TITLE: Electronic outpatient referral system for liver transplant improves appropriateness and allows first visit triage

SHORT TITLE: electronic referral for liver transplantation

Flaminia Ferri¹, Martina Milana², Aurelio Abbatecola¹, Alessandro Pintore¹, Ilaria Lenci², Simona Parisse¹, Alessandro Vitale³, Gianluca Di Croce³, Gianluca Mennini⁴, Quirino Lai⁴, Massimo Rossi⁴, Roberta Angelico², Giuseppe Tisone², Alessandro Anselmo³, Mario Angelico², Stefano Ginanni Corradini¹

1. Department of Translational and Precision Medicine, Sapienza University of Rome, Italy
2. Hepatology and LT Unit, University of Tor Vergata, Rome, Italy
3. Consorzio Innovo, Rome, Italy
4. Hepato-bilio-pancreatic and LT Unit, Department of Surgery, Sapienza University of Rome, Italy

Funding Information: This work was funded with unrestricted grant “Digital Health Program” from Gilead Sciences Inc.

COI: The authors disclose no conflicts.

Abbreviations:
  eReferral: electronic referral
eRW-LT: website for electronic referral for LT
HCC: hepatocellular carcinoma
LT: LT
LTC: LT center
MELD: model for end-stage liver disease
Rs: traditional methods of referral

Word count: 4000

Correspondence:
Flaminia Ferri, MD PhD
University Sapienza of Rome, Italy
Abstract

Background & Aims: Missed or inappropriate referrals of potential candidates for liver transplantation (LT) are common and traditional referral methods (tRs) do not allow for efficient triage. We investigated the effects on these issues of a website developed for electronic outpatient referral to LT (eRW-LT).

Methods: We prospectively collected data on all consecutive outpatient referrals to two Italian LT centers from January 2015 to December 2019. In the second half of the study, starting from July 2017, referring physicians had the option of using eRW-LT, quickly obtaining the judgment on the appropriateness and urgency of the visit from a transplant hepatologist.

Results: In the second half of the study there were 99 eRW-LTs and 96 traditional referrals (new tRs), representing a 17.4% increase over the 161 traditional referrals (old tRs) of the first half. With eRW-LT, 11.1% of referrals were judged inappropriate online without booking a visit. Appropriateness, judged at the time of the first visit, was 59.6%, 56.2% and 94.3% with old tRs, new tRs and eRW-LT, respectively. Considering the appropriate visits, median waiting time in days between referral date and first visit appointment was significantly shorter for urgent visits referred with eRW-LT (5.0 [95% CI 4.8-9.3]) compared to non-urgent visits sent with the same system (17.0 [95% CI 11.5-25.0]; P<0.0001), those referred with old tRs (14.0 [95% CI 8.0-23.0]; P<0.001) and with new tRs (16.0 [95% CI 10.0-23.0]; P<0.001).

Conclusions: eRW-LT allows to increase the number of referrals for LT, ensuring effective triage and better appropriateness of visits.

Keywords: Liver transplant; Telehealth; Transplant referral; Visit triage.
Introduction

Rates of referral to liver transplant centers (LTCs) and accessibility to liver transplantation (LT) waiting lists are low, with reported data in the literature of 5-21% and 4-40%, respectively. The reasons for the suboptimal referral rates to LTCs, which are the main cause of reduced access to waiting lists, are many. The reasons for missed referrals differ by country, but distrust of transplant results, even in patients with hepatocellular carcinoma (HCC) who can be successfully transplanted after effective downstaging, is quite common. Also late referrals are frequent, even if it is currently recommended that the optimal timing for initial referral to a LTC of patients with end stage liver disease should be before their disease reaches the stage when their listing is actually indicated. This is because it takes time to assess eligibility before a patient can be listed and some patients risk to deteriorate rapidly to a point where they dropout from the waiting list or die before getting a transplant. Suboptimal referrals to LTCs can also consist of referrals that are too early or completely inappropriate, which occupy slots for first visits causing flooding of appointment schedules and delays to carry out urgent visits. We felt that the suboptimal referral for LT was due, at least in part, to inefficiency and difficulty in getting appointments for the first outpatient visit using traditional referral methods (e.g. phone call, fax or email).

We have therefore developed and advertised a telemedicine tool, the eReferral website for referral of candidates for LT (eRW-LT). The eRW-LT uses the same principle of the existing electronic referral systems that had been developed in order to reduce waiting times to obtain other first specialist visit. The eRW-LT can be used by all general practitioners or specialists who intend to refer LT candidates who need a first outpatient visit, but not in cases where a rapid evaluation through hospitalization is required. A dedicated transplant hepatologist reviewer of the LTC rapidly judges online the need and timing of the first transplant visit. The purpose of this study is to evaluate the effect of using eRW-LT on the number of patients referred, on the appropriateness of the referral and on the triage and waiting times for the execution of the visit.

Patients and Methods

This study was approved by the local ethics committee of the coordinating LTC Sapienza and was performed in accordance with the ethical standards of the Declaration of Helsinki.
In June 2017 at the "Sapienza" University LTC, in collaboration with “Consorzio Innovo” and with the “Tor Vergata” University LTC, we completed the development of the eRW-LT website (URL: www.eReferral.it) for the first referral visit of candidates to the two above mentioned LTCs of Rome, Lazio region, Italy. Starting from December 2016 until November 2017, eRW-LT was promoted and advertised through various events and communication channels (Supplementary Methods).

We prospectively collected data on all referrals received for outpatient LT visits received from January 1, 2015 until December 31, 2019. During the entire study period we received referrals with tRs that were not standardized and involved multiple steps mainly by telephone and by email and fax. In the second half of the study, from 1 July 2017 to 31 December 2019, as an alternative to the tRs, it was possible for the referring doctors to refer patients using eRW-LT. We divided the patients into three groups according to the method and time of referrals: a) those referred with tRs before the introduction of eRW-LT from 1 January 2015 to 30 June 2017 (old tRs); b) those referred with tRs in the same time frame in which the eRW-LT was used from 1 July 2017 to 31 December 2019 (new tRs) and c) those referred with eRW-LT from 1 July 2017 to 31 December 2019.

The referral appropriateness was assessed prospectively by a transplant hepatologist (GCS, AM, FF, MM, IL) appointed by the certification of the Italian Association for the Study of the Liver (AISF). In the case of eRW-LT, the appropriateness was judged both at the time of online referral, sometimes, if necessary, after exchange of information with the referring physician, and at the time of the first face-to-face visit, when this was carried out. In the case of tRs the appropriateness was judged only at the time of the first visit. Appropriateness was judged on the basis of the simultaneous presence of all the following criteria: 1) availability of sufficient clinical documentation; 2) presence of an accepted indication to referral for the first transplant visit; 3) absence of known absolute contraindications to listing.

eReferral website for liver transplantation

The operation and technical characteristics, including the database structure, are described in Figure 1, Supplementary Methods, Supplementary Figures 1, 2 and 3. Briefly, the primary care practitioner or another specialist, after obtaining the patient's consent, logs in the website www.eReferral.it, is informed that the use of the website is not intended for patients with a need for hospitalization and submits a referral request. This includes the patient's personal and clinical data and blood tests for calculating the MELD and MELDNa score, which are automatically calculated by the system, with the date of the relative blood sampling. An automated email immediately notifies a designated hepatologist transplant reviewer that a new referral has arrived and the latter responds within 24 hours. The specialist reviewer can book the first visit with the right triage, or ask for further data or, in cases
where the visit is deemed inappropriate, redirect the patient to other specialists. To judge whether the patients referred with eRW-LT were entitled to an urgent visit appointment, we used at least one of the following criteria: 1) HCC with an up-to-seven score ≥5; 2) HCC already downstaged or to be downstaged; 3) a Lazio Region MELD score (MELD-R) >22 (Figure 1). The MELD-R score is used to prioritize patients who eventually enter the regional waiting list, also considering any additional points for MELD exceptions (Supplementary methods). Triage was not an option for visits of patients referred with tRs. The site also provides links to the most up-to-date literature on LTs and the correct timing for referrals.

