# TITLE PAGE

**THE IMPACT OF PERFORMANCE STATUS ON LENGTH OF HOSPITAL STAY AND CLINICAL COMPLICATIONS FOLLOWING LIVER TRANSPLANTATION**

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JvdM reports grants from Healthcare Quality Improvement Partnership during the conduct of the study. All other authors declare no competing interests. T.E.C. was supported by the Medical Research Council (grant number MR/S020470/1).

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The funder of the study, National Institute for Health Research, had no role in study design, data collection, data analysis, data interpretation, writing of the report, or the decision to submit for publication. DW, KW, and JvdM had full access to all the data in the study, take responsibility for the integrity of the data and the accuracy of the data analysis, and had final responsibility for the decision to submit for publication.

**ABBREVIATIONS PAGE**

ADL:Activities of daily living

ALF: Acute liver failure

CLD: Chronic liver disease

CAG: Confidentiality Advisory Group

DBD: Brainstem death

DCD: Circulatory death

ECOG: Eastern Cooperative Oncology Group

HCC: Hepatocellular carcinoma

HRA: Health Research Authority

HCV: Hepatitis C

IRQ: Interquartile range

HR: Hazard ratio

LOS: Length of stay

LT: Liver transplantation

PS: Performance status

REC: Research Ethics Committee

SD: Standard deviation

STROBE: Strengthening the Reporting of Observational Studies in Epidemiology

UKELD: United Kingdom Model for End-Stage Liver Disease

# ABSTRACT

**Background**:

Impaired pre-transplant performance status (PS) is associated with chronic liver disease (CLD). We studied its impact on hospital length of stay (LOS), complications and readmissions in the first year after liver transplantation.

**Method:**

The Standard National Liver Transplant Registry was linked to a hospital administrative dataset and all first-time liver transplant recipients with CLD aged ≥ 18 years in England were identified. A modified 3-level Eastern Cooperative Oncology Group score was used to assess PS. Linear and logistic fixed effect regression models were used to estimate the effect of specific post-transplant complications, and readmissions in the first year after transplantation.

**Results:**

6968 recipients were included. Impaired PS was associated with an increased LOS in the initial post-transplant period (comparing ECOG 1 to 3, adjusted difference 7.2 days, 95%CI: 4.8-9.6, p<0.001) and in time spent on the ITU (adjusted difference 1.2 days, 95%CI: 0.4-2.0, p<0.001). There was no significant association between ECOG status and total LOS of later admissions (adjusted difference, 2.5 days, 95%CI: -0.4-5.5, p=0.23). Those with a poorer ECOG status had an increased incidence of renal failure (odds ratio 1.5, 95%CI: 1.1-2.0, p=0.004) and infection (odds ratio 1.2, 95%CI: 1.1-1.4, p=0.02) but not an increased incidence of readmission (odds ratio 1.2, 95%CI: 0.9-1.5, p=0.13).

Conclusion:

In liver transplant recipients with CLD, impaired pre-transplant PS is associated with prolonged LOS in the immediate post-transplant period but not with LOS of later admissions in the first year after transplantation. Impaired PS increased the risk of renal failure and infection.

**INTRODUCTION**

Identifying modifiable factors that predict longer hospital admissions and post-transplant complications has major potential clinical utility.1-6 First, it may help clinicians counsel their patients on what might be experienced in the post-operative period. Second, it can assist service providers plan hospital resource use and optimise resource utilisation.1-6 Third, it could facilitate the introduction of interventions on the waiting list that may serve to reduce morbidity and length of stay (LOS) following transplantation.

To date, studies that have reported LOS following liver transplantation have largely been restricted to small cohorts of patients from single centres.2-6 These have tended to focus on the association of hospital stay with specific markers of organ dysfunction or graft quality.3-6 However, including only clinical measures of organ function may obfuscate other risk factors that have an impact on the post-operative course.7-8 There is now an increasing appreciation of the global decline in physical heath seen in patients with advanced CLD.9-10 This decline includes changes in multiple organ systems and in both the development of liver specific complications including ascites and encephalopathy, and global loss of muscle bulk and function though the development of sarcopenia.9-10 Together, these pathological changes result in progressive frailty and impaired functional status which has major impacts upon quality of life and non-transplanted survival.9-10

Measurements of overall health status capture information beyond that identified through specific measurements of end-organ function.2,7-8 Impaired performance status (PS), is now well established as an independent risk factor for post-transplant mortality.7-8 Given the increasing appreciation of the clinical impact of impaired PS on post-transplant outcomes it is possible that PS will also be a predictor of post-transplant LOS.

Only one single-centre study from the US, including 598 recipients of a liver transplant between 2009 and 2014, has identified an association between PS and hospital LOS2 and none has explored the association of using a national cohort of liver transplant recipients. Whilst in the last decade the number of recipients with hepatocellular carcinoma (HCC) has increased significantly,11 the difference in how PS affects hospital resource use in HCC and non-HCC patients has not been assessed. This is potentially important as at the time of transplantation HCC recipients are often in a better physical condition and have fewer manifestations of end-stage liver disease than non-HCC patients.11

We carried out a cohort study to assess the impact of PS on length of hospital stay, readmissions, and specific key post-transplant complications in the first year after transplantation. We distinguished LOS immediately after transplantation and total LOS of later admissions. We used national data from the United Kingdom Standard National Liver Transplant Registry, including all patients who underwent a liver transplantation in England in the period from 1997 to 2015, linked at patient level with administrative data from all hospital admissions in the English National Health Services (NHS).

# MATERIAL AND METHODS

## Standard National Liver Transplant Registry

The Standard National Liver Transplant Registry contains detailed information about all liver transplants performed in the six liver transplant centres in England.12 This registry was used to identify recipients of a liver transplant from 1997 to 2015 and to capture information on the date of transplant and on donor and recipient characteristics, the number of days ventilated or in ITU, the incidence of specific post-transplant complications of infection or need for renal replacement therapy, and readmissions within the first year after transplantation.12

## Hospital Episodes Statistics (HES) database

The HES database is an administrative dataset capturing records of all admissions to English NHS hospitals.13 Each HES record can contain up to 20 diagnoses using codes based on the 10th revision of the International Classification of Disease, up to 24 operations and procedures using codes from the Office of Population, Census and Surveys Classification of Surgical Operations and Procedures (OPCS-4) and information on length of hospital stay based on the dates of admission and discharge.13 The linked HES records from 1997 to 2016 also provided information on comorbidities and the patients’ socioeconomic status based on the Index of Multiple Deprivation, grouped according to national quintiles.13

