**Healthy life years lost and excess bed days due to six patient safety incidents: Empirical evidence from English hospitals**

**Supplementary Digital Content**

This appendix has been provided by the authors to give readers additional information about their work.

Contents

[1. Supplementary Data: The Patient Safety Indicators 2](#_Toc457312909)

[2. Supplementary Methods 7](#_Toc457312910)

[2.1. Propensity score estimation 7](#_Toc457312911)

[2.2. Estimation of Survival Probabilities and Length of Stay 12](#_Toc457312912)

[2.3. Calculation of lost healthy life years 14](#_Toc457312913)

[3. Supplementary Tables 17](#_Toc457312914)

[Table SDC1: Six AHRQ Patient Safety Incidents – Total national case numbers and observed incidence rates in England, 2005/06 to 2009/10 17](#_Toc457312915)

[Table SDC2: Six AHRQ Patient Safety Incidents – Total case numbers and observed incidence rates in an average1 English hospital, 2005/06 to 2009/10 18](#_Toc457312916)

[Tables SDC3a-f: Summary statistics and bias statistics, all PSIs, year 2009/10 19](#_Toc457312917)

[Table SDC4: Propensity score estimation sample descriptive statistics 25](#_Toc457312918)

[Table SDC5: Estimates of hospital mortality risk for the matched samples across years 26](#_Toc457312919)

[Table SDC6: LOS estimates for the matched samples across years 27](#_Toc457312920)

[Table SDC7: Population QALY weights 28](#_Toc457312921)

[Table SDC8: Reductions in quality-of-life associated with 240 comorbidities (Sullivan et al. 2011) 29](#_Toc457312922)

[Table SDC9: Life expectancy and healthy life expectancy remaining, by age-group 32](#_Toc457312923)

[Table SDC10: Loss of healthy-life-years due to six patient safety incidents, annual estimates for an average English hospital 33](#_Toc457312924)

[Table SDC11: Excess bed days due to six patient safety incidents, annual estimates for an average English hospital 34](#_Toc457312925)

[4. Supplementary Figures 35](#_Toc457312926)

[Figures SDC1a-b: Overlay plots of Kernel densities of predicted propensity scores (Death in low-mortality HRG and Pressure ulcers) 35](#_Toc457312927)

[Figures SDC1c-d: Overlay plots of Kernel densities of predicted propensity scores (Central-line infections and post-operative hip fractures) 35](#_Toc457312928)

[Figures SDC1e-f: Overlay plots of Kernel densities of predicted propensity scores (DVT/PE and post-operative sepsis) 36](#_Toc457312929)

[5. References 37](#_Toc457312930)

# Supplementary Data: The Patient Safety Indicators

The Patient Safety Indicators (PSIs) are a set of indicators providing information on potential in-hospital complications and adverse events following surgeries, procedures, and childbirth. They were developed by the University of California, San Francisco–Stanford University Evidence-based Practice Center and the University of California, Davis, for the US Agency for Healthcare Research and Quality. The AHRQ team used a five-step process: literature review, determination of face validity, consultation with clinical and coding experts, empirical analysis using data from previous datasets and indicators, and public release of software and related information (1, 2). The objective of the AHRQ experts was to define PSIs that constitute safety incidents and medical complications that medical experts judge to be potentially preventable under optimal medical care. For a review of the PSIs and more detailed explanation of the methodology see the AHRQ website, and for an in-depth discussion see Henriksen et al. (3).

Much consideration of AHRQ focused on the exclusion of events that cannot be considered preventable. The AHRQ team achieved this (a) by narrowly defining the event (‘numerator’), and (b) by delineating subgroups of patients based on diagnoses and procedure codes in which particular patients safety (PS) events are considered preventable (‘denominator’). For example, pressure ulcers are deemed not preventable in paraplegic patients by the committee. Therefore they do not constitute a patient safety incident in paraplegic patients, while they do in patients with full mobility. Hence, paraplegic patients are excluded from both the numerator and denominator for this patient safety incident (PSI). The AHRQ experts developed software modules that allow identifying nominator and denominator cases from recorded procedure and diagnoses codes in the International Classification of Diseases (ICD) version 9 that is used by US hospitals. For 10 PSIs, the coding algorithms could be successfully translated into the ICD-10 codes used by English hospitals (4). The number of PS cases is a subset of all cases of the clinical condition reported. For example, pressure ulcers are one of the complications of care that are considered a potential PS event. However, the AHRQ committee judged that they are not preventable in patients with severely restricted mobility, such as paraplegic patients, even under optimal care. Hence, pressure ulcers in paraplegic patients are excluded from the denominator (and automatically the numerator). Only patients with PSIs reported in the secondary and or higher diagnoses are considered cases because these are likely to be complications arising during the stay in hospitals. For all PSIs, only patients above 18 years of age are considered.

AHRQ envisaged that the PSIs provide the opportunity to assess the incidence of adverse events using patient level information found in the typical administrative hospital record, to estimate and compare rates of patient safety incidents in hospitals, and help hospitals identify shortcomings in the quality of care that might need further study and attention (1). Since they were first developed, there were changes in the coding and definitions of some PSIs; for the most recent information, the reader is referred to the website of AHRQ [www.qualityindicators.ahrq.gov](http://www.qualityindicators.ahrq.gov).

**Death in Low-mortality DRGs/HRGs (PSI 2)**

This group identifies patients who died with a diagnosis in one of the disease resource groups (DRG) -or the UK equivalent health resource groups (HRG) classifications- with a typically low mortality rate, where low is defined as (< 0.5%). Such a patient may have experienced an unusual complication. The rationale for inclusion of this indicator is that patients who die in a low-mortality diagnosis-related group (DRG) are more likely to have a patient safety or quality issues associated with their care than those who die in high-mortality DRGs. In-hospital deaths for low mortality Diagnosis Related Groups (DRGs) considers, for example, patients admitted for vaginal deliveries, orthopaedic procedures, mental disorders and substance abuse. It excludes from the denominator cases with trauma, cancer, and an immune-compromised state, and others (5). The incidence rate is below 1 patients in 1000 (see table S1).

**Decubitus Ulcer (PSI 3)**

Pressure ulcers are caused when an area of skin and the tissues below are damaged as a result of being placed under pressure sufficient to impair its blood supply. Typically they occur in a person confined to bed or a chair by an illness. All patients are potentially at risk of developing a pressure ulcer. However, they are more likely to occur in people who are seriously ill, have a neurological condition, impaired mobility, impaired nutrition, or poor posture or a deformity. The use of equipment such as seating or beds which are not specifically designed to provide pressure relief, and substandard nursing care can cause pressure ulcers. Pressure ulcers cause extreme discomfort to the patient and often lead to life threatening infections. The AHRQ PSI considers pressure ulcers of stage III or IV among medical and surgical discharges. The denominator excludes stays less than 5 days, cases with severe mobility restrictions, and with diseases of the skin or skin grafts (6). The incidence rate increased from above 8 patients per 1000 to close to 20. It is possible that this does not reflect a true increase in cases, but rather changes in reporting of ulcers (7).

**Central Venous Catheter-Related Blood Stream Infection (PSI 7)**

Vascular catheters (also called central lines) are thin, flexible plastic tubes that are inserted into patients’ veins for the purpose of taking blood or giving IV fluids and medications. Infections from vascular catheters can occur in the skin (at the site where the catheter was inserted) or in the bloodstream. If central lines are not correctly inserted or kept clean, they can allow germs to enter the body and cause serious blood infections that may in turn lead serious problems and even death. There is a concern that more cases actually occur outside the ICU and in patients receiving haemodialysis. Efforts to track, report, and prevent bloodstream infections in the United States have improved in recent years. Hospital staff members can prevent most by following infection control guidelines. These include guidelines for inserting the central line, for keeping the insertion site clean, and for removing the central line as soon as it is not needed. AHRQ’s PSI 7 indictor considers all medical and surgical discharges, and obstetric cases. It excludes cases with cancer and an immuno-compromised state, among others (8). Central-line infections are relatively rare in comparison to the five other PSIs we investigate. Less than 1 patient per 1000 is affected.

**Postoperative Hip Fracture (PSI 8)**

Hip fracture is a common serious injury that occurs mainly in older people. For many previously fit patients it means loss of prior full mobility, and for some frailer patients the permanent loss of the ability to live at home. Hip fracture is one of the most serious consequences of elderly falls, and therefore preventing falls is key to preventing hip fractures. Hip fractures are associated with higher anxiety and depression scores, loss of confidence and are associated with increased length of stay and higher rates of discharge to long-term institutional care. AHRQ’s PSI 8 considers postoperative hip fracture for surgical patients. It excludes from the denominator cases that are susceptible to falling (e.g. stroke cases), cases with self-inflicted injury, and obstetric cases (9). Of the six PSIs, postoperative hip fractures are least common. There are less than 300 cases reported each year, although there seems to be slight upward trend.

**Deep Vein Thrombosis or Pulmonary Embolism (PSI 12)**

Venous thromboembolic (VTE) diseases cover a spectrum ranging from asymptomatic deep vein thrombosis (DVT) to fatal pulmonary embolism (PE). They are the result of a blood clot (a thrombus) forming in a vein and then dislodging to travel in the blood (an embolus). If the blood clot dislodges and travels to the lungs, this can lead to a potentially fatal PE. However, diagnosis is often far from straightforward and many cases are only diagnosed post-mortem. In addition, although treatments for blood clots are well established once a diagnosis is suspected or has been made, there is currently a wide variation in how such treatments are provided. The majority of deaths are as the result of preventable hospital-acquired blood clots but some are the result of a blood clot acquired in the community. Early diagnosis and appropriate management improves outcomes but is sometimes more difficult to achieve than might be imagined. The treatment for a blood clot in the leg or the lung, once a diagnosis has been confirmed, is itself not without risk since anticoagulants and thrombolytic drugs can cause serious bleeding in some patients (10). AHRQ’s PSI 12 indicator considers secondary diagnoses of PE and DVT in surgical discharges for patients ages 18 years and older (11). The denominator excludes cases in which interruption of vena cava occurs before or on the same day as the first operating room procedure; and obstetric discharges. Incidence is between 1 and 2 per 1000 patients.

**Postoperative Sepsis (PSI 13)**

Sepsis can develop as a result of bacterial, viral, or fungal infection and can arise from infections as common as urinary tract infection and skin infection. Severe sepsis, which occurs when sepsis is accompanied by organ failure, is a serious infection with extremely high rates of death; roughly 30% of patients die within 1 month of diagnosis and 50% die within 6 months (12). Moreover, treatment that is not comprehensive may leave the patient vulnerable to ancillary insults, such as kidney failure or depressed heart rate, and patients may suffer from permanent organ damage. AHRQ developed a ‘Surviving Sepsis Campaign bundle’ that has been associated with a decrease in mortality (13). AHRQs PSI 13 indicator considers elective surgical cases, and excludes from the denominator cases with a principal diagnosis of infection, an immunocompromised state, cancer, obstetric discharges, and cases with stays less than four days. (12). Numbers of Sepsis cases were fluctuating between 2280 and 2,103 for the years between 2006 and 2010, and were markedly lower only in 2005 with 1,772 cases. It is the second most common PSI, with an incidence of between 6 and 7 per 1000 patients.

# Supplementary Methods

## Propensity score estimation

The procedure adopted by the AHRQ experts defines so-called numerator and denominator cases based on purely clinical characteristics. The numerator patients are the ones who actually suffered an incident, the denominator patients are all patients who are at risk of the incident and for whom the incident is be considered preventable. Numerator cases are part of the denominator cases. The presumption of the AHRQ experts is that the denominator patients are in principle equally susceptible to experience the PS incidences as the actual cases, after patients with exclusion conditions are dropped from the investigation. The exclusion conditions are clinical conditions which essentially determine the patients in whom an incident is not considered preventable even with very good standard of care; for example, paraplegic patients are significantly more likely to suffer a pressure ulcers, hence they are not considered a safety incident for patients with this condition and paraplegic patients are not part of the denominator cases for the PSI pressure ulcer.