146

147 Statistical analysis

148 The normality of the data distribution was investigated by the Kolmogorov-Smirnov test. Continuous variables are shown as medians (25th-75th percentile). Categorical variables are expressed as counts and percentages. The Modified Charlson comorbidity index was calculated according to Volk et al. The change in the referral rate due to the introduction of eRW-LT was evaluated by comparing the number of referrals with old tRs with the sum of those with new tRs and eRW-LT. We compared the study groups in terms of percentage and reason for inappropriateness and waiting time from the time of the referral to that of the appointment given for the first visit. The comparison between old tRs and new tRs was made to investigate changes related to the era, while the comparison between new tRs and eRW-LT served to verify the effect of the electronic method. Continuous variables were analyzed with the Mann-Whitney U test or the Student T test, as appropriate. For categorical variables, intergroup differences were analyzed using the χ2 or Fisher’s exact test, as appropriate. The relationship between the waiting time for the first visit and the MELD-R was evaluated with the Pearson correlation coefficient. Statistical data analysis was performed using the “Statistical Social Science Package (SPSS) for Windows (SPSS version 25.0, Chicago, IL, USA). Values of P <0.05 were considered significant.

163

164 RESULTS

165

166 Effect of the introduction of the electronic referral website on referral rates and the appropriateness of the first visit

167 Since the introduction of the eRW-LT, the total number of referrals, the sum of those with eRW-LT (n=99) and new tRs (n=96), was 195, corresponding to an increase of 17.4% compared to the last 171 candidates referred with old tRs throughout the first era of the study. Furthermore, compared to the last
12 months before the introduction of eRW-LT, the average increase in subsequent semesters up to the end of the study was 34.5% (Figure 2). Table 1 shows patient demographic and clinical variables.

Patients referred with old tRs, compared to those referred more recently with new tRs, had fewer comorbidities. Patients referred with eRW-LT had higher comorbidities, MELD, MELDNa and MELD-R scores and were referred more frequently by gastroenterologists/hepatologists than patients referred with old tRs. No difference was present between patients referred with eRW-LT and new tRs. Among patients ≥65 years of age, those referred with eRW-LT had at least five co-morbidities in 5 cases, while none had such a high number in the new tRs group.

Considering patients referred by eRW-LT, 11 out of 99 (11.1%) were found to be inappropriate, judged online by the designated LTC specialist and the appointment for the visit was not scheduled, rapidly redirecting patients to other therapies (Supplementary table 1). Among the 88 remaining patients referred with eRW-LT, at the time of the first visit the latter was judged inappropriate by the transplant hepatologist in 5 cases (5.1% of the total referred with eRW-LT) (Supplementary Table 2).

Regarding patients referred using tRs, all visits were scheduled and judged inappropriate at the time of the first visit in 65/161 (40.4%) and 42/96 (43.8%) cases with old tRs and with new tRs, respectively.

As shown in Figure 3, the difference in the distribution of appropriateness using eRW-LT versus tRs from both periods was highly significant (P <0.0001). As regards the frequency of causes of inappropriateness (Supplementary table 3): a) in those referred with the new tRs, compared to those referred with the old tRs, the contraindications were higher and the incomplete clinical documentation was lower; b) in those referred with eRW-LT, compared to those of the same period referred with new tRs, the contraindications were lower and the lack of an accepted indication for referral was higher. With eRW-LT the incompleteness of clinical documentation was absent.

Effect of the introduction of the electronic referral website on waiting times and triage for the first visit

All visits related to referrals obtained with old tRs and with new tRs were booked for the first available appointment without following any triage criteria. Among the 83 patients referred with eRW-LT who obtained the appointment for the first visit and this was judged appropriate by the transplant specialist, the latter defined 18 (21.7%) as urgent and planned to be overbooked. The remaining 65 (78.3%) visits were scheduled as first available. As shown in Figure 4, median waiting time in days between referral date and first appropriate visit appointment was significantly shorter for urgent visits referred with eRW-LT (5.0 [95% CI 4.8-9.3]) compared to non-urgent visits sent with the same system (17.0 [95% CI 11.5-25.0]; P <0.0001), those referred with old tRs (14.0 [95% CI 8.0-23.0]; P<0.001) and with new tRs (16.0 [95% CI 10.0-23.0]; P<0.001).
Finally, we found a negative correlation between MELD-R, the score used to prioritize patients they eventually enter the waiting list, and the time frame between the referral date and the first visit appointment, only for patients referred using eRW-LT ($r = -0.412, P < 0.0001$), but not for patients referred with tRs (Supplementary Figure 3). Although the introduction of eRW-LT increased the percentage of referred patients who were then evaluated for transplantation, it had no impact on listing and transplant rates (Supplementary table 4).

DISCUSSION

We have developed an electronic referral website for LT, the eRW-LT, which can be easily used by all physicians, using any device connected to the Internet, to refer potential LT candidates and obtain the appointment for the first outpatient visit. Regarding the 99 patients initially referred, the use of eRW-LT led to two favorable consequences: the increase in the number of referrals and not having booked some first outpatient visits as they were deemed inappropriate. The increase in referrals of potential transplant candidates is desirable from the point of view of justice and equity of access to treatment, given published evidence of low referral rates.\(^1\)\(^-\)\(^5\) The use of eRW-LT allowed to define as inappropriate online 11 (11%) referrals without booking the visit while, with the tRs, they would have been booked anyway. The reason for the inappropriate referrals was mostly the absence of severe enough liver disease, probably because the doctor or patient wanted to contact the LTC even if too early. Referrals judged inappropriate online with eRW-LT have not been scheduled and therefore have the favorable effect of freeing up slots for other visits, saving resources and costs, quickly redirecting the patient to other therapies and, in times of pandemics such as COVID-19, reducing the risk of contagion.

As for the 88 patients referred with eRW-LT for whom the first outpatient visit was booked and carried out, we had two further favorable effects of our system: a percentage of inappropriateness judged at the time of the first visit much lower than that of tRs and the reduction of the waiting time for the first visit in urgent cases. In fact, the transplant hepatologist judged inappropriate only 5 (5.7%) first visits booked with eRW-LT, but as many as 40.4% and 43.8% of those booked with tRs, during the first and the second period of the study, respectively. Again, the reason for the few inappropriate visits with eRW-LT was mostly compensated liver disease, which rapidly had improved after the referral. Contraindications as a cause of inappropriateness were reduced, thanks to the educational links on eRW-LT and the online interaction with the transplant hepatologist, despite the patients in the second period of the study having more comorbidities.
With eRW-LT, out of 83 appropriately referred patients, 18 (21.7%) were judged urgent and obtained an appointment for the first overbooked visit. In this way, their waiting time for the first visit was significantly shorter than in patients referred with tRs, for which it was not possible to do a triage because the clinical data available were insufficient or even absent. Conversely, eRW-LT requires the referring physician to enter the minimum clinical documentation necessary to judge the urgency of the referral. With eRW-LT, but not with tRs, we found an inverse correlation between the waiting time from the referral date to the appointment date for the first visit and the MELD-R score which is used to prioritize patients in the waiting list. This is desirable since, even among patients who start transplant evaluation as outpatient, some have such advanced disease that they are at risk of not reaching the transplant due to complications. These patients represent a fair number considering that the patients who had started the evaluation of the transplant during a hospitalization during the study period, and who were not included in the study, were only 35% of the total patients considered for transplantation. Other studies have described the use of telemedicine in the field of evaluation before LT. Two studies from the Richmond VA LTC, as part of the Specialty Care Access Network - Extension of Community Healthcare Outcomes (SCAN-ECHO), reported that all 91 patients referred with an electronic system were admitted to the first face-to-face visit at the transplant center and that electronically completing the entire pre-LT assessment led to a substantial reduction in time from referral to initial evaluation by a hepatologist and placement on the LT waitlist. SCAN-ECHO physicians are part of a specific educational program within the VA system, are liver disease experts and can either complete a full workup and submit a referral or request an initial triage through electronic consult. This type of electronic referral counseling from gastroenterologists / hepatologists was also adopted in another study by the Houston / El Paso group. In contrast, in our present study only 39% of patients were referred by gastroenterologists / hepatologists and this may explain the difference in our results compared to those obtained with the SCAN-ECHO system in terms of appropriateness and effect on listing. Even though our study was done before the COVID-19 pandemic, the use of our eRW-LT system, like other telemedicine technologies that reduce the risk of viral transmission, has the advantages of applicability, convenience, cost effectiveness and is even more advisable and useful during the COVID-19 pandemic and for the future. However, we believe that when the referring physicians are also non-gastroenterologists / hepatologists and the distance between the LTC and the patients' place of residence is not too great, as in our study, patients should undergo their first and subsequent visits in face-to-face mode and complete the pre-listing assessment at the LTC.