## Study population

All patients (aged 17 years or older) who had received a first liver transplant between 1st January 1997 and 31st December 2015 were eligible for inclusion (Figure 1). To include a cohort of liver transplant recipients that were representative of clinical practice, recipients who underwent multivisceral transplants and those who required ITU support prior to transplantation were included. We excluded those whose survival data was missing and those in which a PS score was not recorded prior to their transplant. Recipients were also categorised into two groups: patients transplanted with HCC mentioned in any of the three diagnosis fields available in the Standard National Liver Transplant Registry (HCC patients) and patients transplanted with other liver disease diagnoses (non-HCC patients).12

A modified version of the Eastern Cooperative Oncology Group (ECOG) was used to measure recipients’ performance status (PS).14 ECOG scores were stratified into three groups: ECOG 1 (normal or minimally restricted level of activity), ECOG 2 (able to self-care), and ECOG 3 (confined to bed or chair or completely reliant on medical care). ECOG scores were assessed by clinicians either at the time of transplantation or at the most recent clinic before surgery. Included in the assessment of a patient’s PS were their own reports of their functional ability.7-8 The severity of recipients’ liver disease was assessed using the United Kingdom Model for End-Stage Liver Disease (UKELD) score.15 Ethnic background was categorised into white and non-white groups.

LOS in the initial post-operative period was calculated from the date of transplant to the date of discharge1 LOS of any later admission was calculated from the date of admission to the date of discharge. LOS following the initial post-operative admission was defined as the sum of LOS of every admission in any NHS hospital in England with an admission date within one year from the date of transplant.1 This included days spent in hospital during non-transplant related admissions.31 Post-transplant infections were categorised into those causing infection due to bacterial or viral causes. Post-transplant renal failure was defined as those patients requiring renal replacement therapy. These complications were captured in the national dataset up to 12 months following initial transplantation. Readmissions considered only those related to transplant-specific complications and were dichotomized according to those who had one or more readmissions within the first year of their operation.

## Statistical Analysis

Donor and recipient characteristics, co-morbidities, LOS, post-transplant complications and readmissions were described and stratified according to the modified 3-level ECOG scale. Categorical variables were presented as proportions and continuous variables including were presented as means with standard deviations (SD). In accordance with recent Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines, we did not apply significance tests to the patient characteristics included in descriptive tables.16

Separate multivariable fixed effects regression models were used to estimate the independent effect of PS on each outcome. Linear regression models were used to provide the adjusted mean differences in LOS by PS, and logistic regression models were used to estimate the adjusted odds ratios for post-transplant complications and readmissions by PS. To account for differences in outcomes between hospitals, a categorical variable for transplant centre was fitted in each model.1 ECOG 1 was used as the reference value. In the analysis, LOS, specific post-transplant complications and readmissions were considered for all patients including those who died within the first year following their transplant. A global Wald test was used in the separate multivariable models to test whether the adjusted mean differences in LOS or the incidence of complications and readmissions differed significantly between levels of ECOG status (p for overall association). To determine whether the prognostic impact of ECOG status varied according to HCC or non-HCC indications, models were also fitted on HCC and non-HCC patients together with interaction terms (p for interaction) between ECOG and HCC status. The statistical significance of these interaction terms in each model was again tested using a global Wald test. To account for patients who died early after transplantation a sensitivity analysis was performed that included only patients who survived to one-year.

In all models, risk adjustment included the recipient and donor characteristics (in table 1) and co-morbidities (table S1). Missing donor and recipient characteristics were imputed using chained equations creating ten complete datasets.17 In the imputation procedure all available donor and recipient variables were used to predict missing values, including the outcome variables.18 The regression coefficients across the datasets were pooled using Rubin’s rules.17

Stata V15 (StataCorp, College Station, Texas, USA) was used for all statistical analyses. Health Research Authority (HRA) Confidentiality Advisory Group (17/CAG/0025) approval and Research Ethical Committee (REC reference 17/LO/0231) approval was obtained for this study.

# RESULTS

## Donor and recipient characteristics

A total of 6 968 adult liver transplants were included in the study (Table 1). At the time of transplantation, recipients with the poorest PS scores had more severe liver disease (as captured by UKELD) and were more likely to have been encephalopathic. They were also more frequently required to be inpatients or require renal support prior to transplantation. The presence of comorbidity was infrequently found in recipients (Table S1).

## Length of stay (LOS)

Hospital LOS in the immediate post-operative period was twice as long in those recipients with ECOG 3, who were severely restricted or almost completely reliant on care, as compared to those with ECOG 1 who had a relatively normal level of functional activity (mean length of stay of ECOG 1 and 3; 19.8 days and 41.4 days, respectively, Table 2).

At one year, the overall difference in mean length of stay following the initial post-operative admission to one year was less marked with 22.4 days in those with an ECOG status of 1 compared to 28.5 days in ECOG 3. Stratifying for indication of transplantation, there were increases in LOS for both HCC (comparing ECOG 1 to ECOG 3; 22.8 to 24.6 days) and non-HCC recipients (ECOG 1 to ECOG 3; 22.2 to 28.8 days)

Following risk adjustment, impaired ECOG status remained associated with an increase in LOS in the initial post-operative period (comparing ECOG 3 to 1: adjusted difference; 7.2 days, (95% CI 4.8 - 9.6), p for overall association <0.001, Table S2 & figure 2) and associated with LOS in the ITU (comparing ECOG 3 to 1, 1.2 days, (95% CI: 0.4 – 2.0, p for overall association <0.001). However, following the initial post-operative admission to one year, no independent association was found between ECOG status and LOS (p for overall association =0.23, Table S3 & figure 2). The impact of ECOG status on any of the LOS metrics did not differ according to HCC status (p for interaction >0.05).

## Post-transplant complications and readmissions

In the descriptive analysis, incremental increases in the incidence of specific post-transplant complications of infections and renal failure and intransplant-related readmissions were observed in recipients with the poorer ECOG scores (Table 2). For example, the proportion of those developing post-transplant infection increased from 31.4% in those with ECOG 1 to 45.0% in those with an ECOG status 3. Increases in the incidence of post-transplant renal failure were also seen, with 10.8% of with an ECOG score of 1 observed to have renal failure compared to 21.3% in those with ECOG 3. The proportion of recipients requiring one or more readmissions also increased from 30.9% in those who were most active at the time of transplantation (ECOG 1) to 38.5% in those most reliant or dependent on care (ECOG 3).