Some studies use the number of numerator and denominator cases to estimate incidence rates, and incremental impact of the PS events on mortality, bed days or costs. This is then simply done by taking the difference in those outcomes across numerator and denominator patients (minus numerator patients). However, there is a concern that excluding patients based on medically defined exclusion conditions is in itself insufficient adjustment for systematic differences across numerator and denominator cases that make cases more susceptible to experiencing a PS event. If this is a concern, then the evaluation of the impact of the PS event based on a naïve comparison between cases and denominator patients would wrongly attribute difference in observed outcomes in PS patients to the occurrence of the PS incident, when in fact it could at least partly be explained by other differences related to the patients themselves, or the treating hospital.

In order to address this problem, we use propensity score matching to qualify the AHRQ denominator (minus numerator) patients further on basis of how well they match the numerator or PS patients (or cases) on 10 observable characteristics (14). In principle, all denominator control patients are considered potential matches, but the final impact evaluation of differences in mortality risk, expected remaining healthy life-expectancy and bed days are based on the control patients that are closest matches for each numerator patient or case. The basic idea of propensity score matching is to find in a large group of untreated individuals, i.e. patients without PS incidence, those individuals who are similar to the PS patients in all relevant characteristics that make them equally likely to experience the PS incident. Differences in outcomes of this carefully selected control group and of the cases or PS patients can then be attributed solely to the PS incident.

The underlying identifying assumption is known as un-confoundedness, which implies that all variables that influence treatment assignment (i.e. experiencing a PS incidence) and potential outcomes simultaneously have to be observed by the researcher. A further requirement is the common support condition. It rules out the phenomenon of perfect predictability of a PS incident given the covariates. It ensures that persons with the same covariate values have a positive probability of both experiencing a PS incident or not (15). The usual approach towards matching entails the use of balancing scores, which require that matched observations must have the same distribution of observable (and unobservable) characteristics independently of PS status. The average treatment effect on the treated (ATT) is then defined as the average observed differences between the mortality and bed days of patients who experienced a PS event and the matched controls that are observationally very similar to the PS patients, except for the fact that they did not experience the PS event. The excess mortality risk is then used to determine loss in terms of HLYs.

The PSI ‘Death in low-mortality DRG’ is a special case in our analysis, because by definition the treatment –experiencing the PSI ‘death’- perfectly predicts outcome ‘death’, and not experiencing the PSI perfectly predicts survival. This means that any patients in the denominator group that may have died not due to an adverse event but rather due to underlying medical problems are selected into the ‘treatment’ group of PS patients via the AHRQ algorithm. For this PSI, we cannot control for selection into the ‘treatment’ and take the difference between patients and matched controls as a 95% increase in mortality risk, the AHRQ definition. This effectively means that we accept the AHRQ definitions and exclusion conditions for this PSI without further qualification.

**Covariate adjustment**

Propensity score estimation requires estimating the probability of experiencing the ‘treatment’, the PS event, given a set of covariates. We can only include covariates that influence simultaneously the occurrence of the PS incident and the outcome variable, but that are themselves unaffected by the PS incident (16). Tables S3a to S3f present summary statistics separately for the unmatched and the matches samples and variables used for the propensity score estimation, by PSI and for the year 2009/10 (other years available from the authors on request). Note that the propensity score estimation sample consists of PS patients and both unmatched and matched controls, hence it is significantly larger than the final matched sample that is used for estimation of the treatment effects. We have a large pool of patients to choose from which makes it easier to find close matches. For most PSIs the overall number of control patients exceeds one million, compared to PS patients of at most a few thousand per year.

We use the same variables for all PSIs, but the size of the estimation samples vary considerably across PSI because of differences in the exclusion conditions. For example, the exclusion conditions for Sepsis are very strict, therefore, the group of patients in which Sepsis is considered a potentially preventable patient safety incident by the AHRQ committee is relatively small. Among patient characteristics, we include age at the start of the inpatient spell, gender, and as indicators of patient complexity, the weighted Charlson comorbidity index (17). The Charlson index comprises of chronic conditions that are very unlikely to be related to the PS event. We further condition on the index of multiple social deprivation of the area of residence of the patients, and on the number of diagnoses reported in the main episode of the patient (excluding the PSI code or codes). Among hospital characteristics, we condition on teaching status, whole time equivalents of medical and nursing staffing, number of beds and bed occupancy rates. Summary statistics of covariates for PS compared to non-PS patients (unmatched control patients) indicate that the two groups are very different before matching. PS patients are generally of greater medical complexity (tables SDC3a-f). Differences in covariates is larger for patient than hospital-level covariates. This indicates that the AHRQ algorithms are not sufficient to establish differences in outcomes between PS and other patients, and that further matching is necessary.

**Matching algorithm**

We use the logit model to estimate the propensity score, and STATA MP 13’s psmatch2 command (18) for the propensity score estimation and estimation of the ATTs, and pstest for implementing the various tests of covariate balance before and after matching (18). We undertake separate estimations for all years and PSIs. We use nearest neighbour (NN) matching as the matching algorithm. Individuals from the control group are chosen as matching partner for a PS patient that are closest in terms of the propensity score. We do not allow replacement, therefore a control patient can only be used once as a match. If there are more than one neigbhour with identical propensity scores (tied matches), we use all control patients with identical propensity scores in the calculation of the treatment effects. We set the caliper width at 0.00002 for all PSIs and years, which is well below the recommended 0.2 of the standard deviation of the propensity score (19). This implies that the first four digits of the propensity score are exactly matched, and there is a max difference of 2 points in the fifth digit. We conducted sensitivity analysis on a smaller caliper width of 0.00001 but this does not make a material difference to results. We exclude PS patients and controls that are off the common support, i.e. for which a match cannot be found because the there is no patient with a similar propensity score. We order observations randomly before matching.

Table SDC4 presents summary statistics for the propensity score matching estimation, separately by PSI and year. Presented are the number of PS patients and control patients before and after matching. For all PSIs except ‘Sepsis’, the number of controls is above one million, and in particular for ‘Deaths’ and ‘DVT/PE’ there are several million of controls that are available for choice of matches. PS patients were dropped from the estimation if there were missing values on covariates, and more importantly, if they were off the common support (the number presented in the final column). Given the large number of control patients, above 98% of PS patients were generally well matched with their closest controls; while for PS patients experiencing `Death’ and `Sepsis’, there are a comparably large number of patients off common support, resulting in a lower but still satisfactory percentage of matching patients ranging from 91% to 95%. The number of matched control patients may exceed the number of PS patients because we allow tied matches.

**Diagnostics for validity of propensity score matching**

We evaluate the validity of the matching with a number of tests recommended in the literature (19-22). Generally, these are tests for the equality of means of covariates that are used in the matching between the two samples of the PS patients and the control patients, and for the bias -and the reduction in the bias- in the propensity scores before and after matching. The matched groups need to pass these tests for propensity score adjustment to be trustworthy. If any of them are not satisfied, the differences between the distributions of covariates in the two samples must be regarded as substantial, and adjustment will be unreliable and calculated treatment effects cannot be trusted. To adjust for differences in sample sizes when comparing means in matched and unmatched groups, the difference between means is commonly assessed with the standardized percentage bias. This is the % difference of sample means in PS patients and unmatched and matched control patients as a percentage of the square root of the average of the sample variances in the samples of PS and control patients.

For each PSI and year, we calculate the standardized percentage bias ‘%bias’ in the means of all covariates for PS and unmatched and matched control patients. This should be less than 10% after matching; a zero value for %bias would indicate that the groups are perfectly matched (Austin 2009). We experimented with alternative model specifications (five nearest neighbours, stricter caliper widths, alternative matching algorithms, and allowing replacing), and settled on the final specification on basis of the most favourable balancing diagnostics with %bias below 10% for all covariates. Tables S3a – S3f show that we achieved this target, although before matching the biases in the covariates were substantial, in particular bias in the covariates of patient complexity. For most samples, number of diagnoses is the most badly balanced covariate, with biases exceeding 100% for most PSI and years. This implies that PS patients have a greater number of comorbities than controls before matching. Age and the Charlson index of comorbidities have also biases exceeding 100% for some PSIs. The magnitude of biases for hospital level covariates is generally smaller than for the patient level covariates, and in some cases, there is no bias even in the unmatched sample. Possibly, because there is less variation in these variables across patients. Staffing levels and number of beds have mostly negative biases for all PSIs except for two PSIs, for which the bias is positive. This tells us that patients in hospitals with less staff and smaller number of beds have a greater propensity of experiencing a PSI. The %bias statistics for the matched samples shows that we managed to reduce all biases to acceptable levels. The tables further show that unmatched controls have substantially lower risk of death and LOS. This is indicative of two things: First, PS incidences are indeed more prevalent in sicker patients, and second, the matching seems successful insofar as a comparably sicker subset of control patients is chosen as matches from the large pool of potential candidates.

Lastly, we check the overlap of propensity scores between PSI patients and their matched controls, by plotting separately the Kernel densities of the propensity scores for PS patients on support, and their matched controls. Figures 1a to 1f show overlap plots for all PSIs in the year 2009. Two points are worth mentioning: First, the PSIs are all very rare events, with the mass of the density far below 0.1 for all PSIs; second, there is a near perfect overlap between PSI patients and matched control patients. This implies that we were successful in finding matches that have nearly the same probability of experiencing the PSI as the patients which actually did have the PSI, a finding that is confirmed by the summary statistics discussed above.

**Conclusion propensity score matching**

Considering the tests and summary statistics of the balancing of the covariates and the propensity score, we are confident that the matching is successful and has removed perhaps not all, but most of the selection bias. In summary, after matching on the estimated propensity score, we find that bias in the covariates is substantially reduced. For nearly all covariates, PSIs and years, any remaining bias is within acceptable limits according to standard tests. Similarly, the overlap in propensity scores between PS patients and matched controls is very close. This means that we have found matched controls that had almost the same probability of experiencing a PS event than the patients who actually did, and the fact that these controls did not have a PS event is merely due to random chance. We then use the small sample of PS patients and their matched controls to compare outcomes with respect to mortality and bed days, and we use the group of matched control patients to for calculation of the remaining healthy life expectancy, as explained in the next section.

## Estimation of Survival Probabilities and Length of Stay

Once each PS patient is matched with a control patient, the average differences between their outcomes -the risk of death and LOS- can be determined. These are the Average Treatments effects on the Treated (ATTs). They are computed separately for each PSI, outcome and year. A simple difference in outcomes is taken. Calculation of the health lost due to PSIs requires estimates of the difference in mortality risk of PS and matched control patients and a number of other estimates, as we will explain in more detail in the next section. Estimates of excess LOS due to PS events directly give an indication of the impact of PS events on resource use. Table 5 shows overall average mortality risk and LOS of PSI patients and their matched controls, and associated differences in risk and LOS, the ATTs. The ATTs are the difference in outcomes that are associated with the PSI, and that are in addition to the outcomes the patients would have had in the absence of the PSI.