The novelty of our study is therefore that eRW-LT can be used quickly and easily even by referring physicians who are not experts in liver disease, who are asked for the essential information to judge
the appropriateness and triage of the first visit. Furthermore, the system has an educational value for the links present on the site and for the interactions with transplanted hepatologists.

The study has some limitations: it is an observational study, patients were not randomized to either method of referral and the study was conducted in only two LTCs. Furthermore, since there are no data on referrals to other Italian LTCs, we cannot say with certainty whether the increase in referrals in our study was a true increase driven by convenience of using eRW-LT or a reflection of increased referrals nationwide. However, the introduction of eRW-LT seems to have contributed significantly as, at national level, new registrations on the waiting list had increased in 2017 but then in 2018 had dropped to slightly lower values than in 2016. In our study, on the other hand, we had the peak of referrals starting from the second half of 2017 until the end of 2018. The increase in referrals therefore, at least in part, was due to the training events we implemented, to the educational links on the site and the characteristics of eRW-LT such as the ease of obtaining an appointment quickly, the possibility of co-management of the patient by the referring physician together with the transplant hepatologist and the fact that all contacts between the two doctors are tracked for legal purposes. Finally, the introduction of eRW-LT did not lead to an increase in listings and transplants performed. The latter is expected due to the limited number of donors. The failure to increase the patients listed could be explained by the fact that the patients referred in the second part of the study, and in particular the older ones referred with eRW-LT, had more comorbidities, leading to an increase in excluded patients.

In summary, our results show the usefulness of an electronic referral system to obtain the first LT evaluation outpatient visit for candidates with end stage liver disease. The introduction of our telemedicine tool was associated with an increase in the number of referrals, a reduction in inappropriate visits and waiting times to obtain the first visit, as well as a triage of the latter according to the severity of the patients. Further studies are needed to confirm our data in other countries and in the field of other organ transplants such as kidney transplants where the problem of suboptimal referral exists.

REFERENCES:


Table 1. Patient demographic and clinical variables and specialty of the referring physician according to the referral system and study era

<table>
<thead>
<tr>
<th>Patient Variable</th>
<th>old tR n=161</th>
<th>new tR n=96</th>
<th>eRW-LT n=99</th>
<th>P value old tR vs eRW-LT</th>
<th>P value new tR vs eRW-LT</th>
<th>P value old tR vs new tR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>56 (51-61)</td>
<td>55 (48-61)</td>
<td>56 (49-63)</td>
<td>0.698</td>
<td>0.450</td>
<td>0.580</td>
</tr>
<tr>
<td>Sex male, n (%)</td>
<td>129 (80.1)</td>
<td>69 (71.9)</td>
<td>77 (77.8)</td>
<td>0.651</td>
<td>0.342</td>
<td>0.128</td>
</tr>
<tr>
<td>Etiology, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td>47 (29.2)</td>
<td>33 (34.4)</td>
<td>38 (38.4)</td>
<td>0.095</td>
<td>0.437</td>
<td>0.453</td>
</tr>
<tr>
<td>Virus</td>
<td>51 (31.7)</td>
<td>22 (22.9)</td>
<td>17 (17.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol+Virus</td>
<td>22 (13.7)</td>
<td>14 (14.6)</td>
<td>19 (19.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NASH</td>
<td>24 (14.9)</td>
<td>12 (12.5)</td>
<td>16 (16.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>17 (10.6)</td>
<td>15 (15.6)</td>
<td>9 (9.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MELD score</td>
<td>12 (9-16)</td>
<td>13 (10-18)</td>
<td>13 (11-17)</td>
<td>0.044</td>
<td>0.748</td>
<td>0.117</td>
</tr>
<tr>
<td>MELDNa score</td>
<td>13 (10-18)</td>
<td>15 (11-19)</td>
<td>16 (12-20)</td>
<td>0.001</td>
<td>0.264</td>
<td>0.065</td>
</tr>
<tr>
<td>MELD-R score</td>
<td>18 (12-18)</td>
<td>17 (12-19)</td>
<td>18 (15-20)</td>
<td>0.017</td>
<td>0.089</td>
<td>0.602</td>
</tr>
<tr>
<td>HCC, yes, n (%)</td>
<td>47 (29.2)</td>
<td>27 (28.1)</td>
<td>25 (25.3)</td>
<td>0.491</td>
<td>0.650</td>
<td>0.855</td>
</tr>
<tr>
<td>Previous drug abuse, yes, n (%)</td>
<td>12 (7.5)</td>
<td>17 (17.7)</td>
<td>15 (15.2)</td>
<td>0.052</td>
<td>0.630</td>
<td>0.013</td>
</tr>
<tr>
<td>Modified Charlson Comorbidity Index, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>112 (69.6)</td>
<td>45 (46.9)</td>
<td>47 (47.5)</td>
<td>&lt;0.001</td>
<td>0.806</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1</td>
<td>35 (21.7)</td>
<td>13 (13.5)</td>
<td>13 (13.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10 (6.2)</td>
<td>22 (22.9)</td>
<td>19 (19.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2 (1.2)</td>
<td>7 (7.3)</td>
<td>6 (6.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0 (0.0)</td>
<td>4 (4.2)</td>
<td>7 (7.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 (0.6)</td>
<td>3 (3.1)</td>
<td>1 (1.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1 (0.6)</td>
<td>2 (2.1)</td>
<td>3 (3.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>1 (1.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>1 (1.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data are expressed as median and interquartile range or as proportions.

<table>
<thead>
<tr>
<th>Referring physician</th>
<th>Specialty gastroenterology/hepatology, n (%)</th>
<th>0 (0.0)</th>
<th>0 (0.0)</th>
<th>1 (1.0)</th>
<th>0.201</th>
<th>0.283</th>
<th>0.921</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long distance from home to the LTC (outside the Lazio Region), n (%)</td>
<td>31 (19.3)</td>
<td>18 (18.8)</td>
<td>13 (13.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure legends**

**Figure 1.** Schematic diagram of the interaction on the eRW-LT website between the referring physician and the transplant hepatologist reviewer of the LTC

**Figure 2.** Number of referrals received via online interaction using the eRW-LT or via traditional referral methods (tRs) in the ten semesters of the study

**Figure 3.** Percentage of visits judged as appropriate or inappropriate at the time of the first visit using the eRW-LT or the traditional referral methods (tRs)

**Figure 4.** Box plots of the time elapsed between the referral date and the one for which the first visit was booked in all visits referred with traditional methods (tRs) and in those booked with eRW-LT, also divided into urgent and non-urgent subgroups, and according to appropriateness.