Following risk adjustment, associations remained between ECOG status and renal failure (comparing ECOG 3 with 1; OR 1.5 95% CI 1.1-2.0), p for overall association=0.02, figure 3). For post-transplant infection the largest difference was between ECOG 2 and 1 (OR 1.2, 95%CI: 1.1-1.4, p for overall association =0.004). No association between ECOG status and readmissions were identified (p for overall association =0.13) nor did the effect of ECOG status on post-transplant complications differ according to HCC status (p for interaction >0.05).

**Sensitivity analyses**

In sensitivity analysis that included only those recipients who survived to one-year, no major changes in the association of ECOG status and LOS metrics or post-transplant renal failure, infections or readmissions were observed.

# DISCUSSION

## Summary of results

In multivariable models that included measures of liver disease severity and other donor and recipient characteristics, ECOG scores taken at the time of transplantation were associated with an increased LOS in the initial post-transplant hospital admission. Impaired ECOG status at the time of transplantation was also associated with an increased incidence of specific major post-transplant complications. However, after the initial post-transplant admission, no significant association between impaired pre-transplant ECOG status and LOS was identified.

## Methodological limitations

A first limitation is that the ECOG scores reported by clinicians in the six participating transplant centres are prone to inter-observer error.19-20 In previous analyses, coefficients that have measured the level of agreement between clinicians scoring ECOG score have varied between 0.50 and 0.91.19-20 If we assume in our analysis that a level of disagreement – somewhere between these two coefficients – occurred to the same extent then the true effect of ECOG on LOS may have been larger to that observed in our study.7 Second, clinicians who were recording ECOG scores at the time of transplantation were not blinded to the other known risk factors of prolonged hospital stay and post-transplant complications, including those measures of severe liver dysfunction and other co-morbidity. 7-8 This could have contributed to the observed association between ECOG scores and these risk factors. However, the association between the ECOG scores and post-transplant LOS remained even after extensive adjustment for pre-transplant factors making it unlikely that a lack of blinding fully explains our findings.7 Third, to select a sample of patients that was truly reflective of national practice we included all patients who received a liver transplant during the study period. This meant those who died early after their liver transplantation would shorten the average LOS and reduce the overall rate of complications. However, in a sensitivity analyses that excluded patients who did not survive to 1-year the significance of the association of ECOG and LOS metrics did not change for any metric of LOS or for either of the specific post-transplant complications. It is also important to note that we considered only two specific post-transplant complications. Both impact significantly on patient and graft survival and on post-transplant LOS, but other complications including impaired early graft function or biliary leaks may be also be affected by ECOG status.

Finally, we recognise the importance to understand how the underlying conditions that the determine the pre-operative PS are related to post-transplant infection and renal complications. However, when estimating the impact of pre-operative PS on post-transplant outcomes we did include co-morbidity – as defined by the RCS Charlson score – and the presence of other recipient characteristics including the requirement of pre-operative renal failure.

**Comparison with other studies**

To date the association of ECOG status with LOS and post-transplant complications has not been explored in a national cohort of LT recipients. One study, including 598 patients from a single centre in the United States, used the Karnofsky score2 to group patients into three strata of functional ability and identified impaired PS at the time of transplantation to be associated with a prolonged post-transplant LOS.2 However, the small sample size taken from only one transplant centre, the lack of adjustment for risk factors that have previously been proven to be predictive of prolonged post-transplant LOS, and a focus on LOS only in the immediate post-operative period limit the generalizability of these results.

In the same cohort of liver transplant patients, we have already demonstrated that pre-transplant performance status affects post-transplant mortality and principally within the first 3 months.21 This is in line with findings reported in the current paper that pre-transplant PS is associated with prolonged LOS in the immediate post-transplant period but not with LOS of later admissions. This further confirms that a poor PS at the time of transplantation has a short-term rather than a long-term impact on post-transplant outcomes.

## Explanation of results

The association between pre-transplant functional status and post-operative LOS may arise from a number of contributory factors. ECOG scores are considered a more inclusive assessment of patient health and most probably encompass factors predictive of prolonged LOS that are not captured in the clinical measurements of end-organ function that are adjusted for in this analysis.2,7,21 These factors are likely to range from the more physiological such as measures of sarcopenia – shown in other studies to be independently predictive of post-operative LOS22 -to the more psychosocial including the extent to which functional status scores reflect an assessment of the individual resources and support network a patient has available to be able to cope with undergoing major abdominal surgery.7

It is also possible that assessments of PS also reflect patient behaviors that are known to influence the recovery period following liver transplantation.7-8 Those with poorer PS at the time of transplantation are known to experience prolonged periods of immobilization23 making them more predisposed to a cascade of events after surgery that includes increased susceptibility to complications,22 impaired post-operative recovery,22 extended initial hospital stay,1 and increased risk of readmissions.24-25 In the context of post-transplant complications, the immunoparesis and declining physiological reserve seen in those who are frail will also expose them to an increased risk of post-transplant infection and renal failure – and these complications will also make later readmission more likely.

Beyond the initial post-transplant stay there was no indication that ECOG status had an impact on hospital resource use. In studies that have focused on post-transplant survival there is evidence that PS only affects mortality in the first few months following transplantation.8,21 It is likely that the effect of PS on post-transplant mortality and LOS is influenced by a relatively rapid reversal of the clinical sequelae of severe liver dysfunction that follows restoration of liver function by transplantation. Once this restoration occurs, a reversal in PS8 and its impact of hospital resource use would be expected.

## Clinical implications

Our findings, the first in a complete national cohort of liver transplant recipients, have a number of clinical implications. First, considering the PS of patients prior to transplantation, in addition to other conventional risk factors, can help in the assessment, selection and counselling of patients who are potentially eligible for transplantation.1-2 In particular, the ability to estimate LOS and the risk of key complications can help inform patients and their relatives about what to expect in the initial post-operative period and following discharge from hospital. 1-2 Second, metrics that can be used to identify those at risk of prolonged post-operative stay can also be used to target those on the transplant waitlist who may benefit from intensive pre- or post-operative multidisciplinary led rehabilitation regimes that could serve to decrease post-operative LOS, reduce the incidence of frailty-induced post-transplant complications and potentially improve post-transplant survival. Third, a better understanding of the impact of impaired performance status on LOS and resource use will help to quantify the consequences of proposed selection policies that include offering LT to severely ill cirrhotic patients who are hospitalised - a sub group where mortality outcomes now appear favorable but morbidity is little understood.26-27 The observed association of PS with healthcare utilisation also has implications for other future practices and policies.1-2 For example, the assessment of factors that guide healthcare related expenditure, including LOS, is particularly relevant in an era of constrained resource.2 Economic evaluations that have suggested those with the most severe liver dysfunction and worst PS increase the healthcare expenditure by 40% within the first post-transplant year.2

## Conclusion

Frailty, reflected in impaired performance status is significantly associated with both an increase in LOS in the immediate post-transplant period and in the frequency of major complications following liver transplantation. The use of assessment of pre-operative functional status to predict post-transplant complications and length of stay could be useful to counsel patients prior to surgery and to guide waitlist interventions.