Tables SDC3a to SDC3f present the hospital mortality rate and LOS for PS patients on common support (column ‘Treated’) and matched controls (column ‘Controls’). The average differences in outcomes displayed in the column ‘Difference’ are the estimates of the Average Treatment Effects, and if the matching is valid, these differences are solely attributable to the PSI. Table SDC5 reports mortality risks separately by year and PSI. The standard errors and t-statistics are also reported, to evaluate whether the ATTs are statistically significant different from zero. For example, table SDC3b shows that averaged over the five years, Ulcer patients had an average risk of death of around 29%, whereas the matched control patients had a risk of around 14%. This means that the ATT, i.e. the average difference in risk between PS patients and their matched controls over the sample and the 5 years, is estimated at around 15%. The result also means that experiencing a preventable ulcer during hospital care leads to an increased mortality risk of 15% according to our results. Table SDC5 shows that the risk slightly decreased over the 5 years. Second highest risk of death for PS patients lies at around 22% for Hip fracture patients. The risk for controls in this sample is 8% after matching, and the resulting ATT lies around 14%. This means that a post-operative hip fracture is associated with an increased risk of death of around 14%. Patients with preventable Sepsis have a risk of death of around 18% on average across years, compared to 3% for matched controls. Without sepsis, the patients would have had a relatively low mortality risk, at least compared to the Ulcer and Hip fracture patients. Therefore, the ATT for Sepsis is similar to the ATTs for both Ulcers and Hip fractures. Patients with DVT/PE have a risk of death of around 13%, compared to a risk for matched controls of around 5%, respectively. This results in an ATT of around 8%. Patients with CLI have a 10% overall mortality risk, compared to risks of 8% for matched controls. Matched controls for CLI have high risk of death of all PSIs, which means that patients that experienced this PSI had a relatively high mortality risk to start with and the estimated additional average risk is 1%, but varies between 0% and 3% across years (the minimum value is even negative but this is not statistically significant). In none of the years, the difference is statistically significant, and therefore we assume in all following calculations that suffering a CLI does not increase mortality risk. Lastly, for ‘Deaths in low-mortality HRGs’, by definition, the mortality risk is 100%, and 5% for controls, resulting in an ATT of 95%.

Tables SDC3a-f report LOS differences on average, and table SDC6 LOS differences by year and PSI. LOS is longest for Ulcer patients at an average across years of 37 days (table SDC3b). This compares to the relatively long stays of 21 days for matched controls. The ATT is the estimate of the excess LOS due to Ulcers and lies at around 16 days. This means that PS patients would have stayed in hospital for around 21 days if they had not experienced the Ulcer, and the PS has added another 15 days on top of their stay in hospital. LOS and LOS differences decreased markedly over the years (see table SDC6). The PSI with second longest LOS is Hip fracture (table SDC3d). Patients stay on average 34 days. The stay of matched controls is comparably short at around 13 days. The additional LOS caused by the hip fracture is then 21 days on average, a longer excess LOS than for Ulcer patients. Sepsis patients also stay relatively long in hospital at 31 days. Estimates for controls 13 days resulting in an excess LOS attributable to Sepsis of 19 days. Both patients with a CLI and DVT/PE stay for a total of 27 days. The matched controls for CLI stay also relatively long at 15 days, but matched controls for DVT/PE stay shorter at 9 days. This leads to an excess LOS estimate of 11 days for CLI, and 17 days for DVT/PE patients. Patients that die in a low-mortality HRG experience a LOS of around 15 days before their death. The estimates for their matched controls is 3 days, respectively. This is lower than the mean LOS estimate from the Health and Social Care Information Centre statistics for an admitted patient at 5.2 days (23), but broadly in line with estimates of average inpatient LOS for patients of relatively low complexity in English hospitals (24). For ‘Deaths’, excess LOS is estimated to be around 12 days. The long stay before death shows that the patients were subjected to treatments to avert their death. Considering time trends across the five years. LOS has decreased for Ulcers and Death in low-mortality HRG, for both PS and matched control patients. LOS has also decreased for DVT/PE and Sepsis, but only for PS patients and not the matched controls. LOS has increased for HIP fractures, but there is not really a clear trend for matched controls of HIP fractures. There is no clear trend for CLI patients and matched controls.

## Calculation of lost healthy life years

To calculate the loss of healthy life years (HLYs) we used the concept of Quality-adjusted life-years (QALYs). A QALY is a generic measure of disease burden that considers both health-related quality of life and length of life. Health status is assigned a value ranging from 1.0 (in perfect health) down to a value of 0.0 for being dead. If a year is not lived in full health because the person experiences morbidity from one or several health condition, then the life-year is given a value between 0 and 1 to account for this. For example, for a person with a LE of 10 years, HLE would be only 5 years if quality-of-life was valued at 0.5 for each remaining life-year. A QALY can be a negative number in the case of health states that are valued worse than death. HLYs lost are equivalent to life-years lost only if a person would have lived her remaining life in full health (QALY weight of 1) until death.

In summary, to calculate lost HLYs, we scanned medical records of matched control patients for 141 comorbidities that have been found to be associated with significant reductions in quality of life. This made it possible to calculate a unique QALY value for each age between 20 and 100 years, separately by PSI and year. The product of QALY values and remaining life expectancy of control patients of a particular age then gave healthy life-expectancy (HLEs) for each PS patient with the same age. On the following pages we explain our approach in more detail. To calculate HLYs lost, we first established the individual QALY weight for each control patient *i* considering chronic conditions as

(1).

The QALY weight is the expected QALY of the 10-year age band *b* in which the age at admission of the control patient *i* falls. This was based on the QALY weights of the general UK population (25), see table SDC7. For example, in the UK, a person of age 61 is estimated to have a baseline QALY weight of 0.774. We then determined for each control patient the presence of any of 141 chronic conditions from ICD codes in the episode of the hospital spell that reports most number of diagnoses. These conditions are associated with statistically significant reductions in QALY weights (25), see table SDC8. If one or more of the 141 comorbidities are present, we subtracted the associated QALY reductions from the population QALY weight. Up to *j = 0,…,20* QALY reductions *d* may be subtracted from the population QALY weight because this is the maximum number of diagnoses recorded in the data. We considered comorbidities from all diagnoses codes, including the disutility arising from the primary diagnosis, if it features among the 141 chronic conditions.

There is an additional QALY reduction associated with having multiple (i.e. more than two) chronic conditions. Depending on how many *j* comorbidities are reported, we subtracted from the population QALY on top of the reductions associated with the specific conditions (see table S6). If patient *i* has no comorbidities, then *j = h = 0* and (1) simplifies to and the life year of the patient is valued at the population QALY weight. If there are two or more control patients with the same age and gender, we calculated the average QALY weight for all control patients of the same age *a*. We calculated for each age between 16 and 115. If there are no control patients for a certain age, we apply the QALY weight for the previous year of age (for old patients) or the following year of age (for young patients). Note that only varies by gender. The age-averaged QALY weights provide the counterfactual QALY weights for patients with incidents. They are an estimate of the expected value for the quality-of-life in each year until death for patients that die, weighted by the prevalence of chronic conditions that we would have expected to see in the counterfactual as the patients aged. Note that the QALY weights at successive years of age are not derived from one control patient as s(he) ages, but it is made up of all the control patients of different ages in our sample.

The remaining healthy life years HLYs for patients of age *a* and gender *g* is given by

(2)

Remaining healthy life years *HLYag* are the sum of age-averaged QALY weights for each year of the remaining years of life of the patient, meaning from her age in the year of admission *y* to the last expected year of life as given by the remaining life expectancy *LE*. We obtained information on remaining *LE* from the Office for National Statistics (9). For example, for a female patient of age 61 with a remaining *LE* of around 25 years, the remaining healthy life years are given by the sum of the average QALY weights for control patients of age 62, 63, up to the average QALY weight for control patients of age 86. HLYs varies by age, gender and PSI. Figure S2 plots *LE, HLY* considering only population QALY reductions (i.e. the situation where no patient has any comorbidities), and *HLYag* considering QALY reductions due to comorbidities, for the matched control patients of Pressure Ulcers, as example. Values are similar for other PSIs.

Predictions about the yearly loss in life years need to incorporate the excess mortality risk. Expected loss of healthy life years for patients of age *a* and gender *g* is the difference between the expected loss in healthy life years of PS and control patients, and is given by

(3),

where S(1) and S(0) represent the estimated survival probabilities of PS and matched control patients, derived from the estimated risk of mortality. They represent average risk of death across all age and gender of patients for one PSI. There is a predicted loss in QALYs due to increased risk of death if and . This occurs if the PS event is expected to reduce probability of survival of PS patients below the expected survival of control patients. The magnitude of the loss is then dependent on the value of the remaining *HLYag* of the control patients. *HLYag* loss is higher for younger than older patient because remaining LE is higher, and it is higher for patients that have fewer chronic conditions, i.e. in a situation where we predicted counterfactual health status to be relatively high. If we cannot reject the null hypothesis that there is no difference between the survival probabilities of PS patients and matched controls at 95% confidence level, the PS event is predicted not to reduce probability of survival. We then set the survival probability of PS patients equal to the survival probability of controls, i.e. , and there is no expected loss due to mortality .

The total expected loss in HLYs due to death needs to be summed over all patients for one PSI and year. It is given by

(4)

The number of PS patients in each age group is given by , and the age of patients at admission is allowed to vary from a minimum of 16 to 115. The lost HLYs are standardized to the English population in the respective years, and expressed per 100,000.

# Supplementary Tables

## Table SDC1: Six AHRQ Patient Safety Incidents – Total national case numbers and observed incidence rates in England, 2005/06 to 2009/10

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Patient Safety Incident | Year | Denominator patients1 | Number of Cases | Incidence (per 1000)2 |
| Death in low-mortality HRG | 2005/06 | 4,039,643 | 1,912 | 0.47 |
| (PSI 2) | 2006/07 | 5,098,992 | 1,886 | 0.37 |
|  | 2007/08 | 5,423,222 | 1,756 | 0.32 |
|  | 2008/09 | 5,704,953 | 1,609 | 0.28 |
|  | 2009/10 | 5,876,354 | 1,520 | 0.26 |
| Pressure Ulcer | 2005/06 | 1,615,787 | 13,449 | 8.32 |
| (PSI 3) | 2006/07 | 1,819,657 | 16,539 | 9.09 |
|  | 2007/08 | 1,763,460 | 17,721 | 10.05 |
|  | 2008/09 | 1,786,879 | 20,936 | 11.72 |
|  | 2009/10 | 1,785,718 | 25,223 | 14.12 |
| Central line infection | 2005/06 | 2,649,957 | 607 | 0.23 |
| (PSI 7) | 2006/07 | 3,062,054 | 725 | 0.24 |
|  | 2007/08 | 2,984,036 | 654 | 0.22 |
|  | 2008/09 | 3,018,862 | 464 | 0.15 |
|  | 2009/10 | 3,024,453 | 375 | 0.12 |
| Hip fracture | 2005/06 | 3,008,392 | 215 | 0.07 |
| (PSI 8) | 2006/07 | 3,809,719 | 268 | 0.07 |
|  | 2007/08 | 4,053,074 | 265 | 0.07 |
|  | 2008/09 | 4,340,220 | 298 | 0.07 |
|  | 2009/10 | 4,508,366 | 283 | 0.06 |
| Deep vein thrombosis or | 2005/06 | 3,571,516 | 5,237 | 1.47 |
| Pulmonary embolism | 2006/07 | 4,531,469 | 6,903 | 1.52 |
| (PS 12) | 2007/08 | 4,863,553 | 7,165 | 1.47 |
|  | 2008/09 | 5,239,007 | 7,842 | 1.50 |
|  | 2009/10 | 5,435,497 | 8,606 | 1.58 |
| Sepsis (PSI 13) | 2005/06 | 308,581 | 1,772 | 5.74 |
|  | 2006/07 | 348,250 | 2,280 | 6.55 |
|  | 2007/08 | 343,617 | 2,260 | 6.58 |
|  | 2008/09 | 333,819 | 2,151 | 6.44 |
|  | 2009/10 | 314,445 | 2,196 | 6.98 |

Notes: 1 Denomintator patients are patients ‘at risk’, because they are hospitalizations for which safety incident would be considered preventable according to AHRQ criteria; there was considerable variation in the number of denominator patients across PSIs. This is explained by differences in exclusion criteria across PSIs. For example, Sepsis is considered a preventable PSI in only a very small group patients, and not preventable in all other patients.