*** P<0.001 and ** P<0.01 vs urgent visits referred with eRW-LT
Table 1. Patient demographic and clinical variables and specialty of the referring physician according to the referral system and study era

<table>
<thead>
<tr>
<th>Patient</th>
<th>old tR n= 161</th>
<th>new tR n= 96</th>
<th>eRW-LT n=99</th>
<th>P value old tR vs eRW-LT</th>
<th>P value new tR vs eRW-LT</th>
<th>P value old tR vs new tR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>56 (51-61)</td>
<td>55 (48-61)</td>
<td>56 (49-63)</td>
<td>0.698</td>
<td>0.450</td>
<td>0.580</td>
</tr>
<tr>
<td>Sex male, n (%)</td>
<td>129 (80.1)</td>
<td>69 (71.9)</td>
<td>77 (77.8)</td>
<td>0.651</td>
<td>0.342</td>
<td>0.128</td>
</tr>
<tr>
<td>Etiology, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.095</td>
<td>0.437</td>
<td>0.453</td>
</tr>
<tr>
<td>Alcohol</td>
<td>47 (29.2)</td>
<td>33 (34.4)</td>
<td>38 (38.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virus</td>
<td>51 (31.7)</td>
<td>22 (22.9)</td>
<td>17 (17.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol+Virus</td>
<td>22 (13.7)</td>
<td>14 (14.6)</td>
<td>19 (19.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NASH</td>
<td>24 (14.9)</td>
<td>12 (12.5)</td>
<td>16 (16.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>17 (10.6)</td>
<td>15 (15.6)</td>
<td>9 (9.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MELD score</td>
<td>12 (9-16)</td>
<td>13 (10-18)</td>
<td>13 (11-17)</td>
<td>0.044</td>
<td>0.748</td>
<td>0.117</td>
</tr>
<tr>
<td>MELDNa score</td>
<td>13 (10-18)</td>
<td>15 (11-19)</td>
<td>16 (12-20)</td>
<td>0.001</td>
<td>0.264</td>
<td>0.065</td>
</tr>
<tr>
<td>MELD-R score</td>
<td>18 (12-18)</td>
<td>17 (12-19)</td>
<td>18 (15-20)</td>
<td>0.017</td>
<td>0.089</td>
<td>0.602</td>
</tr>
<tr>
<td>HCC, yes, n (%)</td>
<td>47 (29.2)</td>
<td>27 (28.1)</td>
<td>25 (25.3)</td>
<td>0.491</td>
<td>0.650</td>
<td>0.855</td>
</tr>
<tr>
<td>Previous drug abuse, yes, n (%)</td>
<td>12 (7.5)</td>
<td>17 (17.7)</td>
<td>15 (15.2)</td>
<td>0.052</td>
<td>0.630</td>
<td>0.013</td>
</tr>
<tr>
<td>Modified Charlson Comorbidity Index, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
<td>0.806</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>0</td>
<td>112 (69.6)</td>
<td>45 (46.9)</td>
<td>47 (47.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>35 (21.7)</td>
<td>13 (13.5)</td>
<td>13 (13.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10 (6.2)</td>
<td>22 (22.9)</td>
<td>19 (19.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2 (1.2)</td>
<td>7 (7.3)</td>
<td>6 (6.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0 (0.0)</td>
<td>4 (4.2)</td>
<td>7 (7.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 (0.6)</td>
<td>3 (3.1)</td>
<td>1 (1.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1 (0.6)</td>
<td>2 (2.1)</td>
<td>3 (3.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>1 (1.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>1 (1.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data are expressed as median and interquartile range or as proportions.

*eRW-LT*: electronic referral website for LT; *HCC*: hepatocellular carcinoma; *LTC*: LT center; *MELD*: model for end-stage liver disease; *MELD-R*: regional model for end-stage liver disease; *old tR*: traditional referral in the older era; *new tR*: traditional referral in the most recent era.

<table>
<thead>
<tr>
<th>Referring physician</th>
<th>Specialty gastroenterology/hepatology, n (%)</th>
<th>0 (0.0)</th>
<th>0 (0.0)</th>
<th>1 (1.0)</th>
<th>0.201</th>
<th>0.283</th>
<th>0.921</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long distance from home to the LTC (outside the Lazio Region), n (%)</td>
<td>31 (19.3)</td>
<td>18 (18.8)</td>
<td>13 (13.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Referring physician</td>
<td>Specialty gastroenterology/hepatology, n (%)</td>
<td>55 (34.2)</td>
<td>37 (38.5)</td>
<td>46 (46.5)</td>
<td>0.048</td>
<td>0.263</td>
<td>0.479</td>
</tr>
</tbody>
</table>
Referring physician submits the eRW-LT to the LTC

The eReferral website automatically sends an alert email to the LT specialist immediately

LTC specialist evaluates the eRW-LT

The eRW-LT is appropriate

HCC with an up-to-seven score ≥5 and/or HCC already downstaged or to be downstaged and/or a Lazio Region MELD score (MELD-R) ≥22

[The MELD-R score is used to prioritize patients who eventually enter the regional waiting list and corresponds to the lab MELD-Na or to additional points fixed or granted by the Regional Board in patients with exceptions to the MELD]

The visit is scheduled according to the first availability on the agenda

Possible need for pre-visit additional testing or more information

The visit is scheduled in overbooking

The visit is not scheduled and the reasons explained

First response within 24 h

Referring physician and LTC specialist can communicate through the eRW-LT chat both before and after the first visit
1 SUPPLEMENTARY METHODS

3 PATIENTS and METHODS

In June 2017 at the "Sapienza" University liver transplant center (LTC), in collaboration with “Consorzio Innovo” and with the “Tor Vergata” University LTC, we completed the development of the eRW-LT website (URL: www.ereferral.it) for the outpatient referral of liver transplant (LT) candidates to the two above mentioned LTCs of Rome, Lazio region, Italy. Starting from December 2016 until November 2017, eRW-LT was promoted and advertised in the annual meetings of the Lazio regional sections of the Italian Federation of Societies of Diseases of the Digestive System and of the Federation of Associations of Internist Hospital Doctors, in two specific residential courses organized at Sapienza and Tor Vergata Universities, which also included an online training course and through an interview held by two of the authors (GCS and AM) in a daily newspaper dedicated to medical doctors. On all these occasions, the issues of the sub-optimal referral for LT and the recommendations for a correct referral were also illustrated. The Lazio Regional Transplant Center, the Professional Order of Medical Doctors of Rome, The Italian Federation of Family Doctors and the Lazio Regional Council were also involved to advertise the project.

We prospectively collected data on all referrals received for outpatient LT visits received from January 1, 2015 until December 31, 2019. During the entire study period we received referrals with traditional methods (tRs) that were not standardized and involved multiple steps mainly by telephone and by email and fax. In the second half of the study, from 1 July 2017 to 31 December 2019, as an alternative to the tRs, it was possible for the referring doctors to send patients with electronic referral using eRW-LT. We divided the patients into three groups according to the method and time of referrals: a) those referred with tRs before the introduction of eRW-LT from 1 January 2015 to 30 June 2017 (old tRs); b) those referred with tRs in the same time frame in which the eRW-L was used from 1 July 2017 to 31 December 2019 (new tRs) and c) those referred with eRW-LT from 1 July 2017 to 31 December 2019.

The referral appropriateness was assessed prospectively by a transplant hepatologist (GCS, AM, FF, MM, IL) appointed by the certification of the Italian Association for the Study of the Liver (AISF). In the case of eRW-LT, the appropriateness was judged both at the time of online referral, sometimes, if necessary, after exchange of information with the referring physician, and at the time of the first face-to-face visit, when this was carried out. In the case of tRs, all requested visits have been performed and their appropriateness was judged at the time of the visit. All judgments of appropriateness were subsequently checked blindly by a transplant hepatologist belonging to the LTC.
other than the one where the referral was sent (FF and MM), who agreed 100% with the initial judgments. Appropriateness was judged on the basis of the simultaneous presence of all the following criteria: 1) availability of sufficient clinical documentation; 2) presence of an accepted indication to referral for the first transplant visit \(^{14,15}\); 3) absence of known absolute contraindications to listing.

This study was approved by the local ethics committee of the coordinating LCT Sapienza and was performed in accordance with the ethical standards of the Declaration of Helsinki.

In June 2017 at the "Sapienza" University LTC, in collaboration with “Consorzio Innovo” and with the “Tor Vergata” University LTC, we completed the development of the eRW-LT website (URL: www.ereferral.it) for the first referral visit of candidates to the two above mentioned LTCs of Rome, Lazio region, Italy.

