identified in RQ3?

Through the structure of these research questions, the reader is given an understanding for the issue of infection transmission and how this correlates to the use of mice/keyboards, followed by an analysis of areas in the hospitals where a tocuhfree gesture-based interface potentially can be applied and a cost-benefit of the savings from such a switch.

Findings

The thesis identifies two areas where gesture control can add large value: The Operation Room (OR) and the Intensive Care Unit (ICU). According to previous research, these environments carry the largest Hospital-Acquired Infections (HAI) burden (Klevens et. al., 2002) and field visits in both environments confirms that monetary gains can also be achieved though time savings and less material waste in both settings.

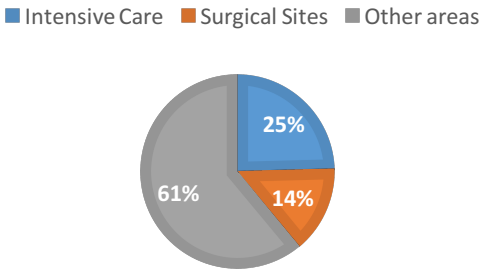

Figure 1 - HAI distribution (Klevens et. al., 2002).

The thesis further suggests that if mice/keyboards were to successfully be replaced by a gesture-based interface in the ICU, the potential annual savings would estimate $2900 per keyboard. These savings can be segmented into "Purchase price" "material waste", "labor" and "infection prevention".

Description	Cost-Benefit
Purchase Price	**$28**
Faster Login	$184
Hand Washing	$293
Wipe of Keyboards	$73
Total Labor	**$582**
Hand Washing Soap	$86
Keyboard wipes	$70
Total Material Waste	**$156**
Infection Prevention	**$2 130**
Total Cost-Benefit	**$2 892**

Table 1 - Cost-Benefit summary

Infection Prevention

The main cost-benefit is derived from prevention of HAI transmission, i.e. bacterial infections spread between staff and patients due to bad hand hygiene and dirty surfaces. These represents a significant burden in modern Healthcare; responsible for more deaths than the most common types of cancers combined (Scott et. al, 2009) and costs the US alone around $30bn.

Mice/keyboards are known to carry and transmit HAI (Wilson et al., 2006; Bures et. al., 2000). However, the monetary impact of infections transmitted via mice/keyboards has not been previously assessed. By comparing documented contamination levels on different near-patient patient surfaces, it can be determined that mice/keyboards are one of the three most contaminated surfaces, accounting for approximately 11% of total cross-contamination. This corresponds to approximately $2130 per keyboard.

Increased Efficiency (Labor)

Gesture control can be implemented to standardize tasks that with mice/keyboards are slow and repetitive. One such example that was identified during a field visit in a particular ICU at a Swedish hospital was the login process. By assuming an average staff salary of $20/h, the hospital could save $184 per keyboard annually by just speeding up the login process via gestures.

Further on, most hospitals apply strict hand hygiene routines to decrease HAI transmission, which includes washing hands before and after physical contact; as well as the frequent disinfection of physical surfaces. These processes take time, but could be removed by implementing gesture control. This as staff would not need to touch a physical surface for every interaction, thus not needing to wash their hands as frequently or wipe of a keyboard. The thesis estimates that $293 could be saved annually on staff not needing to wash their hands when interacting with computers, and that $73 would be saved on not needing to spend time on cleaning keyboards.

Less Material Waste

Except for the initial purchase of the mice/keyboards, the frequent re-sterilization and hand washing creates continuous material costs which should be accounted for. After having interviewed staff at the selected ICU regarding their computer interaction habits and associated hygiene routines, an annual monetary value per keyboard could be assigned the continuous material waste. The thesis found that $86 was spent on soap and $70 on disinfecting

wipes annually per keyboard. Other potential accounts could have been use of disposable gloves and protective keyboard covers, but neither of these were associated with the hygiene processes at the particular ICU.

Research process

To answer the stated research questions, findings from previous research on infection transmission is combined with primary data gathered through filed visits at hospitals in Sweden and UK.

RQ1 is addressed through a literature review on previous findings on HAI transmission. As it turns out, there is extensive research on the area, but no consensus on data; why several angles are presented and compared.
RQ2 is also addressed through a literature review focused on measurements of contamination levels at various near-patient surfaces; including mice/keyboards. This data is later used to calculate a weighted contribution level of infections spread via mice/keyboard to the total costs of infections spread via cross-contamination.
To answer RQ3, participant observations in various hospital wards are conducted. This is necessary to understand how staff actually use mice/keyboards in areas where HAI transmission is high, and to understand the practical dimensions of hygiene routines and what costs that would be eliminated when making the switch.
RQ4 is answered by combining data gathered in the previous research questions and could be considered the most quantitative part of the study. As mouse/keyboard usage differs between the various settings presented in RQ3, one setting was selected for the actual cost-benefit calculation.