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# TABLES:

## Table 1 Donor and recipient characteristics according to performance status.

|  |  |  |
| --- | --- | --- |
|  | **ECOG Status** |  |
| **Number** | **ECOG 1** | **ECOG 2** | **ECOG 3** | **Missing values** |
| **2 207** | **3 721** | **1 040** |  |
| **DONOR CHARACTERISTICS** |
| Female sex | 46.7% (1 032) | 46.2% (1 718) | 49.1% (511) | 0.1% (1) |
| Donor age | 47.2 (16.1) | 46.0 (15.3) | 46.5 (15.3) | 0.1% (1) |
| BMI in kg/M2 | 26.0 (4.6) | 26.1 (4⋅8) | 26.5 (4.0) | 3.0% (209) |
| Trauma as cause of death | 12.3% (80) | 14⋅2% (90) | 6.0% (5) | 0.0% (0) |
| DCD Donor | 18.9% (418) | 11⋅5% (426) | 8.7% (91) | 0.01% (1) |
| Segmental graft type | 10.0% (220) | 7⋅5% (279) | 6.4% (67) | 0.0% (0) |
| Cold ischaemic time in mins | 548.5 (180.7) | 567.7 (182.6) | 577.2 (180.7) | 5.7% (400) |
| **RECIPIENT CHARACTERISTICS** |
| Female sex | 34.4% (759) | 35.9% (1 337) | 37.4% (389) | 0.0% (0) |
| Age in years | 51.4 (11.6) | 52.3 (10.7) | 50.7 (11.9) | 0.0% (0) |
| HCC indication for transplantation | 29.4% (650) | 17.0% (633) | 8.0% (83) | 0.0% (0) |
| BMI in kg/M2 | 26.5 (4.8) | 26.8 (5.0) | 26.7 (5.3) | 3.3% (228) |
| Liver only transplant | 99.6% (2 177) | 98.0% (3 645) | 97.6% (1 016) | 0.0% (0) |
| Non-white ethnicity | 13.0% (288) | 12.9% (478) | 12.3% (128) | 0.0% (0) |
| Ascites | 37.4% (823) | 55.1% (2 049) | 74.1% (771) | 0.2% (12) |
| Previous variceal bleed | 25.1% (552) | 31.4% (1 161) | 35.8% (369) | 0.5% (38) |
| Previous abdominal surgery | 12.1% (267) | 14.4% (533) | 15.9% (165) | 0.2% (13) |
| Encephalopathy | 17.2% (379) | 22.4% (833) | 52.1% (539) | 0.2% (13) |
| Requiring ventilation | 0.1% (2) | 0.2% (8) | 3.9% (41) | 0.1% (4) |
| Requiring renal support | 3.7% (82) | 4.3% (158) | 13.4% (139) | 0.1% (9) |
| Inpatient prior to transplant | 1.5% (10) | 3.6% (23) | 48.2% (40) | 0.03% (2) |
| UKELD | 53.3 (5.2) | 54.4 (5.2) | 58.8 (6.5) | 2.7% (185) |
| Era of transplant2007-2015 | 66.9% (1 478) | 52.2% (1 904) | 54.5% (567) | 0.0% (0) |

**Table 2: Mean length of hospital stay and incidence of post-operative complications and readmissions stratified by performance status.**

|  |  |
| --- | --- |
| **LENGTH OF STAY** | **ECOG Status** |
| **1998 – 2015** |
| **ECOG 1****n=2 207** | **ECOG 2****n=3 721** | **ECOG 3****N=1 040** |
| INITIAL LOS | 19.8 (21.3) | 22.8 (23.6) | 41.4 (41.9) |
| LOS ON ITU | 3.4 (5.7) | 4.9 (9.8) | 5.9 (10.2) |
| LOS FOLLOWING THE INTIAL POST-OPERATIVE PERIOD AT 1-YEAR | 22.2 (33.0) | 22.7 (33.3) | 28.8 (38.8) |
| **POST-OPERATIVE COMPLICATIONS** |  |  |  |
| INFECTION | 31.4% | 43.3% | 45.0% |
| RENAL FAILURE | 10.8% | 14.5% | 21.3% |
| READMISSIONS | 30.9% | 39.3% | 38.5% |

**FIGURES:**

**Figure 1: Flow chart presenting selection of study population**

**Linked NHSBT-HES dataset**

**N=6 968**

**Hospital Episode Statistics 1997-2016**

**Patient records: N=1 177 044**

**First adult elective orthotopic liver transplants.**

**N=8 003**

**Non-HCC patients**

**N=5 602**

**HCC patients**

**N=1 366**

**Unlinked records**

**N=1 035**

**Missing survival information**

**N=630**

**Non-English patients**

**N=1 011**

**Missing performance status score**

**N=127**

**Limit transplant years from 1997 to 2015**

**N=2 143**

**NHSBT Standard Liver Transplant dataset (1995-2016).**

**First adult elective liver transplants (age ≥ 17)**

**N=11 926**

**Figure 2: Impact of performance status on mean length of hospital stay adjusted for donor and recipient factors.**

 **a. Post-operative LOS b. LOS on Ventilation c. LOS on ITU d. LOS at 1-year\***

*\*Excluding initial post-operative admission.*

*Adjusted for**a)**recipient characteristics: sex, age, ethnicity, socioeconomic status, BMI (Kg/M2), ascites, varices, encephalopathy, cirrhosis, HCV status, UKELD, pre-transplant inpatient status, pre-transplant renal support, pre-transplant ventilatory support, previous abdominal surgery, transplant type (liver only, liver & kidney, liver & other), transplant centre and era of transplantation b) donor characteristics: donor sex, donor age, donor BMI (Kg/m2), cause of death, donor type (donation after cardiac death, donation after brain death), steatosis, capsular damage, organ appearance, graft type, cold ischaemic time, and c) Comorbidity; diabetes, myocardial infarction, peripheral vascular disease, cerebrovascular disease, congestive cardiac failure, chronic pulmonary disease, chronic renal disease, rheumatological disease, dementia, non-hepatic malignancy, hemi and paraplegia and atherosclerosis.*

**Figure 3: Impact of performance status on post-operative complications and readmission adjusted for donor and recipient factors.**