Starting from December 2016 until November 2017, eRW-LT was promoted and advertised in the annual meetings of the Lazio regional sections of the Italian Federation of Societies of Diseases of the Digestive System and of the Federation of Associations of Internist Hospital Doctors, in two specific residential courses organized at La Sapienza and Tor Vergata Universities, which also included an online training course and through an interview held by two of the authors (GCS and AM) in a daily newspaper dedicated to medical doctors. On all these occasions, the issues of the suboptimal referral for LT and the recommendations for a correct referral were also illustrated. The Lazio Regional Transplant Center, the Professional Order of Medical Doctors of Rome, The Italian Federation of Family Doctors and the Lazio Regional Council were also involved to advertise the project.

We have prospectively collected data on all consecutive traditional referrals (tRs) from January 1\(^{st}\) 2017, 6 months before the start of using eRW-LT, until December 31\(^{st}\) 2019, and all electronic referrals using eRW-LT from June 1\(^{st}\) 2017 until December 31\(^{st}\) 2019.

The referral appropriateness was assessed by a transplant hepatologist (GCS, AM, FF, MM, IL) appointed by the certification of the Italian Association for the Study of the Liver (AISF)\(^ {16}\). In the case of eRW-LT, the appropriateness was judged both at the time of online referral, sometimes, if necessary, after exchange of information with the referring physician, and at the time of the first face-to-face visit, when this was carried out. In the case of tRs, all requested visits have been performed and their appropriateness was judged at the time of the visit. All judgments of appropriateness were subsequently checked blindly by a transplant hepatologist belonging to the LTC other than the one where the referral was sent (FF and MM), who agreed 100% with the initial judgments.

Appropriateness was judged on the basis of the following criteria: 1) availability of sufficient clinical documentation (i.e., blood sampling with data needed for the MELDNa score calculation); 2) presence of an accepted indication to referral for the first transplant visit, according to the recommendations of
68 an expert panel of transplant hepatologists appointed by the AISF which met on 12-13 May 2017. 16,18
69 3) absence of known absolute contraindications to listing.
70 To judge whether the patients referred with eRW-LT were entitled to an urgent visit appointment
71 instead of the first non-urgent visit slot available on the agenda, we used at least one of the following
72 criteria: 1) HCC with an up to seven score ≥5; 2) HCC already downstaged or to be downstaged; 3)
73 a Lazio Region MELD score (MELD-R) >22. The MELD-R score is used to prioritize patients who
74 eventually enter the waiting regional list and corresponds to the laboratory MELDNa score 20. For
75 patients in whom the transplant indication was an exception to the MELD system, the MELD-R was
76 defined by additional points fixed or granted by the Regional Board 21. For example, for patients with
77 HCC, if the laboratory MELDNa score was less than 18, the MELD-R at registration was 18,
78 otherwise they were listed with a MELD-R corresponding to their MELDNa score.
79 This study was approved by the local ethics committee of the coordinating LCT Sapienza and was
80 performed in accordance with the ethical standards of the Declaration of Helsinki.
81
82 83 eReferral website for liver transplantation
84 The operation and technical characteristics, including the database structure and Structured Query
85 Language (SQL), of the eRW-LT software are described in Figure 1, Supplementary Figures 1, 2 and
86 3. The website was developed using the Debian Server (v 7.0 and its latest updated versions) as
87 operating system and LAMP as web service stack, which include the use of: the Linux operating
88 system, the Apache HTTP Server, the MySQL relational database management system (RDBMS), and
89 the hypertext preprocessor scripting language. The main data elements collected through the referral
90 process and how the exchange of clinical information takes place in chat between the referring
91 physician and the transplant hepatologist are described in Supplementary Figure 3 which shows
92 screenshots of some relevant steps. Briefly, the primary care practitioner or another specialist, after
93 obtaining the patient's consent, submits a referral request through eRW-LT, available on the website
94 www.eReferral.it. The referring physician logs in and is informed that the use of the website is not
95 intended for patients who require expedite inpatient evaluation. The referring physician can choose the
96 Center via a drop-down menu that changes randomly each time the order in which the LTCs appear.
97 Then he or she is asked to enter the patient's personal data and the blood tests for calculating the
98 MELD and MELDa score 18, which are automatically calculated by the system, with the date of the
99 relative blood sampling. In the event that these blood tests had not been performed on the same date, or
100 were dated prior to 30 days before the referral, an automated alert for the referring physician appears
101 on eRW to request a new blood sampling. The referring physician can also attach reports of other
102 analyzes and radiological and endoscopic examinations and can write a message to the specialist with
a brief history of the patient and the indication for LT in free text format. An automated email
immediately notifies a designated transplant hepatologist reviewer that a new referral has arrived, and
the latter responds within 24 hours to each referral request. The transplant hepatologist reviewer uses
the eRW-LT system to communicate with the referring physician to obtain additional patient
information if necessary. Whenever the two doctors receive a communication from the other on the
site, an automated email immediately alerts them to enter the site to respond. The specialist reviewer
can already schedule an appointment for the first visit with the right triage at the first response, if
deemed appropriate. Alternatively, an iterative communication begins between the two doctors if the
clinical documentation is judged to be implemented by the specialist reviewer. In this way, too early
referrals are avoided and, once the communication is completed, the specialist reviewer can schedule
an appointment with the right timing based on the urgency or, in cases where the visit is deemed
inappropriate, redirect the patient to other specialists. A further utility of the eRW-LT is educational.
In fact, the site provides links to the most up-to-date literature on transplantation and referral for
referring doctors. To judge whether the patients referred with eRW-LT were entitled to an urgent visit
appointment, we used at least one of the following criteria: 1) HCC with an up-to-seven score ≥5; 2)
HCC already downstaged or to be downstaged; 3) a Lazio Region MELD score (MELD-R) >22
(Figure 1). The MELD-R score is used to prioritize patients who eventually enter the regional waiting
list, also considering any additional points for MELD exceptions. The MELD-R score corresponds
to the MELDNa score or, for patients in whom the transplant indication is an exception to the MELD
system, the MELD-R was defined by additional points fixed or granted by the Regional Board. For
example, for patients with HCC, if the laboratory MELDNa score was less than 18, the MELD-R at
registration was 18, otherwise they were listed with a MELD-R corresponding to their MELDNa score.
Triage was not an option for visits of patients referred with tRs.
The website was developed using the Debian Server (v 7.0 and its latest updated versions) as operating
system and LAMP as web service stack, which include the use of: the Linux operating system, the
Apache HTTP Server, the MySQL relational database management system (RDBMS), and the
hypertext preprocessor scripting language. The operation of the eRW-LT is described in Figure 1.
Briefly, the primary care practitioner or another specialist, after obtaining the patient’s consent, submits
a referral request through eRW-LT, available on the website www.eReferral.it. The referring physician
logs in and is informed that the use of the website is not intended for patients who require expedite
inpatient evaluation for severe acute hepatitis, acute liver failure, acute on chronic liver failure or a
MELDNa score greater than 30. The referring physician can choose the Center via a drop-down menu
that changes randomly each time the order in which the LTCs appear. Then he is asked to enter the
patient’s personal data and the blood tests for calculating the MELD and MELDNa score, which are
automatically calculated by the system, with the date of the relative blood sampling. In the event that these blood tests had not been performed on the same date, or were dated prior to 30 days before the referral, an automated alert for the referring physician appears on eRWT to request a new blood sample. The referring physician can also attach reports of other analyzes and radiological and endoscopic examinations and can write a message to the specialist with a brief history of the patient and the indication for LT in free text format. An automated email immediately notifies a designated transplant hepatologist reviewer that a new referral has arrived, and the latter responds within 24 hours to each referral request. The transplant hepatologist reviewer uses the eRW-LT system to communicate with the referring physician to obtain additional patient information if necessary. Whenever the two doctors receive a communication from the other on the site, an automated email immediately alerts them to enter the site to respond. The specialist reviewer can already schedule an appointment for the first visit with the right triage at the first response, if deemed appropriate. Alternatively, an iterative communication begins between the two doctors if the clinical documentation is judged to be implemented by the specialist reviewer, or thanks to some automated steps of the eRW-LT system that allow to verify the completeness and recent execution of laboratory and imaging tests. In this way, too early referrals are avoided and, once the communication is completed, the specialist reviewer can schedule an appointment with the right timing based on the urgency or, in cases where the visit is deemed inappropriate, redirect the patient to other specialists. A further utility of the eRW-LT is educational. In fact, the site provides links to the most up-to-date literature on transplantation and referral for referring doctors.