2 Incidence is assessed with respect to denominator cases, and expressed per 1000 patients.

## Table SDC2: Six AHRQ Patient Safety Incidents – Total case numbers and observed incidence rates in an average1 English hospital, 2005/06 to 2009/10

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Patient Safety Incident | Year | Denominator patients2 | Number of Cases | Incidence (per 1000)3 |
| Death in low-mortality HRG | 2005/06 | 20,814 | 9.0 | 0.43 |
| (PSI 2) | 2006/07 | 22,470 | 7.9 | 0.35 |
|  | 2007/08 | 24,184 | 7.5 | 0.31 |
|  | 2008/09 | 24,698 | 6.8 | 0.28 |
|  | 2009/10 | 25,843 | 6.7 | 0.26 |
| Pressure Ulcer | 2005/06 | 7,850 | 63.9 | 8.14 |
| (PSI 3) | 2006/07 | 7,577 | 68.2 | 9.01 |
|  | 2007/08 | 7,604 | 76.1 | 10.01 |
|  | 2008/09 | 7,664 | 89.7 | 11.71 |
|  | 2009/10 | 7,657 | 108.6 | 14.19 |
| Central line infection | 2005/06 | 12,879 | 3.0 | 0.23 |
| (PSI 7) | 2006/07 | 12,769 | 3.1 | 0.24 |
|  | 2007/08 | 12,772 | 2.9 | 0.22 |
|  | 2008/09 | 12,820 | 2.0 | 0.16 |
|  | 2009/10 | 12,877 | 1.6 | 0.13 |
| Hip fracture | 2005/06 | 19,519 | 1.4 | 0.07 |
| (PSI 8) | 2006/07 | 20,916 | 1.4 | 0.07 |
|  | 2007/08 | 23,151 | 1.5 | 0.06 |
|  | 2008/09 | 24,414 | 1.6 | 0.07 |
|  | 2009/10 | 24,890 | 1.6 | 0.06 |
| Deep vein thrombosis or | 2005/06 | 22,698 | 33.2 | 1.46 |
| Pulmonary embolism | 2006/07 | 24,439 | 37.1 | 1.52 |
| (PS 12) | 2007/08 | 27,349 | 40.3 | 1.47 |
|  | 2008/09 | 29,043 | 43.9 | 1.51 |
|  | 2009/10 | 29,722 | 47.6 | 1.60 |
| Sepsis (PSI 13) | 2005/06 | 2,080 | 12.0 | 5.75 |
|  | 2006/07 | 1,996 | 13.1 | 6.55 |
|  | 2007/08 | 1,946 | 13.0 | 6.68 |
|  | 2008/09 | 1,883 | 12.3 | 6.55 |
|  | 2009/10 | 1,774 | 12.8 | 7.22 |

Notes: 1 Average hospital size is determined with respect to number of PS incidencts; 2 Denomintator patients comprises hospitalizations for which safety incident would be considered preventable according to AHRQ criteria; 3 Incidence is assessed with respect to denominator cases, and expressed per 1000 patients. The incidence rate is similar to the national estimates. We would not expect the rates to be exactly the same, because the association between number of cases and size of hospital is unlikely to be perfectly linear.

## Tables SDC3a-f: Summary statistics and bias statistics, all PSIs, year 2009/10

**Table SDC3a: Death in low-mortality HRGs, year 2009/10**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Patients with incidents (n=1,444) | | Unmatched control patients (n=5,701,555) | | | Matched control patients (n=1,571) | | |
| Outcomes | Mean | SD | Mean | SD | %bias | Mean | SD | %bias |
| Death, in-hospital | 0.95 | 0 | 5 | 0.01 |  | 5 | 0.06 |  |
| Bed-days | 13.28 | 40.67 | 0.93 | 5.52 |  | 3.16 | 12.67 |  |
| Covariates |  |  |  |  |  |  |  |  |
| Age | 71.18 | 16.49 | 49.22 | 19.93 | 117.3 | 70.76 | 13.86 | -4.8 |
| Sex of patient, 0: male 1: female | 0.45 | 0.5 | 0.66 | 0.47 | -42.9 | 0.44 | 0.5 | 2.3 |
| Weighted Charlson Index | 1.98 | 1.99 | 0.25 | 0.7 | 119.7 | 1.88 | 2.05 | 4.7 |
| Index of multiple deprivation | 23.15 | 16.23 | 23.13 | 16.18 | 0.6 | 23.01 | 16.31 | -3.1 |
| Number of diagnoses in patient record (excl. PSI codes) | 6.47 | 3.13 | 2.39 | 1.64 | 164.7 | 6.29 | 3.15 | 1.6 |
| Medical and dental staff WTE | 655.26 | 396.01 | 639.05 | 373 | -4.3 | 631.28 | 370.85 | -0.2 |
| Nursing, midwifery and health visiting staff WTE | 1643.78 | 849.02 | 1593.05 | 816.75 | 4.3 | 1603.93 | 801.41 | -0.4 |
| Average number of available beds | 860.13 | 428 | 848.05 | 412.69 | 1.3 | 845.94 | 417.07 | -0.4 |
| Average bed occupancy rate | 86.35 | 6.76 | 86.5 | 6.59 | -2.2 | 86.5 | 6.07 | -1 |
| Teaching status, 0: non-teaching, 1: teaching | 0.45 | 0.5 | 0.44 | 0.5 | 2.6 | 0.42 | 0.49 | 2.5 |

Note: %bias should be <|10| after matching (21). There are slightly more matched control patients than patients with incidents because we allow tied matches, i.e. control patients with the same propensity score are used to calculate ATTs; Number of patients with incidents in this table are smaller than all patients with incidents in table S1, because patients with missing observations on any of the covariates and patients off the common support (i.e. for whom there is no control patient with sufficiently similar propensity score) are excluded from analysis; Results for other years are available from the corresponding author on request.

**Table SDC3b: Pressure Ulcers, year 2009/10**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Patients with incidents (n=25,142 | | Unmatched control patients (n=1,748,618) | | | Matched control patients (n=25,793) | | |
| Outcomes | Mean | SD. | Mean | SD | %bias | Mean | SD | %bias |
| Death, in-hospital | 0.29 | 0.46 | 0.07 | 0.26 |  | 0.14 | 0.34 |  |
| Bed days | 37.3 | 40.39 | 18.77 | 32.09 |  | 22.61 | 27.24 |  |
| Covariates |  |  |  |  |  |  |  |  |
| Age | 79.07 | 12.62 | 67.75 | 18.6 | 68 | 79.1 | 11.3 | -1.7 |
| Sex of patient, 0: male 1: female | 0.58 | 0.49 | 0.55 | 0.5 | 27.7 | 0.57 | 0.49 | -0.4 |
| Weighted Charlson Index | 1.98 | 1.89 | 1.47 | 1.79 | 82.5 | 1.98 | 1.91 | 1.9 |
| Index of multiple deprivation | 23.35 | 15.97 | 23.5 | 16.31 | -0.8 | 23.44 | 16.39 | -0.4 |
| Number of diagnoses in patient record (excl. PSI codes) | 8.31 | 3.1 | 5.73 | 3.18 | -5 | 8.23 | 3.24 | 0.2 |
| Medical and dental staff WTE | 592.2 | 354.5 | 627.92 | 385.79 | -10.3 | 593.33 | 357.1 | 0.3 |
| Nursing, midwifery and health visiting staff WTE | 1497.18 | 796.16 | 1587.42 | 825.71 | -3.4 | 1498.11 | 793.5 | 0.3 |
| Average number of available beds | 820.41 | 411.56 | 848.16 | 419.13 | 6.5 | 819.18 | 405.3 | -0.1 |
| Average bed occupancy rate | 86.96 | 5.58 | 86.57 | 6.59 | 6.2 | 86.95 | 5.6 | 0.6 |
| Teaching status, 0: non-teaching, 1: teaching | 0.41 | 0.49 | 0.42 | 0.49 | -2.5 | 0.41 | 0.49 | 0.5 |

**Table SDC3c: Central Line Infections, year 2009/10**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Patients with incidents (n=374) | | Unmatched control patients (n=2,997,745) | | | Matched control patients (n=382) | | |
| Outcomes | Mean | SD | Mean | SD | %bias | Mean | SD | %bias |
| Death, in-hospital | 0.09 | 0.29 | 0.05 | 0.22 |  | 0.08 | 0.27 |  |
| Bed-days | 31.17 | 45.21 | 12.94 | 28.66 |  | 18.92 | 31.9 |  |
| Covariates |  |  |  |  |  |  |  |  |
| Age | 61.87 | 18.63 | 62.02 | 20.46 | 3 | 63.27 | 20.84 | -1.7 |
| Sex of patient, 0: male 1: female | 0.47 | 0.5 | 0.56 | 0.5 | -17.3 | 0.49 | 0.5 | -2.1 |
| Weighted Charlson Index | 1.58 | 1.91 | 1.02 | 1.5 | 32.9 | 1.52 | 1.84 | 3.7 |
| Index of multiple deprivation | 24.39 | 16.93 | 23.57 | 16.36 | 4.9 | 22.82 | 16.44 | 9.9 |
| Number of diagnoses in patient record (excl. PSI codes) | 7.85 | 3.47 | 4.74 | 2.94 | 96.8 | 7.76 | 3.71 | 1.9 |
| Medical and dental staff WTE | 580.58 | 342.63 | 626.21 | 386.39 | -4.6 | 560.21 | 349.56 | 4.2 |
| Nursing, midwifery and health visiting staff WTE | 1452.31 | 771.08 | 1584.4 | 827.64 | -17.3 | 1393.96 | 776.79 | 6.7 |
| Average number of available beds | 778.87 | 380.62 | 843.66 | 421.64 | -9.8 | 768.3 | 400.02 | 4 |
| Average bed occupancy rate | 86.24 | 4.55 | 86.53 | 6.6 | -5 | 86.58 | 4.63 | -6.3 |
| Teaching status, 0: non-teaching, 1: teaching | 0.27 | 0.45 | 0.42 | 0.49 | -23.5 | 0.24 | 0.43 | 0 |

**Table SDC3d: Post-operative Hip fractures, year 2009/10**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Patients with incidents (n=282) | | Unmatched control patients (n=4,386,208) | | | Matched control patients (n=292) | | |
| Outcomes | Mean | SD | Mean | SD | %bias | Mean | SD | %bias |
| Death, in-hospital | 0.27 | 0.44 | 0.01 | 0.08 |  | 0.08 | 0.26 |  |
| Bed-days | 44.47 | 44.25 | 2.12 | 9.77 |  | 14.68 | 27.58 |  |
| Covariates |  |  |  |  |  |  |  |  |
| Age | 77.03 | 12.67 | 58.81 | 18.21 | 106.2 | 76.1 | 10.59 | 1.4 |
| Sex of patient, 0: male 1: female | 0.62 | 0.49 | 0.51 | 0.5 | 21.3 | 0.63 | 0.48 | 0.7 |
| Weighted Charlson Index | 1.68 | 1.8 | 0.46 | 0.91 | 85.7 | 1.69 | 1.67 | -3.5 |
| Index of multiple deprivation | 22.86 | 16.26 | 21.73 | 15.57 | 7.3 | 22.42 | 16.14 | 2.8 |
| Number of diagnoses in patient record (excl. PSI codes) | 7.88 | 3.3 | 2.83 | 2.17 | 180.3 | 7.78 | 3.65 | -1.5 |
| Medical and dental staff WTE | 615.44 | 352.46 | 654.09 | 372.26 | -12.3 | 599.65 | 338.57 | 2.8 |
| Nursing, midwifery and health visiting staff WTE | 1529.7 | 770 | 1622.06 | 813.41 | -11.6 | 1500.81 | 756.96 | 4.9 |
| Average number of available beds | 813.02 | 376.42 | 862.98 | 404.55 | -8.5 | 808.4 | 368.71 | 2.7 |
| Average bed occupancy rate | 86.91 | 5.43 | 86.54 | 6.77 | 6.4 | 86.19 | 7.11 | 9.4 |
| Teaching status, 0: non-teaching, 1: teaching | 0.42 | 0.49 | 0.44 | 0.5 | -4.8 | 0.43 | 0.5 | -2.1 |