 **a. Infection\* b. Renal failure c. Readmissions**

*\*Includes bacterial and viral infection.*

*Adjusted for**a)**recipient characteristics: sex, age, ethnicity, socioeconomic status, BMI (Kg/M2), ascites, varices, encephalopathy, cirrhosis, HCV status, UKELD, pre-transplant inpatient status, pre-transplant renal support, pre-transplant ventilatory support, previous abdominal surgery, transplant type (liver only, liver & kidney, liver & other), transplant centre and era of transplantation b) donor characteristics: donor sex, donor age, donor BMI (Kg/m2), cause of death, donor type (donation after cardiac death, donation after brain death), steatosis, capsular damage, organ appearance, graft type, cold ischaemic time, and c) Comorbidity; diabetes, myocardial infarction, peripheral vascular disease, cerebrovascular disease, congestive cardiac failure, chronic pulmonary disease, chronic renal disease, rheumatological disease, dementia, non-hepatic malignancy, hemi and paraplegia and atherosclerosis.*

# SUPPLEMENTAL INFORMATION

## Table S1: Comorbidity in HCC (n=1 366) and non-HCC patients (n=5 602) according to performance status.

|  |  |
| --- | --- |
|  | **Performance status** |
| **Number**  |  | **ECOG 1** | **ECOG 2** | **ECOG 3** |
| **HCC recipients** | **650** | **633** | **83** |
|  | **Non-HCC recipients** | **1 557** | **3 088** | **957** |
| Myocardial Infarction | HCC | 0.6% (4) | 0⋅5% (3) | 1.2% (1) |
| Non-HCC | 0.5% (8) | 0⋅7% (21) | 1.2% (11) |
| Peripheral vascular disease | HCC | 1.5% (10) | 1.4% (9) | 2.4% (2) |
| Non-HCC | 1.0% (16) | 1.7% (53) | 1.2% (11) |
| Cerebrovascular disease | HCC | 0.3% (2) | 0.8% (5) | 1.2% (1) |
| Non-HCC | 0.6% (10) | 0.8 (26) | 0.8% (8) |
| Congestive cardiac failure | HCC | 1.1% (7) | 1⋅1% (7) | 2.4% (2) |
| Non-HCC | 1.1% (17) | 1⋅3% (41) | 1.7% (16) |
| Chronic pulmonary disease | HCC | 6.5% (42) | 5.2% (33) | 9.6% (8) |
| Non-HCC | 5.0% (78) | 6.6% (203) | 8.0% (77) |
| Chronic renal disease | HCC | 4.2% (27) | 4.9% (31) | 8.4% (7) |
| Non-HCC | 7.4% (115) | 8.4% (259) | 8.7% (83) |
| Rheumatological disease | HCC | 0.5% (3) | 0⋅8% (5) | 0.0% (0) |
| Non-HCC | 1.8% (28) | 1⋅3% (40) | 1.0% (10) |
| Dementia | HCC | 0.3% (2) | 0⋅6% (4) | 1.2% (1) |
| Non-HCC | 2.2% (34) | 2⋅8% (87) | 2.6% (26) |
| Non-hepatic malignancy | HCC | 4.9% (32) | 3⋅8% (24) | 1.2% (1) |
| Non-HCC | 0.3% (4) | 0⋅3% (9) | 0.8% (6) |
| Hemi and paraplegia | HCC | 0.0% (0) | 0.2% (0) | 0.0% (0) |
| Non-HCC | 0.1% (1) | 0.2% (5) | 0.3% (3) |
| Atherosclerosis | HCC | 2.5% (16) | 2.7% (17) | 4.8% (4) |
| Non-HCC | 2.2% (34) | 3.2% (99) | 3.0% (29) |