Supplementary Figure 1. Structured query language (SQL) of the eRW-LT software. Note that the blood tests required for the calculation of the MELD and MELDNa scores (see the end of this Figure) are entered in the "CREATE TABLE bridgePatientScreenings" area of the general SQL.
CREATE TABLE `bridgeDoctorPatient` (  
    `idBridgeDoctorPatient` int(255) NOT NULL AUTO_INCREMENT,  
    `fkUser` int(255) NOT NULL,  
    `fkPatientDetails` int(255) NOT NULL,  
    PRIMARY KEY (`idBridgeDoctorPatient`) USING BTREE,  
    INDEX `fkUser`(`fkUser`) USING BTREE,  
    INDEX `fkPatientDetails`(`fkPatientDetails`) USING BTREE  
) ENGINE = InnoDB AUTO_INCREMENT = 470 CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE `bridgeDoctorTransplantCenter` (  
    `idBridgeDoctorTransplantCenter` int(11) NOT NULL AUTO_INCREMENT,  
    `fkTransplantCenter` int(11) NOT NULL,  
    `fkDoctor` int(11) NOT NULL,  
    PRIMARY KEY (`idBridgeDoctorTransplantCenter`) USING BTREE,  
    UNIQUE INDEX `fkTransplantCenter`(`fkTransplantCenter`) USING BTREE,  
    INDEX `fkDoctor`(`fkDoctor`) USING BTREE  
) ENGINE = InnoDB AUTO_INCREMENT = 1 CHARACTER SET = latin1 COLLATE = latin1_swedish_ci ROW_FORMAT = Dynamic;

CREATE TABLE `bridgePatientOtherScreenings` (  
    `idBridgePatientOtherScreening` int(255) NOT NULL AUTO_INCREMENT,  
    `name` varchar(150) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,  
    `fkPatientDetails` int(255) NOT NULL,  
    `date` date NOT NULL,  
    `pathScreeningScanning` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,  
    PRIMARY KEY (`idBridgePatientOtherScreening`) USING BTREE,  
    INDEX `fkPatientDetails`(`fkPatientDetails`) USING BTREE  
) ENGINE = InnoDB AUTO_INCREMENT = 230 CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE `bridgePatientScreenings` (  
    `idBridgePatientScreening` int(255) NOT NULL AUTO_INCREMENT,
    `user` `user` (255) NOT NULL,  
    `fkPatientDetails` int(255) NOT NULL,  
    PRIMARY KEY (`idBridgePatientScreening`) USING BTREE,  
    INDEX `fkPatientDetails`(`fkPatientDetails`) USING BTREE  
) ENGINE = InnoDB AUTO_INCREMENT = 1 CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;
CREATE TABLE 'bridgeReferralResponses' (  
'idBridgeReferralResponses' int(255) UNSIGNED NOT NULL AUTO_INCREMENT,
'fkSender' int(255) NOT NULL,
'fkReceiver' int(255) NOT NULL,
'fkReferral' int(10) NOT NULL,
'fkReferralState' int(10) NOT NULL,
'date' datetime NOT NULL,
'notes' text CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
'pathAttachment' varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
PRIMARY KEY ('idBridgeReferralResponses') USING BTREE,
INDEX 'fkSender'('fkSender') USING BTREE,
INDEX 'fkReceiver'('fkReceiver') USING BTREE,
INDEX 'fkReferral'('fkReferral') USING BTREE,
INDEX 'fkReferralState'('fkReferralState') USING BTREE
) ENGINE = InnoDB AUTO_INCREMENT = 2026 CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE 'cities' (  
'idCity' int(255) NOT NULL DEFAULT 0,
CREATE TABLE `doctorDetails` (
    `idDoctorDetails` int(255) NOT NULL AUTO_INCREMENT,
    `name` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `surname` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `telephoneNumber` varchar(25) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `address` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `city` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `province` varchar(5) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `specializationType` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `registrationCode` varchar(55) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `registrationProvince` varchar(55) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `privacy` int(1) NULL DEFAULT 0,
    `fkUser` int(255) NOT NULL,
    PRIMARY KEY (`idDoctorDetails`) USING BTREE,
    INDEX `fkUser`(`fkUser`) USING BTREE
) ENGINE = InnoDB AUTO_INCREMENT = 235 CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE `dsrDetails` (
    `idDettagliDsr` int(255) NOT NULL AUTO_INCREMENT,
    `name` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `surname` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `fkUser` int(255) NOT NULL,
    `fkTransplantCenter` int(10) NOT NULL,
    PRIMARY KEY (`idDettagliDsr`) USING BTREE,
    INDEX `fkTransplantCenter`(`fkTransplantCenter`) USING BTREE,
INDEX `fkUser`(`fkUser`) USING BTREE

) ENGINE = InnoDB AUTO_INCREMENT = 14 CHARACTER SET = utf8 COLLATE = utf8_general_ci
ROW_FORMAT = Dynamic;

CREATE TABLE `extentionCirrhosis` ( 
    `idExtentionCirrhosis` int(255) NOT NULL AUTO_INCREMENT,
    `HCV` int(1) NOT NULL DEFAULT 0,
    `HBV` int(1) NOT NULL DEFAULT 0,
    `HDV` int(1) NOT NULL DEFAULT 0,
    `Alcohol` int(1) NOT NULL DEFAULT 0,
    `Nonalcoholic Steatohepatitis (NASH)` int(1) NOT NULL DEFAULT 0,
    `Cryptogenic` int(1) NOT NULL DEFAULT 0,
    `PrimaryBiliaryCholangitis` int(1) NOT NULL DEFAULT 0,
    `SecondaryBiliaryCholangitis` int(1) NOT NULL DEFAULT 0,
    `PrimarySclerosingCholangitis` int(1) NOT NULL DEFAULT 0,
    `Autoimmune` int(1) NOT NULL DEFAULT 0,
    `Hemochromatosis` int(1) NOT NULL DEFAULT 0,
    `fkPatientClinicalDetails` int(255) NOT NULL,
    PRIMARY KEY ( `idExtentionCirrhosis` ) USING BTREE,
    INDEX `fkPatientClinicalDetails`(`fkPatientClinicalDetails`) USING BTREE
) ENGINE = InnoDB AUTO_INCREMENT = 466 CHARACTER SET = utf8 COLLATE = utf8_general_ci
ROW_FORMAT = Dynamic;

CREATE TABLE `login` ( 
    `idLogin` int(255) NOT NULL AUTO_INCREMENT,
    `fkUser` int(255) NOT NULL,
    `tempCode` varchar(8) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `expiration` datetime NOT NULL,
    PRIMARY KEY ( `idLogin` ) USING BTREE,
    UNIQUE INDEX `fkUser`(`fkUser`) USING BTREE
) ENGINE = InnoDB AUTO_INCREMENT = 2308 CHARACTER SET = utf8 COLLATE = utf8_general_ci
ROW_FORMAT = Dynamic;
CREATE TABLE `nationalities` (  
  `idNationality` int(255) NOT NULL AUTO_INCREMENT,  
  `name` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,  
  PRIMARY KEY (`idNationality`) USING BTREE  
) ENGINE = InnoDB AUTO_INCREMENT = 334 CHARACTER SET = utf8 COLLATE = utf8_general_ci  
ROW_FORMAT = Dynamic;