**Table SDC3e: Deep-vein Thrombosis/Pulmonary Embolism, year 2009/10**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Patients with incidents (n=8,407) | | Unmatched control patients (n=5,233,912) | | | Matched control patients (n=9,040) | | |
| Outcomes | Mean | SD | Mean | SD | %bias | Mean | SD | %bias |
| Death, in-hospital | 0.12 | 0.33 | 0.01 | 0.08 |  | 0.05 | 0.22 |  |
| Bed-days | 27.9 | 41.29 | 2.46 | 10.6 |  | 9.64 | 23.43 |  |
| Covariates |  |  |  |  |  |  |  |  |
| Age | 65.93 | 15.84 | 58.49 | 18.16 | 43.5 | 67.17 | 14.97 | -8.2 |
| Sex of patient, 0: male 1: female | 0.5 | 0.5 | 0.52 | 0.5 | -4.1 | 0.5 | 0.5 | -0.3 |
| Weighted Charlson Index | 2.05 | 2.31 | 0.52 | 1.11 | 85 | 1.92 | 2.13 | 3.7 |
| Index of multiple deprivation | 22.18 | 15.57 | 21.67 | 15.52 | 3.3 | 22.17 | 15.73 | 0.2 |
| Number of diagnoses in patient record (excl. PSI codes) | 6.37 | 3.37 | 2.85 | 2.18 | 123.7 | 6.2 | 3.42 | -0.6 |
| Medical and dental staff WTE | 702.74 | 394.65 | 647.96 | 371.2 | 13.1 | 696.64 | 394.68 | 0.2 |
| Nursing, midwifery and health visiting staff WTE | 1705.78 | 849.33 | 1609.19 | 813.41 | 9.9 | 1704.84 | 861.45 | 0.3 |
| Average number of available beds | 871.71 | 408.68 | 858.02 | 405.38 | 4.8 | 889.6 | 431.47 | 2.4 |
| Average bed occupancy rate | 86.41 | 6.77 | 86.5 | 6.69 | -1.1 | 86.25 | 6.94 | 0.1 |
| Teaching status, 0: non-teaching, 1: teaching | 0.49 | 0.5 | 0.44 | 0.5 | 10.2 | 0.49 | 0.5 | -2 |

**Table SDC3f: Post-operative Sepsis, year 2009/10**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Patients with incidents (n=2,086) | | Unmatched control patients (n=297,198) | | | Matched control patients (n=2,092) | | |
| Outcomes | Mean | SD | Mean | SD | %bias | Mean | SD | %bias |
| Death, in-hospital | 0.17 | 0.38 | 0.01 | 0.09 |  | 0.03 | 0.17 |  |
| Bed-days | 33.46 | 39.02 | 9.06 | 12.6 |  | 14.12 | 19.28 |  |
| Covariates |  |  |  |  |  |  |  |  |
| Age | 65.68 | 14.4 | 64.03 | 14.89 | 10.3 | 65.08 | 14.21 | 3.5 |
| Sex of patient, 0: male 1: female | 0.42 | 0.49 | 0.56 | 0.5 | -30.4 | 0.41 | 0.49 | 0.5 |
| Weighted Charlson Index | 1.83 | 2 | 1.02 | 1.54 | 48.3 | 1.88 | 2.04 | -2.6 |
| Index of multiple deprivation | 22.56 | 15.92 | 20.94 | 15.02 | 10.2 | 22.53 | 15.95 | 0.3 |
| Number of diagnoses in patient record (excl. PSI codes) | 7.31 | 3.37 | 3.96 | 2.6 | 114.4 | 7.27 | 3.45 | 1.5 |
| Medical and dental staff WTE | 751.8 | 416.75 | 678.46 | 399.49 | 19 | 755.89 | 408.65 | -2.1 |
| Nursing, midwifery and health visiting staff WTE | 1824.18 | 901.35 | 1674.27 | 873.78 | 17.5 | 1833.28 | 886.95 | -2.1 |
| Average number of available beds | 919.78 | 443.61 | 873.08 | 430.98 | 12.2 | 933.17 | 450.22 | -1.7 |
| Average bed occupancy rate | 86.56 | 5.75 | 86.24 | 6.59 | 5.4 | 86.68 | 6.46 | -2.1 |
| Teaching status, 0: non-teaching, 1: teaching | 0.52 | 0.5 | 0.47 | 0.5 | 10.7 | 0.52 | 0.5 | -0.1 |

## Table SDC4: Propensity score estimation sample descriptive statistics

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Patient safety incident | Year | PS patients | Control patients | Matched  PS pats (%) | Matched controls | PS pats off common support |
| Deaths in low- HRGs | 2005/06 | 1,912 | 4,037,731 | 1,735 (91%) | 1,923 | 130 |
| Mortality | 2006/07 | 1,886 | 5,097,106 | 1,771 (94%) | 1,979 | 107 |
|  | 2007/08 | 1,756 | 5,421,466 | 1,632 (93%) | 1,887 | 95 |
|  | 2008/09 | 1,609 | 5,703,344 | 1,540 (96%) | 1,665 | 54 |
|  | 2009/10 | 1,520 | 5,874,834 | 1,444 (95%) | 1,569 | 72 |
| Pressure ulcers | 2005/06 | 13,449 | 1,602,338 | 13,377 (99%) | 13,880 | 4 |
|  | 2006/07 | 16,539 | 1,803,118 | 16,505 (100%) | 17,053 | 5 |
|  | 2007/08 | 17,721 | 1,745,739 | 17,496 (99%) | 17,986 | 22 |
|  | 2008/09 | 20,936 | 1,765,943 | 20,861 (100%) | 21,430 | 60 |
|  | 2009/10 | 25,223 | 1,760,495 | 25,142 (100%) | 25,793 | 62 |
| Central line infections | 2005/06 | 607 | 2,649,350 | 605 (100%) | 631 | 0 |
|  | 2006/07 | 725 | 3,061,329 | 725 (100%) | 751 | 0 |
|  | 2007/08 | 654 | 2,983,382 | 652 (100%) | 681 | 0 |
|  | 2008/09 | 464 | 3,018,398 | 463 (100%) | 491 | 1 |
|  | 2009/10 | 375 | 3,024,078 | 374 (100%) | 382 | 0 |
| Post-operative hip | 2005/06 | 215 | 3,008,177 | 215 (100%) | 232 | 0 |
| Fractures | 2006/07 | 268 | 3,809,451 | 268 (100%) | 290 | 0 |
|  | 2007/08 | 265 | 4,052,809 | 260 (98%) | 274 | 2 |
|  | 2008/09 | 298 | 4,339,922 | 297 (100%) | 318 | 1 |
|  | 2009/10 | 283 | 4,508,083 | 282 (100%) | 292 | 1 |
| DVT/PE | 2005/06 | 5,237 | 3,566,279 | 5,220 (100%) | 5,661 | 16 |
|  | 2006/07 | 6,903 | 4,524,566 | 6,887 (100%) | 7,451 | 12 |
|  | 2007/08 | 7,165 | 4,856,388 | 6,950 (97%) | 7,513 | 28 |
|  | 2008/09 | 7,842 | 5,231,165 | 7,732 (99%) | 8,377 | 18 |
|  | 2009/10 | 8,606 | 5,426,891 | 8,407 (98%) | 9,040 | 32 |
| Sepsis | 2005/06 | 1,772 | 306,809 | 1,653 (93%) | 1,668 | 118 |
|  | 2006/07 | 2,280 | 345,970 | 2,175 (95%) | 2,190 | 105 |
|  | 2007/08 | 2,260 | 341,357 | 2,111 (93%) | 2,122 | 103 |
|  | 2008/09 | 2,151 | 331,668 | 2,045 (95%) | 2,062 | 86 |
|  | 2009/10 | 2,196 | 312,249 | 2,086 (95%) | 2,092 | 74 |

Notes:

The table shows the number of patients with incidents (PS patients) and without incidents (control patients, all);

Control patients can be considered all patients at risk;

Propensity score estimation chooses matches from all control patients based on observable characteristics, and establishes a matched sample of control patients without incidents that is much smaller than all patients without incidents;

A number of PS patients and quite a few control patients get dropped in the estimation because of missing observations on covariates. PS Patients off the common support, i.e. patients for whom a match cannot be found because there is no control patient with a sufficiently similar propensity score, are dropped from the analysis.

## Table SDC5: Estimates of hospital mortality risk for the matched samples across years

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Treated | Controls | Difference | S.E. | Tstat |
| Death in | **2005/2006** | 1 | 0.05 | 0.95 | 0 | . |
| low-mortality | **2006/2007** | 1 | 0.05 | 0.95 | 0 | . |
| HRGs | **2007/2008** | 1 | 0.05 | 0.95 | 0 | . |
|  | **2008/2009** | 1 | 0.05 | 0.95 | 0 | . |
|  | **2009/2010** | 1 | 0.05 | 0.95 | 0 | . |
| Decubitus | **2005/2006** | 0.3 | 0.14 | 0.16 | 0.005 | 32.82 |
| Ulcer | **2006/2007** | 0.3 | 0.14 | 0.16 | 0.004 | 36.58 |
|  | **2007/2008** | 0.29 | 0.14 | 0.15 | 0.004 | 35.5 |
|  | **2008/2009** | 0.28 | 0.13 | 0.14 | 0.004 | 37.13 |
|  | **2009/2010** | 0.28 | 0.13 | 0.15 | 0.004 | 42.62 |
| Central Line | **2005/2006** | 0.11 | 0.08 | 0.03 | 0.017 | 1.53 |
| Infections | **2006/2007** | 0.1 | 0.09 | 0.01 | 0.016 | 0.71 |
|  | **2007/2008** | 0.1 | 0.09 | 0.01 | 0.016 | 0.92 |
|  | **2008/2009** | 0.09 | 0.09 | 0 | 0.018 | 0 |
|  | **2009/2010** | 0.09 | 0.07 | 0.02 | 0.019 | 0.83 |
| Postoperative | **2005/2006** | 0.19 | 0.08 | 0.11 | 0.032 | 3.48 |
| Hip fracture | **2006/2007** | 0.26 | 0.05 | 0.22 | 0.03 | 7.28 |
|  | **2007/2008** | 0.22 | 0.1 | 0.11 | 0.031 | 3.55 |
|  | **2008/2009** | 0.2 | 0.08 | 0.12 | 0.028 | 4.51 |
|  | **2009/2010** | 0.21 | 0.07 | 0.14 | 0.028 | 4.85 |
| DVT/PE | **2005/2006** | 0.14 | 0.05 | 0.09 | 0.006 | 16.27 |
|  | **2006/2007** | 0.13 | 0.05 | 0.08 | 0.005 | 16.68 |
|  | **2007/2008** | 0.14 | 0.05 | 0.09 | 0.005 | 19.29 |
|  | **2008/2009** | 0.13 | 0.04 | 0.08 | 0.004 | 19.26 |
|  | **2009/2010** | 0.11 | 0.05 | 0.07 | 0.004 | 16.38 |
| Sepsis | **2005/2006** | 0.2 | 0.03 | 0.17 | 0.011 | 16.26 |
|  | **2006/2007** | 0.2 | 0.03 | 0.17 | 0.009 | 18.46 |
|  | **2007/2008** | 0.18 | 0.03 | 0.15 | 0.009 | 17.16 |
|  | **2008/2009** | 0.17 | 0.03 | 0.14 | 0.009 | 15.15 |
|  | **2009/2010** | 0.16 | 0.03 | 0.13 | 0.009 | 15.14 |