## Table S2: Comparison of recipients and donor characteristics in linked and unlinked NHSBT records.

|  |  |  |
| --- | --- | --- |
| **LINKAGE** | **Unlinked (n=1 033)****HCC=193 / Non-HCC=842** | **Linked (n=6 968)****HCC=1 366 / Non-HCC=5 602** |
|  | **Performance status** | **Performance status** |
|  |  | **ECOG 1** | **ECOG 2** | **ECOG 3** | **ECOG 1** | **ECOG 2** | **ECOG 3** |
| **DONOR CHARACTERISTCS** |
| Female Sex | HCC | 42.1% (40) | 36.5% (31) | 66.7% (8) | 42.8% (278) | 41⋅8% (264) | 49.4% (41) |
| Non-HCC | 50.2% (119) | 47.4% (210) | 43.8% (70) | 48.4% (754) | 47⋅1% (1 454) | 49.1% (470) |
| Age (years) | HCC | 48 (15.8) | 48.8 (13.5) | 48.7 (16.3) | 48.2 (16.2) | 46.8 (15⋅6) | 47.4 (17.1) |
| Non-HCC | 46.3 (16.5) | 45.3 (16.0) | 46.1 (16.6) | 46.8 (16.0) | 45.8 (15⋅3) | 46.4 (15.1) |
| BMI (Kg/M2) | HCC | 25.7 (4.5) | 26.4 (4.6) | 24.9 (3.1) | 26.0 (4.6) | 26.1 (4⋅8) | 26.5 (4.0) |
| Non-HCC | 25.4 (5.0) | 25.8 (5.0) | 26.0 (4.7) | 25.6 (4.6) | 25.9 (4⋅9) | 25.6 (4.2) |
| Trauma as cause of death | HCC | 17.9% (17) | 9.4% (8) | 0.0% (0) | 12.3% (80) | 14⋅2% (90) | 6.0% (5) |
| Non-HCC | 11.8% (28) | 14.2% (63) | 14.4% (23) | 11.4% (178) | 13⋅6% (421) | 14.5% (139) |
| DCD donor | HCC | 20.0% (19) | 8.2% (7) | 16.7% (2) | 24.6% (160) | 16⋅6% (105) | 20.5% (17) |
| Non-HCC | 15.2% (36) | 3.4% (15) | 5.6% (9) | 16.6% (258) | 10⋅4% (321) | 7.7% (74) |
| Steatosis | HCC | 56.5% (39) | 52.2% (36) | 62.5% (5) | 45.4% (271) | 43⋅1% (251) | 43.1% (31) |
| Non-HCC | 43.4% (75) | 48.2% (171) | 46.0% (51) | 44.1% (594) | 40⋅4% (1 079) | 43.2% (351) |
| Presence of capsular damage | HCC | 7.3% (5) | 9.0% (6) | 0.0% (0) | 14.0% (83) | 15⋅0% (87) | 15.3% (11) |
| Non-HCC | 9.8% \*17) | 15.8% (55) | 17.1% (19) | 12.8% (171) | 14⋅1% (374) | 11.0% (89) |
| Abnormal organ appearance | HCC | 29.7% (19) | 36.4% (28) | 37.5% (3) | 27.9% (141) | 27⋅5% (161) | 26.0% (19) |
| Non-HCC | 26.5% (41) | 37.9% (152) | 44.1% (56) | 22.4% (282) | 22⋅2% (638) | 21.2% (179) |
| Segmental Graft type | HCC | 8.4% (8) | 7.1% (6) | 0.0% (0) | 7.7% (50) | 6⋅0% (38) | 3.6% (3) |
| Non-HCC | 16.0% (38) | 11.3% (50) | 11.3% (18) | 10.9% (170) | 7⋅8% (241) | 6.7% (64) |
| Cold Ischaemic Time (mins) | HCC | 533.1 (223.5) | 602.0 (176.0) | 640.8 (149.6) | 527.1 (181.4) | 534.1 (174.5) | 569.7 (187.6) |
| Non-HCC | 544.3 (229.3) | 619.6 (208.7) | 606.5 (212.5) | 557.2 (179.7) | 574.6 (183.5) | 577.9 (180.2) |
| **RECIPIENT CHARACTERISTICS** |
| Age (years) | HCC | 57.2 (8.3) | 55.5 (8.1) | 56.0 (9.1) | 56.4 (8.1) | 56.8 (8.2) | 56.0 (9.0) |
| Non-HCC | 47.7 (13.0) | 50.8 (10.4) | 49.7 (11.6) | 49.3 (12.2) | 51.4 (11.0) | 50.2 (12.0) |
| BMI (Kg/M2) | HCC | 27.6 (4.0) | 27.0 (3.9) | 24.3 (3.0) | 27.3 (4.5) | 27.6 (4.6) | 27.1 (5.2) |
| Non-HCC | 26.0 (5.1) | 27.1 (5.2) | 25.5 (4.9) | 26.1 (4.9) | 26.6 (5.1) | 26.7 (5.4) |
| Liver transplant only | HCC | 100% (95) | 100% (85) | 100% (12) | 99.5% (647) | 99.5% (630) | 99.8% (82) |
| Non-HCC | 99.6% (236) | 99.6% (441) | 98.8% (158) | 98.1% (1 530) | 97.6% (3 015) | 97.5% (934) |
| Non-white ethnicity | HCC | 28.4% (27) | 36.9% (31) | 25.0% (3) | 19.7% (128) | 19.4% (123) | 16.9% (14) |
| Non-HCC | 32.6% (77) | 36.8% (163) | 46.3% (74) | 10.3% (160) | 11.5% (355) | 11.9% (114) |
| Ascites | HCC | 25.3% (24) | 45.9% (39) | 83.3% (10) | 20.0% (130) | 35.2% (223) | 71.2% (59) |
| Non-HCC | 43.5% (103) | 67.7% (299) | 88.8% (142) | 44.6% (693) | 59.2% (1 826) | 74.3% (712) |
| Previous variceal bleed | HCC | 83.2% (16) | 20.0% (17) | 25.0% (3) | 13.5% (87) | 21.8% (137) | 36.1% (30) |
| Non-HCC | 23.7% (56) | 29.1% (129) | 40.0% (64) | 30.0% (465) | 33.3% (1 024) | 35.7% (339) |
| Previous abdominal surgery | HCC | 12.8% (12) | 21.2% (18) | 25.0% (3) | 10.3% (67) | 11.9% (75) | 16.9% (14) |
| Non-HCC | 18.2% (43) | 13.0% (57) | 18.8% (30) | 12.9% (200) | 14.9% (458) | 15.8% (151) |
| Encephalopathy | HCC | 12.6% (12) | 7.1% (6) | 33.3% (4) | 7.5% (49) | 11.5% (73) | 47.0% (39) |
| Non-HCC | 18.6% (44) | 23.8% (105) | 53.2% (84) | 21.2% (330) | 24.6% (760) | 52.5% (500) |
| Requiring ventilation | HCC | 0.0% (0) | 0.0% (0) | 8.3% (1) | 0.0% (0) | 0.0% (0) | 2.4% (2) |
| Non-HCC | 0.4% (1) | 0.0% (0) | 8.8% (14) | 0.1% (2) | 0.3% (8) | 4.1% (39) |
| Requiring renal support | HCC | 3.2% (3) | 3.5% (3) | 16.7% (2) | 2.3% (15) | 3.3% (21) | 13.3% (11) |
| Non-HCC | 4.2% (10) | 3.6% (16) | 18.1% (29) | 4.3% (67) | 4.4% (137) | 13.4% (128) |
| Inpatient prior to transplant | HCC | 3.2% (3) | 4.7% (4) | 66.7% (8) | 1.5% (10) | 3.6% (23) | 48.2% (40) |
| Non-HCC | 4.2% (10) | 8.1% (36) | 65.6% (105) | 3.0% (46) | 6.9% (214) | 65.1% (624) |
| HCV antibodies | HCC | 51.1% (45) | 68.4% (54) | 33.3% (4) | 45.5% (274) | 44.2% (266) | 32.9% (25) |
| Non-HCC | 21.9% (47) | 33.0% (133) | 32.2% (48) | 12.2% (169) | 14.9% (436) | 14.5% (126) |
| UKELD | HCC | 51.1 (4.6) | 52.3 (5.2) | 58.6 (9.6) | 50.4 (4.4) | 51.4 (5.1) | 56.1 (6.8) |
| Non-HCC | 54.3 (6.2) | 55.1 (5.1) | 59.4 (6.4) | 54.5 (5.1) | 55.0 (5.0) | 59.0 (6.4) |
| Era of transplant 2007-2015 | HCC | 46.3% (44) | 31.8% (27) | 33.3% (4) | 73.7% (479) | 62.2% (394) | 66.3% (55) |
| Non-HCC | 51.% (121) | 27.8% (123) | 30.6% (49) | 64.1% (999) | 48.9% (1 510) | 53.4% (512) |

## **Table S3: The effect** of performance status on mean length of hospital stay (days) in HCC (n=1 366) and non-HCC recipients (n=5 602) adjusted for recipient and donor characteristics.