CREATE TABLE `patientClinicalDetails` (  
  `idClinicalPatientDetails` int(255) NOT NULL AUTO_INCREMENT,  
  `cirrhosis` int(1) NOT NULL DEFAULT 0,  
  `etiology` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `hepatocellularCarcinoma` int(1) NOT NULL DEFAULT 0,  
  `otherDisease` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `fkPatientDetails` int(255) NOT NULL,  
  PRIMARY KEY (`idClinicalPatientDetails`) USING BTREE,  
  INDEX `fkPatientDetails`(`fkPatientDetails`) USING BTREE  
) ENGINE = InnoDB AUTO_INCREMENT = 446 CHARACTER SET = utf8 COLLATE = utf8_general_ci  
ROW_FORMAT = Dynamic;

CREATE TABLE `patientDetails` (  
  `idPatientDetails` int(255) NOT NULL AUTO_INCREMENT,  
  `name` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,  
  `surname` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,  
  `birthDate` datetime NOT NULL,  
  `sex` varchar(1) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,  
  `fiscalCode` varchar(16) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `city` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `province` varchar(5) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `domicileAddress` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `domicileCity` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `domicileProvince` varchar(5) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,  
  `telephoneNumber` varchar(25) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
CREATE TABLE `province` (
    `idProvince` int(255) NOT NULL,
    `name` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `sigle` varchar(2) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    PRIMARY KEY (`idProvince`) USING BTREE,
    INDEX `sigle`(`sigle`) USING BTREE
) ENGINE = InnoDB CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE `referral` (
    `idReferral` int(255) NOT NULL AUTO_INCREMENT,
    `fkUser` int(255) NOT NULL,
    `fkDsr` int(255) NULL DEFAULT NULL,
    `fkPatientDetails` int(255) NOT NULL,
    `openingDate` datetime NOT NULL,
    `updatingDate` datetime NOT NULL,
    `notes` text CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL DEFAULT NULL,
    `fkReferralState` int(10) NOT NULL,
    `fkTransplantCenter` int(10) NOT NULL,
    PRIMARY KEY (`idReferral`) USING BTREE,
    INDEX `fkUser`(`fkUser`) USING BTREE,
    INDEX `fkPatientDetails`(`fkPatientDetails`) USING BTREE,
    INDEX `fkReferralState`(`fkReferralState`) USING BTREE
) ENGINE = InnoDB CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;
INDEX `fkDsr`(`fkDsr`) USING BTREE,
INDEX `fkReferralState`(`fkReferralState`) USING BTREE,
INDEX `fkTransplantCenter`(`fkTransplantCenter`) USING BTREE
)
ENGINE = InnoDB AUTO_INCREMENT = 414 CHARACTER SET = utf8 COLLATE = utf8_general_ci
ROW_FORMAT = Dynamic;

CREATE TABLE `referralState`(
    `idReferralState` int(10) NOT NULL,
    `name` varchar(150) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `final` int(1) NOT NULL,
    PRIMARY KEY (`idReferralState`) USING BTREE
)
ENGINE = InnoDB CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE `roles`(
    `idRole` int(10) NOT NULL,
    `name` varchar(150) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    PRIMARY KEY (`idRole`) USING BTREE
)
ENGINE = InnoDB CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE `screenings`(
    `idScreening` int(20) NOT NULL AUTO_INCREMENT,
    `name` varchar(150) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    PRIMARY KEY (`idScreening`) USING BTREE
)
ENGINE = InnoDB AUTO_INCREMENT = 5 CHARACTER SET = utf8 COLLATE = utf8_general_ci
ROW_FORMAT = Dynamic;

CREATE TABLE `screeningScanning`(
    `idScreeningScanning` int(10) NOT NULL AUTO_INCREMENT,
    `path` varchar(50) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `fileName` varchar(50) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    PRIMARY KEY (`idScreeningScanning`) USING BTREE
)
ENGINE = InnoDB AUTO_INCREMENT = 22 CHARACTER SET = utf8 COLLATE = utf8_general_ci
ROW_FORMAT = Dynamic;
```sql
CREATE TABLE `transplantCenter` (
    `idTransplantCenter` int(10) NOT NULL,
    `name` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `address` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `city` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `province` varchar(5) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `responsible` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `director` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `surgery` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `telephoneNumber` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `faxNumber` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `webSite` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `url_map` blob NOT NULL,
    PRIMARY KEY (`idTransplantCenter`) USING BTREE,
    INDEX `city` (`city`) USING BTREE,
    INDEX `province` (`province`) USING BTREE
) ENGINE = InnoDB CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

CREATE TABLE `users` (
    `idUser` int(255) NOT NULL AUTO_INCREMENT,
    `username` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `password` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
    `email` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
    `active` tinyint(1) NOT NULL DEFAULT 1,
    `deleted` tinyint(1) NOT NULL DEFAULT 0,
    `fkRole` int(10) NOT NULL,
    PRIMARY KEY (`idUser`) USING BTREE,
    UNIQUE INDEX `username`(`username`) USING BTREE,
    UNIQUE INDEX `email`(`email`) USING BTREE,
    INDEX `fkRole`(`fkRole`) USING BTREE
) ENGINE = InnoDB CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;
```
ALTER TABLE `bridgeDoctorPatient` ADD CONSTRAINT `bridgeMedicoPaziente_ibfk_1` FOREIGN KEY (`fkUser`) REFERENCES `users` (`idUser`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `bridgeDoctorPatient` ADD CONSTRAINT `bridgeMedicoPaziente_ibfk_2` FOREIGN KEY (`fkPatientDetails`) REFERENCES `patientDetails` (`idPatientDetails`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `bridgeDoctorTransplantCenter` ADD CONSTRAINT `bridgeMedicoCentro_ibfk_1` FOREIGN KEY (`fkTransplantCenter`) REFERENCES `transplantCenter` (`idTransplantCenter`) ON DELETE NO ACTION ON UPDATE CASCADE;

ALTER TABLE `bridgeDoctorTransplantCenter` ADD CONSTRAINT `bridgeMedicoCentro_ibfk_2` FOREIGN KEY (`fkDoctor`) REFERENCES `users` (`idUser`) ON DELETE NO ACTION ON UPDATE CASCADE;

ALTER TABLE `bridgePatientOtherScreenings` ADD CONSTRAINT `bridgeAltreEsamePaziente_ibfk_1` FOREIGN KEY (`fkPatientDetails`) REFERENCES `patientDetails` (`idPatientDetails`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `bridgePatientScreenings` ADD CONSTRAINT `bridgeEsamePaziente_ibfk_1` FOREIGN KEY (`fkPatientDetails`) REFERENCES `patientDetails` (`idPatientDetails`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `bridgePatientScreenings` ADD CONSTRAINT `bridgeEsamePaziente_ibfk_2` FOREIGN KEY (`fkScreening`) REFERENCES `screenings` (`idScreening`) ON DELETE NO ACTION ON UPDATE CASCADE;

ALTER TABLE `bridgePatientScreenings` ADD CONSTRAINT `bridgeEsamePaziente_ibfk_3` FOREIGN KEY (`fkScreeningScanning`) REFERENCES `screeningScanning` (`idScreeningScanning`) ON DELETE NO ACTION ON UPDATE CASCADE;

ALTER TABLE `bridgeReferralResponses` ADD CONSTRAINT `bridgeReferralRisposte_ibfk_1` FOREIGN KEY (`fkReferral`) REFERENCES `referral` (`idReferral`) ON DELETE NO ACTION ON UPDATE CASCADE;

ALTER TABLE `bridgeReferralResponses` ADD CONSTRAINT `bridgeReferralRisposte_ibfk_2` FOREIGN KEY (`fkReferralState`) REFERENCES `referralState` (`idReferralState`) ON DELETE NO ACTION ON UPDATE CASCADE;

ALTER TABLE `cities` ADD CONSTRAINT `comuni_fk` FOREIGN KEY (`fkProvince`) REFERENCES `province` (`idProvince`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `doctorDetails` ADD CONSTRAINT `dettaglioMedico_ibfk_1` FOREIGN KEY (`fkUser`) REFERENCES `users` (`idUser`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `doctorDetails` ADD CONSTRAINT `dettaglioDsr_ibfk_1` FOREIGN KEY (`fkUser`) REFERENCES `users` (`idUser`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `doctorDetails` ADD CONSTRAINT `dettaglioDsr_ibfk_2` FOREIGN KEY (`fkTransplantCenter`) REFERENCES `transplantCenter` (`idTransplantCenter`) ON DELETE CASCADE ON UPDATE CASCADE;

ALTER TABLE `extensionCirrhosis` ADD CONSTRAINT `extraCirrosi_ibfk_1` FOREIGN KEY (`fkPatientClinicalDetails`) REFERENCES `patientClinicalDetails` (`idClinicalPatientDetails`) ON DELETE CASCADE ON UPDATE CASCADE;
Supplementary Figure 2. Graphic representation of the Structured Query Language (SQL) of the eRW-LT software. Each box represents a table, while the lines indicate the fields present in the table, which will contain the data entered through the software. The lines that connect the various boxes represent the relationships between the tables.
Supplementary Figure 3. Screenshots of the eRW-LT referral procedure illustrating the main steps of its operation (English translations are provided)
After registering (only the first time) and entering his email address, the referring physician receives an automatic email immediately with a temporary code to log into the system.