QUESTION	APPROACH	SOURCE
RQ 1	Explanatory	Literature Review
RQ 2	Explanatory	Literature Review
RQ 3	Exploratory	Participant Observations
RQ 4	Explanatory	Combination

Discussion

It is evident that HAI transmission is a problem in modern Healthcare. It is estimated that around 5% of US patients acquire at least one HAI during their hospital stay, resulting in annual monetary costs of approximately $30bn. Not only does HAI cause monetary loss, but also a loss of lives: In fact, more people die from HAI infections than from the most common types of cancers combined (Scott et. al, 2009).

Mice/keyboards represents a physical surface that staff members touch every day, which makes it a transmission source via cross-contamination. After having compared data from 12 different studies, the thesis concludes that mice/keyboards represent the 2nd most contaminated near-patient surface and accounts for around 11% of all infections spread via cross-contamination (i.e. via physical near-patient surfaces).

Most hospitals have adopted rigorous cleaning procedures in terms of both hand hygiene and sterilization of physical surfaces to cope with the problem. Even though proper hand hygiene and continuous sterilization of mice/keyboards do help to decrease contamination levels, it is not adequate to fully remove the problem. One reason is that strings of bacteria, especially the dangerous MRSA, can survive the most commonly used disinfectants (Tacconelli et al., 2007); but what is more important is that hygiene routines rarely are followed in reality (confirmed by both previous research and staff at several hospitals).

HAIs affects all cites of the hospital, but is particularly an issue in areas where the patient is vulnerable through open wounds or significantly decreased immune system; such as in Operation Theatres, Intensive Care Units and Isolation/Infection control wards.

If one looks at gesture control in Healthcare today, almost all usage is found in the OR. The technology is well suited for efficiency gains during surgery, which due to the high

costs can result in significant savings, but it is very difficult to assess the impact a switch would have on infection transmission. As opposed to the ICU, where staff regularly interact with a large amount of computers, the OR usually host only a few displays which are rarely being touched. This was the argument for looking closer at the Cost-Benefit in the ICU.

Accounting for direct savings via efficiency gains, material waste and indirect savings via infection prevention, the analysis estimates that $2900 can be saved annually per keyboard by making the switch to gesture-based interfaces. For the reference unit which houses 80 computer stations, this corresponds to annual savings of $232 000. Even though these numbers may provide a pinpoint of potential cost savings, the exact calculation would likely differ if another ward was used as reference. It is more interesting to look at the relationship between the individual cost segments:

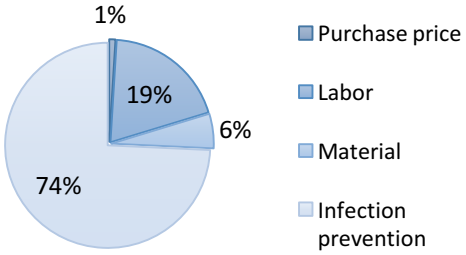

Figure 2 - Cost-Benefit distribution

The most significant conclusion to be drawn from Figure 2 is that monetary savings due to decreased infection transmission should be accounted for in this type of Cost-Benefit calculation. Another important observation is that purchase price only corresponds to a fraction of the costs, even if compared only to material waste from keeping keyboards clean.

It should also be noted that the calculation of the indirect cost-benefit relies on the assumption that contamination levels on various surfaces are directly linked to infection acquisition, which may or may not be true in reality. It is for example probably more likely that the pathogen harbored by a patient gown would be transferred to a patient than the one's harbored on a keyboard; which have to be transferred via staff. However, an investment case can be made solemnly on the merits of direct costs savings, which amounts to $766 per keyboard.

While previous research has focused on proving the link between HAI and mice/keyboards, this master thesis is believed to be the first academic piece that provides a monetary estimation to the costs associated with the use of mice/keyboards in a hygienic environment. It suggests that the indirect costs of infection prevention correspond to the largest cost and that the purchase price accounts for less than what is spent on material to keep the keyboards clean. If mice/keyboards are compared relative a more efficient alternative, such as gesture control, there are also time savings to account for. These findings are of interest both to the research community; who might look at conducting additional reference studies utilizing similar research methodology, to hospitals; who might look at measurements to decrease infection transmission or adopt new technologies, and to technology companies who provide a solution capable of replacing mice/keyboards in hygienic environments.

Research Validation

The validity of the study has been secured by using triangulation and backing data interviews with experts in the field.

As data on HAI contamination found in previous research is non consistent, this thesis can however not be considered statistically reliable. Instead, the sources considered most relevant have been used to provide a case specific number with high validity.

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