## Table SDC6: LOS estimates for the matched samples across years

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Treated | Controls | Difference | S.E. | Tstat |
| Death in | **2005/2006** | 17.89 | 4.03 | 13.87 | 1.109 | 12.5 |
| low-mortality | **2006/2007** | 14.95 | 3.07 | 11.88 | 0.906 | 13.11 |
| HRGs | **2007/2008** | 15.38 | 2.9 | 12.49 | 1.14 | 10.95 |
|  | **2008/2009** | 14.61 | 2.21 | 12.4 | 1.159 | 10.7 |
|  | **2009/2010** | 13.28 | 2.49 | 10.79 | 1.09 | 9.9 |
| Decubitus | **2005/2006** | 40.24 | 22.46 | 17.78 | 0.455 | 39.05 |
| Ulcer | **2006/2007** | 38.07 | 21.45 | 16.62 | 0.383 | 43.4 |
|  | **2007/2008** | 36.34 | 20.82 | 15.52 | 0.336 | 46.15 |
|  | **2008/2009** | 34.72 | 20.49 | 14.23 | 0.286 | 49.72 |
|  | **2009/2010** | 33.7 | 20.21 | 13.49 | 0.26 | 51.89 |
| Central Line | **2005/2006** | 24.66 | 15.99 | 8.68 | 1.445 | 6 |
| Infections | **2006/2007** | 28.89 | 14.77 | 14.13 | 1.559 | 9.06 |
|  | **2007/2008** | 26.31 | 15.77 | 10.54 | 1.553 | 6.79 |
|  | **2008/2009** | 26.6 | 14.2 | 12.4 | 1.915 | 6.47 |
|  | **2009/2010** | 26.03 | 15.82 | 10.2 | 2.065 | 4.94 |
| Postoperative | **2005/2006** | 31.22 | 11.83 | 19.39 | 2.972 | 6.52 |
| Hip fracture | **2006/2007** | 33.79 | 10.74 | 23.04 | 2.609 | 8.83 |
|  | **2007/2008** | 34.6 | 14.66 | 19.94 | 2.896 | 6.88 |
|  | **2008/2009** | 34.16 | 12.18 | 21.98 | 2.893 | 7.6 |
|  | **2009/2010** | 34.89 | 13.39 | 21.5 | 2.674 | 8.04 |
| DVT/PE | **2005/2006** | 26.86 | 9.12 | 17.74 | 0.53 | 33.5 |
|  | **2006/2007** | 26.89 | 9.13 | 17.76 | 0.492 | 36.09 |
|  | **2007/2008** | 26.19 | 8.73 | 17.46 | 0.461 | 37.9 |
|  | **2008/2009** | 25.42 | 8.76 | 16.66 | 0.47 | 35.48 |
|  | **2009/2010** | 24.71 | 8.95 | 15.76 | 0.424 | 37.2 |
| Sepsis | **2005/2006** | 32.25 | 12.21 | 20.04 | 0.959 | 20.88 |
|  | **2006/2007** | 31.91 | 12.68 | 19.23 | 0.767 | 25.07 |
|  | **2007/2008** | 31.3 | 12.09 | 19.2 | 0.849 | 22.62 |
|  | **2008/2009** | 31.37 | 13.13 | 18.24 | 0.888 | 20.53 |
|  | **2009/2010** | 30.36 | 12.92 | 17.44 | 0.798 | 21.87 |

## Table SDC7: Population QALY weights

|  |  |  |
| --- | --- | --- |
|  |  | QALY values *()* |
|  | Age 17-29 | 0.905 |
| Age 30-39 | 0.879 |
| Age 40-49 | 0.837 |
| Age 50-59 | 0.798 |
| Age 60-69 | 0.774 |
| Age 70-79 | 0.723 |
| Age 80+ | 0.657 |

Note: The table shows the population QALY values used in the calculation of loss of health due to mortality from Sullivan et al (2011).

## Table SDC8: Reductions in quality-of-life associated with 240 comorbidities (Sullivan et al. 2011)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Comorbidity | QALY reduction (dij) | Std. Err. | z | P>|z| |
| 005 HIV Infection | -0.056 | 0.029 | -1.930 | 0.053 |
| 006 Hepatitis | -0.058 | 0.019 | -3.140 | 0.002 |
| 011 Cancer Of Head And Neck | -0.056 | 0.020 | -2.870 | 0.004 |
| 014 Cancer Of Colon | -0.038 | 0.018 | -2.060 | 0.039 |
| 019 Cancer Of Bronchus, Lung | -0.112 | 0.032 | -3.440 | 0.001 |
| 021 Cancer Of Bone And Connective Tissue | -0.090 | 0.065 | -1.390 | 0.163 |
| 022 Melanomas Of Skin | -0.003 | 0.010 | -0.260 | 0.792 |
| 023 Other Non-Epithelial Cancer Of Skin | -0.002 | 0.007 | -0.220 | 0.824 |
| 024 Cancer Of Breast | -0.023 | 0.012 | -1.940 | 0.052 |
| 025 Cancer Of Uterus | -0.163 | 0.038 | -4.330 | 0.000 |
| 026 Cancer Of Cervix | -0.003 | 0.021 | -0.160 | 0.876 |
| 029 Cancer Of Prostate | -0.049 | 0.012 | -4.020 | 0.000 |
| 032 Cancer Of Bladder | -0.041 | 0.027 | -1.540 | 0.124 |
| 038 Non-Hodgkin's Lymphoma | 0.002 | 0.016 | 0.130 | 0.895 |
| 039 Leukemias | -0.037 | 0.025 | -1.510 | 0.131 |
| 041 Cancer, Other And Unspecified Primar | -0.003 | 0.009 | -0.300 | 0.766 |
| 043 Malignant Neoplasm Without Specifica | -0.009 | 0.013 | -0.660 | 0.510 |
| 046 Benign Neoplasm Of Uterus | 0.056 | 0.030 | 1.850 | 0.064 |
| 047 Other And Unspecified Benign Neoplas | 0.000 | 0.001 | 0.350 | 0.727 |
| 048 Thyroid Disorders | -0.020 | 0.005 | -4.200 | 0.000 |
| 049 Diabetes Mellitus Without Complicati | -0.062 | 0.004 | -16.190 | 0.000 |
| 050 Diabetes Mellitus With Complications | -0.057 | 0.018 | -3.120 | 0.002 |
| 051 Other Endocrine Disorders | -0.012 | 0.007 | -1.690 | 0.091 |
| 052 Nutritional Deficiencies | -0.084 | 0.018 | -4.730 | 0.000 |
| 053 Disorders Of Lipid Metabolism | -0.003 | 0.003 | -1.140 | 0.254 |
| 054 Gout And Other Crystal Arthropathies | -0.034 | 0.007 | -4.970 | 0.000 |
| 058 Other Nutritional, Endocrine, And Me | -0.034 | 0.009 | -3.850 | 0.000 |
| 059 Deficiency And Other Anemia | -0.020 | 0.009 | -2.210 | 0.027 |
| 062 Coagulation And Hemorrhagic Disorder | -0.045 | 0.028 | -1.620 | 0.105 |
| 064 Other Hematologic Conditions | -0.072 | 0.012 | -5.900 | 0.000 |
| 065 Mental Retardation | -0.146 | 0.063 | -2.310 | 0.021 |
| 066 Alcohol-Related Mental Disorders | -0.003 | 0.022 | -0.140 | 0.893 |
| 067 Substance-Related Mental Disorders | -0.058 | 0.019 | -3.020 | 0.003 |
| 068 Senility And Organic Mental Disorder | -0.192 | 0.014 | -13.610 | 0.000 |
| 069 Affective Disorders | -0.130 | 0.011 | -12.310 | 0.000 |
| 070 Schizophrenia And Related Disorders | -0.107 | 0.027 | -4.000 | 0.000 |
| 071 Other Psychoses | -0.121 | 0.043 | -2.800 | 0.005 |
| 072 Anxiety, Somatoform, Dissociative, A | -0.067 | 0.005 | -13.440 | 0.000 |
| 073 Preadult Disorders | -0.002 | 0.006 | -0.260 | 0.797 |
| 074 Other Mental Conditions | -0.101 | 0.005 | -21.230 | 0.000 |
| 075 Personal History Of Mental Disorder, | -0.040 | 0.022 | -1.820 | 0.069 |
| 079 Parkinson's Disease | -0.208 | 0.025 | -8.330 | 0.000 |
| 080 Multiple Sclerosis | -0.227 | 0.034 | -6.600 | 0.000 |
| 081 Other Hereditary And Degenerative Ne | -0.097 | 0.019 | -5.090 | 0.000 |
| 082 Paralysis | -0.247 | 0.099 | -2.480 | 0.013 |
| 083 Epilepsy, Convulsions | -0.067 | 0.009 | -7.450 | 0.000 |
| 084 Headache, Including Migraine | -0.027 | 0.007 | -4.070 | 0.000 |
| 086 Cataract | -0.027 | 0.006 | -4.520 | 0.000 |
| 087 Retinal Detachments, Defects, Vascul | -0.020 | 0.011 | -1.830 | 0.067 |
| 088 Glaucoma | -0.028 | 0.006 | -4.450 | 0.000 |
| 089 Blindness And Vision Defects | 0.000 | 0.001 | 0.000 | 1.000 |
| 091 Other Eye Disorders | -0.009 | 0.006 | -1.630 | 0.103 |
| 094 Other Ear And Sense Organ Disorders | -0.010 | 0.007 | -1.470 | 0.141 |
| 095 Other Nervous System Disorders | -0.069 | 0.006 | -12.390 | 0.000 |
| 096 Heart Valve Disorders | -0.028 | 0.009 | -3.040 | 0.002 |
| 098 Essential Hypertension | -0.037 | 0.004 | -9.010 | 0.000 |
| 100 Acute Myocardial Infarction | -0.056 | 0.011 | -4.970 | 0.000 |
| 101 Coronary Atherosclerosis And Other H | -0.047 | 0.008 | -6.140 | 0.000 |
| 102 Nonspecific Chest Pain | -0.039 | 0.006 | -6.250 | 0.000 |
| 104 Other And Ill-Defined Heart Disease | -0.079 | 0.006 | -12.460 | 0.000 |
| 105 Conduction Disorders | -0.022 | 0.026 | -0.850 | 0.396 |
| 106 Cardiac Dysrhythmias | -0.025 | 0.005 | -4.620 | 0.000 |
| 107 Cardiac Arrest And Ventricular Fibri | -0.044 | 0.026 | -1.700 | 0.089 |
| 108 Congestive Heart Failure, Nonhyperte | -0.103 | 0.016 | -6.390 | 0.000 |
| 109 Acute Cerebrovascular Disease | -0.101 | 0.012 | -8.200 | 0.000 |
| 110 Occlusion Or Stenosis Of Precerebral | -0.040 | 0.021 | -1.950 | 0.052 |
| 112 Transient Cerebral Ischemia | -0.032 | 0.024 | -1.330 | 0.184 |
| 113 Late Effects Of Cerebrovascular Dise | -0.067 | 0.025 | -2.630 | 0.009 |
| 114 Peripheral And Visceral Atherosclero | -0.034 | 0.014 | -2.350 | 0.019 |
| 115 Aortic, Peripheral, And Visceral Art | -0.054 | 0.020 | -2.710 | 0.007 |
| 116 Aortic And Peripheral Arterial Embol | -0.051 | 0.013 | -4.030 | 0.000 |
| 117 Other Circulatory Disease | -0.053 | 0.008 | -6.720 | 0.000 |
| 118 Phlebitis, Thrombophlebitis And Thro | -0.056 | 0.009 | -5.960 | 0.000 |
| 119 Varicose Veins Of Lower Extremity | 0.000 | 0.012 | 0.020 | 0.984 |
| 120 Hemorrhoids | -0.005 | 0.009 | -0.500 | 0.616 |
| 127 Chronic Obstructive Pulmonary Diseas | -0.027 | 0.006 | -4.440 | 0.000 |
| 128 Asthma | -0.034 | 0.006 | -5.720 | 0.000 |
| 132 Lung Disease Due To External Agents | -0.079 | 0.042 | -1.880 | 0.060 |
| 138 Esophageal Disorders | -0.033 | 0.005 | -7.100 | 0.000 |
| 139 Gastroduodenal Ulcer (Except Hemorrh | -0.055 | 0.014 | -3.930 | 0.000 |
| 140 Gastritis And Duodenitis | -0.037 | 0.016 | -2.350 | 0.019 |
| 141 Other Disorders Of Stomach And Duode | -0.040 | 0.006 | -6.600 | 0.000 |
| 143 Abdominal Hernia | -0.049 | 0.007 | -7.040 | 0.000 |
| 144 Regional Enteritis And Ulcerative Co | -0.086 | 0.026 | -3.360 | 0.001 |
| 146 Diverticulosis And Diverticulitis | -0.046 | 0.009 | -5.140 | 0.000 |
| 147 Anal And Rectal Conditions | -0.002 | 0.016 | -0.110 | 0.911 |
| 151 Other Liver Diseases | -0.038 | 0.016 | -2.380 | 0.017 |
| 152 Pancreatic Disorders (Not Diabetes) | -0.134 | 0.048 | -2.770 | 0.006 |
| 154 Noninfectious Gastroenteritis | -0.073 | 0.017 | -4.340 | 0.000 |
| 155 Other Gastrointestinal Disorders | -0.051 | 0.005 | -9.640 | 0.000 |
| 161 Other Diseases Of Kidney And Ureters | -0.096 | 0.012 | -8.360 | 0.000 |
| 162 Other Diseases Of Bladder And Urethr | -0.070 | 0.014 | -5.210 | 0.000 |
| 163 Genitourinary Symptoms And Ill-Defin | -0.025 | 0.008 | -3.060 | 0.002 |
| 164 Hyperplasia Of Prostate | 0.002 | 0.010 | 0.200 | 0.843 |
| 167 Nonmalignant Breast Conditions | -0.002 | 0.004 | -0.500 | 0.620 |
| 169 Endometriosis | -0.056 | 0.020 | -2.790 | 0.005 |
| 170 Prolapse Of Female Genital Organs | -0.001 | 0.019 | -0.030 | 0.977 |
| 171 Menstrual Disorders | -0.001 | 0.001 | -0.850 | 0.397 |
| 172 Ovarian Cyst | -0.002 | 0.003 | -0.550 | 0.585 |
| 173 Menopausal Disorders | -0.001 | 0.005 | -0.300 | 0.764 |
| 175 Other Female Genital Disorders | -0.005 | 0.006 | -0.840 | 0.402 |
| 198 Other Inflammatory Condition Of Skin | -0.002 | 0.002 | -0.940 | 0.346 |
| 199 Chronic Ulcer Of Skin | -0.065 | 0.011 | -5.900 | 0.000 |
| 200 Other Skin Disorders | -0.001 | 0.001 | -0.740 | 0.459 |
| 202 Rheumatoid Arthritis And Related Dis | -0.157 | 0.013 | -12.370 | 0.000 |
| 203 Osteoarthritis | -0.102 | 0.007 | -15.110 | 0.000 |
| 204 Other Non-Traumatic Joint Disorders | -0.099 | 0.004 | -25.040 | 0.000 |
| 205 Spondylosis, Intervertebral Disc Dis | -0.085 | 0.004 | -19.610 | 0.000 |
| 206 Osteoporosis | -0.042 | 0.006 | -6.590 | 0.000 |
| 208 Acquired Foot Deformities | -0.036 | 0.014 | -2.480 | 0.013 |
| 209 Other Acquired Deformities | -0.010 | 0.017 | -0.560 | 0.572 |
| 210 Systemic Lupus Erythematosus And Con | -0.077 | 0.019 | -3.990 | 0.000 |
| 211 Other Connective Tissue Disease | -0.063 | 0.004 | -14.580 | 0.000 |
| 212 Other Bone Disease And Musculoskelet | -0.023 | 0.011 | -2.060 | 0.040 |
| 215 Genitourinary Congenital Anomalies | -0.007 | 0.015 | -0.480 | 0.634 |
| 217 Other Congenital Anomalies | -0.005 | 0.021 | -0.230 | 0.819 |
| 227 Spinal Cord Injury | -0.170 | 0.051 | -3.350 | 0.001 |
| 245 Syncope | -0.004 | 0.011 | -0.350 | 0.727 |
| QALY reductions for more than 2 comorbidities (cih) |  |  |  |  |
| 2 concomitant comorbidities | -0.061 | 0.008 | -7.610 | 0.000 |
| 3 concomitant comorbidities | -0.067 | 0.010 | -6.750 | 0.000 |
| 4 concomitant comorbidities | -0.043 | 0.012 | -3.690 | 0.000 |
| 5 concomitant comorbidities | -0.029 | 0.015 | -1.870 | 0.061 |
| 6 concomitant comorbidities | -0.005 | 0.018 | -0.270 | 0.787 |
| 7 concomitant comorbidities | 0.024 | 0.019 | 1.260 | 0.209 |
| 8 concomitant comorbidities | 0.039 | 0.022 | 1.790 | 0.073 |
| 9 concomitant comorbidities | 0.044 | 0.025 | 1.770 | 0.076 |
| 10 or more concomitant comorbidities | 0.100 | 0.029 | 3.510 | 0.000 |