**Mandatory temporary code**

Enter the temporary code received by email.

The referring physician enters the temporary code and logs into the system.

To log in to the system, enter the following temporary access code: the temporary code will be active until 07:34 PM on ...

---

The referring physician can choose the Liver Transplant Center via a drop-down menu that changes randomly each time the order in which the Liver Transplant Centers appear.

Sending of eReferral

Select the Liver Transplant Center

Note

Send

Annulla  Invia

Cancel
The referring physician enters the patient's mandatory demographics and diagnosis.

Page for diagnosis: in the case of cirrhosis and/or hepatocellular carcinoma, a drop-down menu opens with the various etiological possibilities. In the case of other diseases, it is possible to write the diagnosis in free text.
Mandatory entry of blood test results (both texting and PDF copy of the analysis laboratory report) for the calculation of MELD and MELDNa scores which is carried out automatically by the system. The dates of the blood sampling must also be entered and, if the exams are older than 30 days, a visible warning appears both to the referring physician and to the transplant hepatologist of the transplant center.

The referring physician can upload additional exams.
Example of the chat fields between the referring physician (green field) and the transplant hepatologist (light blue) for a patient who was deemed temporarily not eligible, as the blood tests for calculating MELD and MELD-Na were too old.
### SUPPLEMENTARY RESULTS

**Supplementary table 1. Reasons for inappropriateness judged online at the time of referral of the eleven patients who had been referred by eRW-LT.**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Reason for inappropriateness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 1</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was &lt;10 with no HCC or other MELD exceptions. The patient was referred to the “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 2</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was &lt;10 with no HCC or other MELD exceptions. The patient was referred to the “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 3</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was &lt;10 with no HCC or other MELD exceptions. The patient was referred to the “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 4</td>
<td>Contraindication: The patient had a diagnosis of HCC with portal vein invasion, the patient was referred to the “Hepatocellular carcinoma” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 5</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was &lt;10 with no HCC or other MELD exceptions. The patient was referred to the “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 6</td>
<td>Contraindication: The patient had a diagnosis of HCC with portal vein invasion, the patient was referred to the “Hepatocellular carcinoma” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 7</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was &lt;10 with no HCC or other MELD exceptions. The patient was referred to the</td>
</tr>
</tbody>
</table>
Supplementary table 2. Reasons for inappropriateness judged at the time of the first face-to-face visit of the five patients who had been referred by eRW-LT:

<table>
<thead>
<tr>
<th>Patient</th>
<th>Reason for inappropriateness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 8</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was &lt;10 with no HCC or other MELD exceptions. The patient was referred to the “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center.</td>
</tr>
<tr>
<td>Patient 9</td>
<td>Contraindication: The patient had a diagnosis of HCC with portal vein invasion, the patient was referred to “Hepatocellular carcinoma” outpatient service</td>
</tr>
<tr>
<td>Patient 10</td>
<td>Contraindication: The patient was 76 years old with multiple comorbidities, the patient was referred to “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 11</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was &lt;10 with no HCC or other MELD exceptions. The patient was referred to the “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center</td>
</tr>
<tr>
<td>Patient 12</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was 13, while with the most recent new tests performed immediately before the first visit the MELD score was 8</td>
</tr>
<tr>
<td>Patient 13</td>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral): The laboratory MELD score calculated by the eRW-LT system based on blood tests performed within 30 days prior to referral was 12</td>
</tr>
</tbody>
</table>

eRW-LT: electronic referral website for liver transplantation; HCC: hepatocellular carcinoma; MELD: model for end-stage liver disease
while with the most recent new tests performed immediately before the first visit, the MELD score was 8.

| Patient 14 | Contraindication: | The patient had resumed an active alcohol intake after the initial referral using eRW-LT |
| Patient 15 | Absence of an accepted indication to referral for the first transplant visit (Early referral): | The patient had polycystic liver disease and a reduced quality of life reported to the referring physician which led to the indication for liver transplantation. However, the patient then reported a significant improvement in quality of life during the face-to-face visit with the transplant hepatologist |
| Patient 16 | Contraindication: | A cholangiocarcinoma was diagnosed by a liver biopsy performed after referral. |

eRW-LT: electronic referral website for liver transplantation; MELD: model for end-stage liver disease

Supplementary table 3. Specialization of the referring physician and reasons for inappropriateness of referrals of patients who had been referred with traditional methods judged at the time of the first visit according to the study era, and of those who had been referred with eRW-LT judged both at the time of the referral and at the first visit.
### Supplementary Table 4. Distribution with respect to the total number of referred patients of those subsequently placed on the waiting list and those transplanted according to the referral system and study era.

<table>
<thead>
<tr>
<th>Reasons for inappropriateness</th>
<th>Inappropriate old tRs judged at first visit n=65</th>
<th>Inappropriate new tRs judged at first visit n=42</th>
<th>Inappropriate eRW-LT judged at referral or at first visit n=16</th>
<th>P value old tRs vs eRW-LT</th>
<th>P value new tRs vs eRW-LT</th>
<th>P value old tRs vs new tR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence of an accepted indication to referral for the first transplant visit (Early referral), n (%)</td>
<td>20 (30.8)</td>
<td>9 (21.4)</td>
<td>10 (62.5)</td>
<td>0.0019</td>
<td>0.0106</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Contraindications, n (%)</td>
<td>19 (29.2)</td>
<td>31 (74.0)</td>
<td>6 (37.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incomplete clinical documentation, n (%)</td>
<td>26 (40.0)</td>
<td>2 (4.8)</td>
<td>0 (0)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Referring physician**

| Specialty gastroenterology/hepatology, n (%) | 12 (18.5) | 12 (28.6) | 3 (18.8) | 1.000 | 0.552 | 0.243 |

eRW-LT: electronic referral website for liver transplantation; MELD: model for end-stage liver disease; old tRs: traditional referral methods in the older era; new tRs: traditional referral methods in the most recent era.
eRW-LT: electronic referral website for liver transplantation; MELD: model for end-stage liver disease; old tRs: traditional referral methods in the older era; new tRs: traditional referral methods in the most recent era.

Supplementary Figure 4. Panel A: scatter plots showing that, using eRW-LT, the time between the date of referral and the date the first transplant visit was booked is negatively correlated with each patient's MELD-R ($r = -0.412$, $P < 0.0001$). Empty circles refer to non-urgent visits and filled diamonds refer to urgent visits. Panel B: scatter plots showing that, using traditional referral methods (tRs), the time between the date of the referral and the date the first transplant visit was booked did not correlate with each patient's MELD-R.
"What You Need to Know"

**Background:** although potential liver transplant candidates have the right to be evaluated according to the severity of their disease and without overloading clinics with inappropriate visits, this is often not the case.

**Findings:** we have developed an electronic system for outpatient referral to liver transplantation by all doctors, obtaining an increase in the number of referrals, the appropriateness of visits and their triage.

**Implications for patient care:** potential candidates for liver transplantation are quickly booked for a visit with the right triage or, if unsuitable, are redirected to other therapies without having an unnecessary face-to-face visit.