|  |  |  |
| --- | --- | --- |
| **HOSPITAL STAY** | **Unadjusted length of stay (mean no of days)** | **Length of stay adjusted for donor and recipient characteristics and comorbidity\*** |
| **HCC** **(mean no of days 95%CI)** | **Non-HCC** **(mean no of days 95%CI)** | **P-value for interaction\*\*** | **HCC** **(mean no of days 95%CI)** | **Non-HCC****(mean no of days 95%CI)** | **P-value for interaction\*\*** |
| **POST-OPERATIVE LOS** |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | 3.0 (0.9 – 5.2) | 2.4 (0.7 – 4.1) |  | 1.3 (-0.8 – 3.5) | 0.6 (-1.1 – 2.3) |  |
| ECOG 3 | 21.2 (16.8 – 25.7) | 20.8 (18.5 – 23.0) | 0.93 | 10.5 (5.2 – 15.7) | 6.6 (3.9 – 9.3) | 0.63 |
|  |  |  |  |  |  |  |
| **LOS ON VENTILATION** |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | 1.2 (0.5 – 1.9) | 1.0 (0.6 – 1.4) |  | 0.9 (0.2 – 1.6) | 0.8 (0.4 - 1.3) |  |
| ECOG 3 | 0.9 (-0.5 – 2.4) | 1.5 (0.9 – 2.1) | 0.67 | 0.5 (-1.3 – 2.2) | 0.7 (0.02 - 1.4) | 0.53 |
| **LOS ON ITU**  |  |  |  |  |  |  |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | 1.2 (0.4 – 1.9) | 1.5 (1.0 – 2.1) |  | 0.9 (0.1 – 1.7) | 1.3 (0.7 – 1.9) |  |
| ECOG 3 | 0.7 (-0.8 – 2.3) | 2.5 (1.8 – 3.3) | 0.26 | -0.2 (-2.1 – 1.7) | 1.3 (0.4 – 2.2) | 0.20 |
| **LOS AT 1-YEAR** |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | -0.3 (-4.6 – 4.1) | 0.9 (-0.9 – 2.8) |  | -1.0 (-5.5 – 3.5) | 0.5 (-1.3 – 2.4) |  |
| ECOG 3 | 3.4 (-5.7 – 12.5) | 5.4 (2.9 – 7.8) | 0.80 | 2.1 (-8.8 – 13.3) | 2.4 (-0.6 – 5.4) | 0.90 |

\**Adjusted for**a)**recipient characteristics: sex, age, ethnicity, socioeconomic status, BMI (Kg/M2), ascites, varices, encephalopathy, cirrhosis, HCV status, UKELD, pre-transplant inpatient status, pre-transplant renal support, pre-transplant ventilatory support, previous abdominal surgery, transplant type (liver only, liver & kidney, liver & other), transplant centre and era of transplantation b) donor characteristics: donor sex, donor age, donor BMI (Kg/m2), cause of death, donor type (donation after cardiac death, donation after brain death), steatosis, capsular damage, organ appearance, graft type, cold ischaemic time, and c) Comorbidity; diabetes, myocardial infarction, peripheral vascular disease, cerebrovascular disease, congestive cardiac failure, chronic pulmonary disease, chronic renal disease, rheumatological disease, dementia, non-hepatic malignancy, hemi and paraplegia and atherosclerosis.*

*\*\*P-value for interaction between LOS and HCC status (HCC vs non-HCC).*

## **Table S4: The effect** of performance status on post-operative complications and readmissions in HCC (n=1 366) and non-HCC recipients (n=5 602), adjusted for recipient and donor characteristics.

|  |  |  |
| --- | --- | --- |
| **COMPLICATIONS / READMISSION** | **Unadjusted** | **Adjusted for donor and recipient characteristics and comorbidity\*** |
| **HCC** **(OR 95%CI)** | **Non-HCC** **(OR 95% CI)** | **P-value for interaction\*\*** | **HCC** **(OR 95%CI)** | **Non-HCC****(OR 95%CI)** | **P-value for interaction\*\*** |
| **INFECTION** |
| ECOG 1 |  **1** |  **1** | 0.30 |  **1** |  **1** | 0.38 |
| ECOG 2 | 1.5 (1.2 – 1.8) | 1.7 (1.5 – 1.9) | 1.1 (0.8-1.4) | 1.3 (1.1-1.5) |
| ECOG 3 | 2.0 (1.3 – 3.2) | 1.7 (1.5 – 2.1) | 1.5 (0.8-2.9) | 1.1 (0.9-1.4) |
|  |  |  |  |  |  |  |
| **RENAL FAILURE** |  |  | 0.56 |  |  | 0.56 |
| ECOG 1 |  **1** |  **1** |  **1** |  **1** |
| ECOG 2 | 1.3 (0.9 – 1.8) | 1.4 (1.2 – 1.7) | 1.2 (0.8 – 1.7) | 1.2 (0.9 – 1.5) |
| ECOG 3 | 1.6 (0.8 – 3.0) | 2.3 (1.8 – 2.8) | 1.2 (0.5 – 2.8) | 1.5 (1.1 – 2.0) |
|  |  |  |  |  |  |  |
| **READMISSIONS** |  |  |  |  |  | 0.22 |
| ECOG 1 |  **1** |  **1** | 0.08 |  **1** |  **1** |
| ECOG 2 | 1.2 (0.9 – 1.5) | 1.5 (1.4 – 1.8) | 1.0 (0.7 – 1.3) | 1.2 (1.0 – 1.4) |
| ECOG 3 | 1.5 (0.9 – 2.4) | 1.4 (1.2 – 1.7) | 1.5 (0.8 – 2.8) | 1.2 (0.9 – 1.5) |

\**Adjusted for**a)**recipient characteristics: sex, age, ethnicity, socioeconomic status, BMI (Kg/M2), ascites, varices, encephalopathy, cirrhosis, HCV status, UKELD, pre-transplant inpatient status, pre-transplant renal support, pre-transplant ventilatory support, previous abdominal surgery, transplant type (liver only, liver & kidney, liver & other), transplant centre and era of transplantation b) donor characteristics: donor sex, donor age, donor BMI (Kg/m2), cause of death, donor type (donation after cardiac death, donation after brain death), steatosis, capsular damage, organ appearance, graft type, cold ischaemic time, and c) Comorbidity; diabetes, myocardial infarction, peripheral vascular disease, cerebrovascular disease, congestive cardiac failure, chronic pulmonary disease, chronic renal disease, rheumatological disease, dementia, non-hepatic malignancy, hemi and paraplegia and atherosclerosis.*

*\*\*P-value for interaction between LOS and HCC status (HCC vs non-HCC).*

## **Table S5: Sensitivity analysis comparing the effect** of performance status on mean length of hospital stay (days) in HCC (n=1 366) and non-HCC recipients (n=5 602) who did or did not survive to 1-year following transplantation.