Note: we only use quality-of-life reductions that are statistically significant

## Table SDC9: Life expectancy and healthy life expectancy remaining, by age-group

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Agegroups | Life expectancy (remaining) | Death in low-mortality HRG | | Pressure Ulcer | | Central-line infections | | Hip fracture | | DVT/PE | | Sepsis | |
|  |  | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| 20-30 | LE | 55.7 | 3.1 | 55.4 | 3.1 | 56.4 | 3.3 | 57.3 | 3.1 | 55.5 | 3.2 | 55.4 | 3.0 |
|  | HLE | 34.4 | 2.4 | 32.1 | 2.2 | 33.5 | 2.4 | 30.4 | 2.7 | 34.0 | 2.3 | 31.6 | 2.0 |
| 30-40 | LE | 47.0 | 3.6 | 46.2 | 3.4 | 47.1 | 3.4 | 46.6 | 2.3 | 46.1 | 3.4 | 46.4 | 3.3 |
|  | HLE | 27.2 | 2.6 | 25.0 | 2.3 | 26.0 | 2.4 | 25.3 | 2.0 | 26.7 | 2.3 | 24.8 | 2.1 |
| 40-50 | LE | 36.8 | 3.4 | 36.6 | 3.3 | 37.1 | 3.4 | 38.5 | 2.9 | 37.0 | 3.4 | 36.8 | 3.4 |
|  | HLE | 19.8 | 2.2 | 18.4 | 2.0 | 19.0 | 2.1 | 19.7 | 1.7 | 20.2 | 2.2 | 18.2 | 2.0 |
| 50-60 | LE | 27.0 | 3.1 | 27.2 | 3.1 | 27.5 | 3.2 | 26.6 | 2.6 | 27.6 | 3.2 | 27.1 | 3.2 |
|  | HLE | 13.6 | 1.8 | 12.6 | 1.7 | 13.1 | 1.8 | 12.6 | 1.3 | 14.1 | 1.9 | 12.5 | 1.7 |
| 60-70 | LE | 18.9 | 2.8 | 18.9 | 2.8 | 19.0 | 2.8 | 19.0 | 2.8 | 19.4 | 2.9 | 19.0 | 2.8 |
|  | HLE | 8.9 | 1.5 | 8.1 | 1.4 | 8.2 | 1.4 | 8.4 | 1.4 | 9.2 | 1.6 | 8.1 | 1.4 |
| 70-80 | LE | 11.9 | 2.2 | 11.7 | 2.2 | 11.9 | 2.2 | 12.0 | 2.3 | 12.2 | 2.3 | 12.1 | 2.2 |
|  | HLE | 5.3 | 1.1 | 4.6 | 1.0 | 4.5 | 1.0 | 4.9 | 1.1 | 5.3 | 1.2 | 4.8 | 1.0 |
| 80-90 | LE | 7.0 | 1.4 | 6.7 | 1.5 | 6.8 | 1.4 | 7.1 | 1.5 | 7.1 | 1.4 | 7.2 | 1.4 |
|  | HLE | 3.0 | 0.6 | 2.5 | 0.5 | 2.4 | 0.5 | 2.7 | 0.6 | 2.9 | 0.6 | 2.7 | 0.5 |
| 90-100 | LE | 3.7 | 0.6 | 3.7 | 0.7 | 3.7 | 0.7 | 3.8 | 0.6 | 3.8 | 0.6 | 3.9 | 0.6 |
|  | HLE | 1.7 | 0.3 | 1.5 | 0.3 | 1.4 | 0.4 | 1.6 | 0.3 | 1.6 | 0.3 | 1.4 | 0.3 |

Note: The table displays remaining life expectancy and healthy life expectancy for different age groups. These estimates are based on the matched control patients, and therefore do not incorporate the loss of health due to the safety incident. Healthy-life expectancy considers the existence of 141 comorbidities in our sample of inpatients, and values life-years that are predicted to be lived in less than perfect as smaller than unity. We obtain healthy life-expectancy as the sum of these ‘devalued’ life years. Therefore, healthy life-expectancy is smaller than life expectancy, which is not adjusted for quality-of-life. For example, a Hip fracture patient in the age-group 60-70 has a remaining life expectancy of 19 years, however, these years are predicted to be lived in less than perfect health. Hence, healthy life-expectancy is only estimated to be 8.4 years. This implies that the remaining 19 years are valued at just above 0.5, due to the presence of one or several of the 141 comorbidities.

## Table SDC10: Loss of healthy-life-years due to six patient safety incidents, annual estimates for an average English hospital

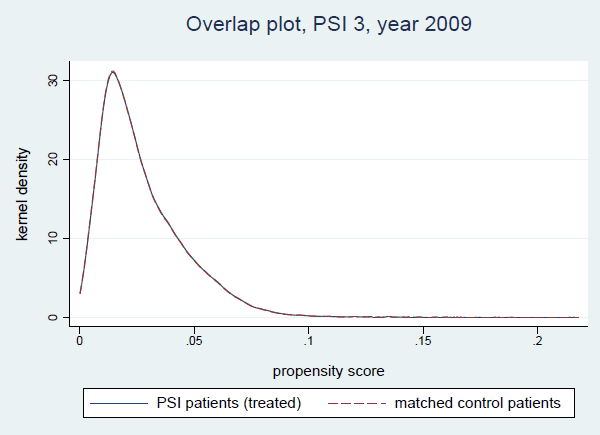
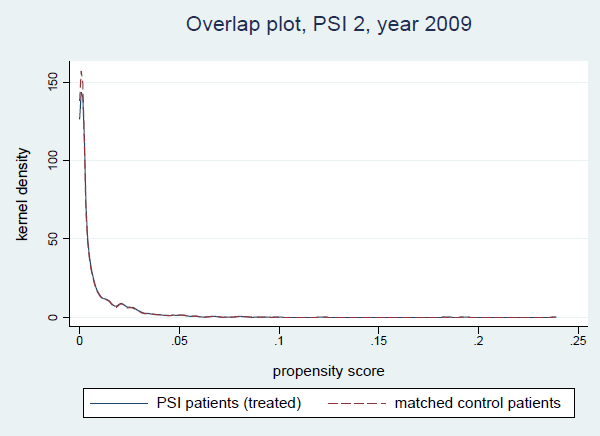
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Death in low-mortality HRG | | | Pressure Ulcer | | | Central line infection | | Hip fracture | | | | DVT/PE | | | Sepsis | | | Total |
| year | **HLYs lost** | **95% CI** | | **HLYs lost** | **95% CI** | | **HLYs lost** | **95% CI** | **HLYs lost** | | **95% CI** | | **HLYs lost** | **95% CI** | | **HLYs lost** | **95% CI** | |  |
| 2005/06 | 60.4 | [60.4; | 60.4] | 49.5 | [46.5; | 52.4] | 0 | n.a. | 0.8 | [0.4; | | 1.3] | 30.3 | [26.7; | 33.9] | 18.1 | [16.1; | 20.2] | 159.1 |
| 2006/07 | 58.3 | [58.3; | 58.3] | 52.3 | [49.6; | 55] | 0 | n.a. | 1.8 | [1.3; | | 2.3] | 29.5 | [26.2; | 32.8] | 19.3 | [17.4; | 21.2] | 161.2 |
| 2007/08 | 55.6 | [55.6; | 55.6] | 54.6 | [51.7; | 57.5] | 0 | n.a. | 1 | [0.5; | | 1.4] | 37.8 | [34.1; | 41.6] | 18 | [16.1; | 19.9] | 167 |
| 2008/09 | 50 | [50; | 50] | 59.7 | [56.6; | 62.7] | 0 | n.a. | 1.1 | [0.6; | | 1.6] | 37.6 | [33.9; | 41.2] | 15.3 | [13.4; | 17.2] | 163.7 |
| 2009/10 | 51 | [51; | 51] | 74.1 | [70.9; | 77.4] | 0 | n.a. | 1.1 | [0.7; | | 1.6] | 32.7 | [28.9; | 36.5] | 15.2 | [13.3; | 17.1] | 174.1 |
| Average across all years | 55.06 |  |  | 58.04 |  |  | 0 |  | 1.16 |  | |  | 33.58 |  |  | 17.18 |  |  | 165.02 |