|  |  |  |
| --- | --- | --- |
| **HOSPITAL STAY** | **Length of stay in all patients** | **Length of stay in only patients who survived to 1-year.**  |
| **HCC****(mean no of days +/- SD)** | **Non-HCC****(mean no of days +/- SD)** | **P-value for interaction\*\*** | **HCC** **(mean no of days 95%CI)** | **Non-HCC****(mean no of days 95%CI)** | **P-value for interaction\*\*** |
| **POST-OPERATIVE LOS** |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | 1.3 (-0.8 – 3.5) | 0.6 (-1.1 – 2.3) |  | 0.6 (-1.5 – 2.7) | 0.6 (-0.9 – 2.3) |  |
| ECOG 3 | 10.5 (5.2 – 15.7) | 6.6 (3.9 – 9.3) | 0.63 | 7.7 (2.6 – 12.7) | 6.7 (4.0 – 9.4) | 0.82 |
| **LOS ON VENTILATION** |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | 0.9 (0.2 – 1.6) | 0.8 (0.4 - 1.3) |  | 0.3 (-0.1 – 0.8) | 0.5 (0.2 - 0.8) |  |
| ECOG 3 | 0.5 (-1.3 – 2.2) | 0.7 (0.02 - 1.4) | 0.53 | 0.6 (-0.4 – 1.7) | 0.8 (0.3 - 1.3) | 0.88 |
| **LOS ON ITU** |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | 0.9 (0.1 – 1.7) | 1.3 (0.7 – 1.9) |  | 0.5 (-0.1 – 1.2) | 0.7 (0.3 – 1.2) |  |
| ECOG 3 | -0.2 (-2.1 – 1.7) | 1.3 (0.4 – 2.2) | 0.20 | -0.3 (-1.8 – 1.2) | 1.1 (0.3 – 1.8) | 0.18 |
| **LOS AT 1-YEAR** |
| ECOG 1 | **Reference** | **Reference** |  | **Reference** | **Reference** |  |
| ECOG 2 | -1.0 (-5.5 – 3.5) | 0.5 (-1.3 – 2.4) |  | -0.6 (-5.5 – 4.3) | 1.0 (-0.8 – 2.9) |  |
| ECOG 3 | 2.1 (-8.8 – 13.3) | 2.4 (-0.6 – 5.4) | 0.90 | 0.2 (-11.7 – 12.1) | 3.1 (0.1 – 6.2) | 0.65 |

\**Adjusted for**a)**recipient characteristics: sex, age, ethnicity, socioeconomic status, BMI (Kg/M2), ascites, varices, encephalopathy, cirrhosis, HCV status, UKELD, pre-transplant inpatient status, pre-transplant renal support, pre-transplant ventilatory support, previous abdominal surgery, transplant type (liver only, liver & kidney, liver & other), transplant centre and era of transplantation b) donor characteristics: donor sex, donor age, donor BMI (Kg/m2), cause of death, donor type (donation after cardiac death, donation after brain death), steatosis, capsular damage, organ appearance, graft type, cold ischaemic time, and c) Comorbidity; diabetes, myocardial infarction, peripheral vascular disease, cerebrovascular disease, congestive cardiac failure, chronic pulmonary disease, chronic renal disease, rheumatological disease, dementia, non-hepatic malignancy, hemi and paraplegia and atherosclerosis.*

*\*\*P-value for interaction between LOS and HCC status (HCC vs non-HCC).*

## **Table S6: Sensitivity analysis comparing the effect** of performance status on post-operative complications and readmissions in HCC (n=1 366) and non-HCC recipients (n=5 602) who did or did not survive to 1-year following transplantation.

|  |  |  |
| --- | --- | --- |
| **COMPLICATIONS / READMISSIONS** | **Post-operative complications and readmission in all patients** | **Post-operative complications and readmission in only patients who survived to 1-year.**  |
|  **HCC** **(OR 95%CI)** |  **Non-HCC** **(OR 95%CI)** | **P-value for interaction\*\*** |  **HCC**  **(OR 95%CI)** |  **Non-HCC****(OR 95%CI)** | **P-value for interaction\*\*** |
| **INFECTION** |
| ECOG 1 |  **1** |  **1** |  |  **1** |  **1** |  |
| ECOG 2 | 1.1 (0.8-1.4) | 1.3 (1.1-1.5) |  | 1.0 (0.8 – 1.4) | 1.3 (1.1 – 1.5) |  |
| ECOG 3 | 1.5 (0.8-2.9) | 1.1 (0.9-1.4) | 0.38 | 1.1 (0.6 – 2.2) | 1.2 (0.9 – 1.5) | 0.27 |
|  |  |  |  |  |  |  |
| **RENAL FAILURE** |
| ECOG 1 |  **1** |  **1** |  |  **1** |  **1** |  |
| ECOG 2 | 1.2 (0.8 – 1.7) | 1.2 (0.9 – 1.5) |  | 1.1 (0.7 – 1.7) | 1.3 (1.0 - 1.6) |  |
| ECOG 3 | 1.2 (0.5 – 2.8) | 1.5 (1.1 – 2.0) | 0.56 | 0.9 (0.3 – 2.5) | 1.5 (1.1 - 2.2) | 0.30 |
|  |  |  |  |  |  |  |
| **READMISSIONS** |
| ECOG 1 |  **1** |  **1** |  |  **1** |  **1** |  |
| ECOG 2 | 1.0 (0.7 – 1.3) | 1.2 (1.0 – 1.4) |  | 1.0 (0.7 – 1.3) | 1.2 (1.1 – 1.4) |  |
| ECOG 3 | 1.5 (0.8 – 2.8) | 1.2 (0.9 – 1.5) | 0.22 | 1.5 (0.8 – 3.1) | 1.2 (0.9 – 1.6) | 0.10 |

\**Adjusted for**a)**recipient characteristics: sex, age, ethnicity, socioeconomic status, BMI (Kg/M2), ascites, varices, encephalopathy, cirrhosis, HCV status, UKELD, pre-transplant inpatient status, pre-transplant renal support, pre-transplant ventilatory support, previous abdominal surgery, transplant type (liver only, liver & kidney, liver & other), transplant centre and era of transplantation b) donor characteristics: donor sex, donor age, donor BMI (Kg/m2), cause of death, donor type (donation after cardiac death, donation after brain death), steatosis, capsular damage, organ appearance, graft type, cold ischaemic time, and c) Comorbidity; diabetes, myocardial infarction, peripheral vascular disease, cerebrovascular disease, congestive cardiac failure, chronic pulmonary disease, chronic renal disease, rheumatological disease, dementia, non-hepatic malignancy, hemi and paraplegia and atherosclerosis.*

*\*\*P-value for interaction between LOS and HCC status (HCC vs non-HCC).*