## Table SDC11: Excess bed days due to six patient safety incidents, annual estimates for an average English hospital

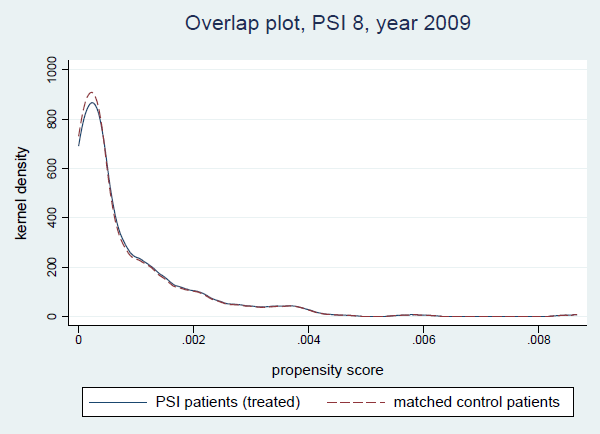
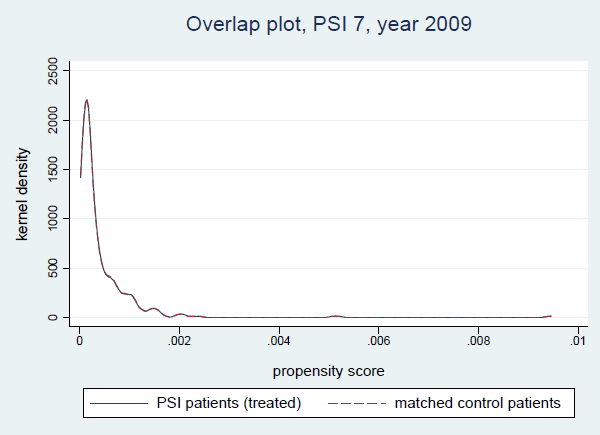
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Death in low-mortality HRG | | Pressure Ulcer | | Central line infection | | Hip fracture | | DVT/PE | | Sepsis | | Total |
| year | **Bed days** | **95% CI** | **Bed days** | **95% CI** | **Bed days** | **95% CI** | **Bed days** | **95% CI** | **Bed days** | **95% CI** | **Bed days** | **95% CI** |  |
| 2005/06 | 124.6 | [105.3; 144] | 885.5 | [747.7; 1023.2] | 41.9 | [35.4; 48.5] | 19 | [16; 21.9] | 460.3 | [388.7; 531.9] | 165.7 | [139.9; 191.5] | 1697 |
| 2006/07 | 109.5 | [92.5; 126.5] | 946.1 | [799; 1093.3] | 43.2 | [36.5; 50] | 19.9 | [16.8; 23] | 514.2 | [434.2; 594.1] | 181.2 | [153; 209.4] | 1814.1 |
| 2007/08 | 103.8 | [87.7; 119.9] | 1055.6 | [891.4; 1219.7] | 39.8 | [33.6; 46] | 20.6 | [17.4; 23.8] | 559.3 | [472.3; 646.2] | 180.3 | [152.3; 208.4] | 1959.4 |
| 2008/09 | 94.8 | [80.1; 109.6] | 1243.8 | [1050.3; 1437.2] | 28.1 | [23.7; 32.5] | 22.6 | [19.1; 26.1] | 608.9 | [514.2; 703.6] | 170.9 | [144.3; 197.5] | 2169.1 |
| 2009/10 | 92.3 | [77.9; 106.7] | 1506.2 | [1271.9; 1740.4] | 22.7 | [19.2; 26.2] | 21.8 | [18.4; 25.1] | 660.4 | [557.7; 763.1] | 177.6 | [150; 205.2] | 2481 |
| Average across all years | 105 |  | 1127.44 |  | 35.14 |  | 20.78 |  | 560.62 |  | 175.14 |  | 2024.12 |

Note: The average hospital is defined with respect to number of PSIs per year.

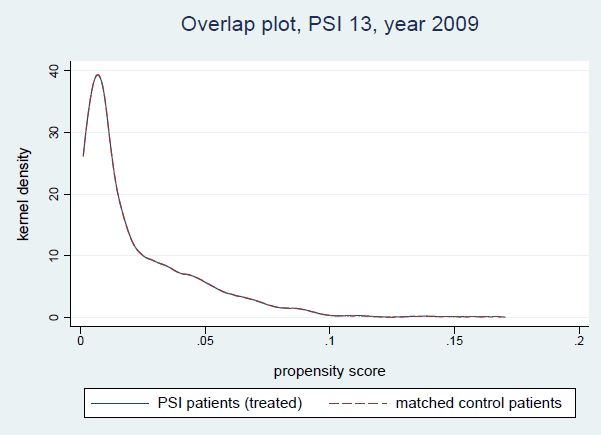
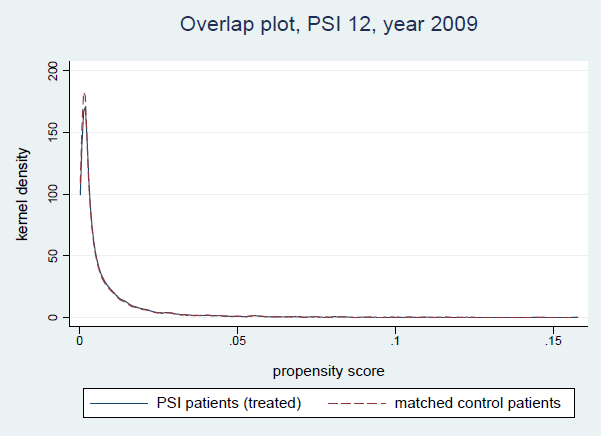
# Supplementary Figures



## Figures SDC1a-b: Overlay plots of Kernel densities of predicted propensity scores (Death in low-mortality HRG and Pressure ulcers)



## Figures SDC1c-d: Overlay plots of Kernel densities of predicted propensity scores (Central-line infections and post-operative hip fractures)



## Figures SDC1e-f: Overlay plots of Kernel densities of predicted propensity scores (DVT/PE and post-operative sepsis)

Note:

The figures show the distribution of predicted propensity of experiencing the safety incident. These were estimated for patients with and matched patients without incidents, and are plotted separately here. Low/high predicted scores indicate that an individual has a low/high propensity of experiencing an incident. The plots show that all PSIs are relatively rare events, with the mass of the density far below 0.1 for all PSIs. There is a near perfect overlap between PSI patients and matched control patients. This implies that we were successful in finding matches that have nearly the same probability of experiencing the PSI as the patients which actually did have the PSI, a finding that is confirmed by the summary statistics of the propensity score differences. Plots for other years are very similar, and available on request from corresponding author.

# References

1. AHRQ. Measures of Patient Safety Based on Hospital Administrative Data: The Patient Safety Indicators - Technical Review 5. In: Agency for Healthcare Research and Quality, ed.: Department of Health and Human Services; 2002

2. AHRQ. Patient Safety Indicators. In: Agency for Healthcare Research and Quality, ed. Rockville, Maryland: U.S. Department of Health and Human Services; 2010

3. Henriksen K, Battles JB, Marks ES, et al. Applying patient safety indicators (PSIs) across health care systems: achieving data comparability. In: Henriksen K, Battles JB, Marks ES, et al., eds. Advances in Patient Safety: From Research to Implementation Rockville, MD: Agency for Healthcare Reserach and Quality; 2005

4. Bottle A, Aylin P. Application of AHRQ patient safety indicators to English hospital data. Quality and Safety in Health Care 2009;18:303-308

5. AHRQ. Death Rate in Low-Mortality Diagnosis Related Groups (DRGs) Technical Specifications. In: Agency for Healthcare Research and Quality, ed.: U.S. Department of Health and Human Services; 2014

6. AHRQ. Pressure Ulcer Rate Technical Specification,. In: Agency for Healthcare Research and Quality, ed.: U.S. Department of Health and Human Services; 2014

7. Tissue Viability Society. Achieving Consensus in Pressure Ulcer Reporting. 2012

8. AHRQ. Central Venous Catheter-Related Blood Stream Infection Rate Technical Specifications. In: Agency for Healthcare Research and Quality, ed.: U.S. Department of Health and Human Services; 2014

9. AHRQ. Postoperative Hip Fracture Rate Technical Specifications,. In: Agency for Healthcare Research and Quality, ed.: U.S. Department of Health and Human Services; 2014

10. AHRQ. PSI 12: Perioperative Pulmonary Embolism (PE) or Deep Vein Thrombosis (DVT) - Selected Best Practices and Suggestions for Improvement. In: Agency for Healtcare Research and Quality, ed.: U.S. Department of Health and Social Services; 2014

11. AHRQ. Perioperative Pulmonary Embolism or Deep Vein Thrombosis Rate Technical Specifications. In: Agency for Healthcare Research and Quality, ed.: U.S. Department of Health and Human Services; 2014

12. AHRQ. Postoperative Sepsis Rate - Technical Specifications. In: Agency for Healthcare Research and Quality, ed.: U.S. Department of Health and Human Services; 2014

13. AHRQ. PS 13: Postoperative Sepsis - Selected Best Practice and Suggestions for Improvements. In: Agency for Healthcare Research and Quality, ed.: U.S. Department of Health and Human Services; 2014

14. Rubin DB. Using Multivariate Matched Sampling and Regression Adjustment to Control Bias in Observational Studies. Journal of the American Statistical Association 1979;74:318-328

15. Heckman JJ, LaLonde RJ, Smith JA. The economics and econometrics of active labor market programs. Handbook of labor economics 1999;3:1865-2097

16. Smith JA, Todd PE. Does matching overcome LaLonde's critique of nonexperimental estimators? Journal of econometrics 2005;125:305-353

17. D'Hoore W, Bouckaert A, Tilquin C. Practical considerations on the use of the Charlson comorbidity index with administrative data bases. Journal of clinical epidemiology 1996;49:1429-1433

18. StataCorp. Stata 13 Base Reference Manual. College Station, TX: Stata Press; 2013

19. Austin PC. Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. Statistics in Medicine 2009;28:3083-3107

20. Austin PC. Propensity-score matching in the cardiovascular surgery literature from 2004 to 2006: A systematic review and suggestions for improvement. The Journal of Thoracic and Cardiovascular Surgery 2007;134:1128-1135.e1123

21. Rubin DB. Using Propensity Scores to Help Design Observational Studies: Application to the Tobacco Litigation. Health Services & Outcomes Research Methodology 2001;2:169-188

22. Rosenbaum PR, Rubin DB. Constructing a Control Group Using Multivariate Matched Sampling Methods That Incorporate the Propensity Score. The American Statistician 1985;39:33-38

23. Frontier Economics. Exploring the costs of unsafe care in the NHS - A report prepared for the Department of Health. London, UK: Frontier Economics, ; 2014

24. Gaughan J, Mason A, Street A, et al. English hospitals can improve their use of resources: analysis of costs and length of stay for ten treatments In: Centre for Health Economics, ed. CHE Working Paper. York: University of York; 2012

25. Sullivan PW, Slejko JF, Sculpher MJ, et al. Catalogue of EQ-5D Scores for the United Kingdom. Medical Decision Making 2011;31:800-804