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

Flaminia Ferri, Martina Milana, Aurelio Abbatecola, Alessandro Pintore, Ilaria Lenci, Simona Parisse, Alessandro Vitale, Gianluca Di Croce, Gianluca Mennini, Quirino Lai, Massimo Rossi, Roberta Angelico, Giuseppe Tisone, Alessandro Anselmo, Mario Angelico, Stefano Ginanni Corradini



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

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5 **SHORT TITLE: electronic referral for liver transplantation**

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7 Flaminia Ferri¹, Martina Milana², Aurelio Abbatecola¹, Alessandro Pintore¹, Ilaria Lenci², Simona
8 Parisse¹, Alessandro Vitale³, Gianluca Di Croce³, Gianluca Mennini⁴, Quirino Lai⁴, Massimo Rossi⁴,
9 Roberta Angelico², Giuseppe Tisone², Alessandro Anselmo², Mario Angelico², Stefano Ginanni
10 Corradini¹

11 1. Department of Translational and Precision Medicine, Sapienza University of Rome, Italy

12 2. Hepatology and LT Unit, University of Tor Vergata, Rome, Italy

13 3. Consorzio Innovo, Rome, Italy

14 4. Hepato-bilio-pancreatic and LT Unit, Department of Surgery, Sapienza University of Rome, Italy

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20

21 **Abbreviations:**

22 *e*Referral: electronic referral

23 *e*RW-LT: website for electronic referral for LT

24 HCC: hepatocellular carcinoma

25 LT: LT

26 LTC: LT center

27 MELD: model for end-stage liver disease

28 *t*Rs: traditional methods of referral

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32 **Correspondence:**

33 Flaminia Ferri, MD PhD

34 University Sapienza of Rome, Italy

35 Viale dell'Università 37, 00185 Roma, Italy

36 Tel: +393341437165

37 Email: flaminia.ferri@uniroma1.it

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42 **Abstract**

43 **Background & Aims:** Missed or inappropriate referrals of potential candidates for liver
44 transplantation (LT) are common and traditional referral methods (*t*Rs) do not allow for efficient
45 triage. We investigated the effects on these issues of a website developed for electronic outpatient
46 referral to LT (*e*RW-LT)

47

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

52

53 **Results:** In the second half of the study there were 99 *e*RW-LTs and 96 traditional referrals (new *t*Rs),
54 representing a 17.4% increase over the 161 traditional referrals (old *t*Rs) of the first half. With *e*RW-
55 LT, 11.1% of referrals were judged inappropriate online without booking a visit. Appropriateness,
56 judged at the time of the first visit, was 59.6%, 56.2% and 94.3% with old *t*Rs, new *t*Rs and *e*RW-LT,
57 respectively. Considering the appropriate visits, median waiting time in days between referral date and
58 first visit appointment was significantly shorter for urgent visits referred with *e*RW-LT (5.0 [95% CI
59 4.8-9.3]) compared to non-urgent visits sent with the same system (17.0 [95% CI 11.5-25.0];
60 $P < 0.0001$), those referred with old *t*Rs (14.0 [95% CI 8.0-23.0]; $P < 0.001$) and with new *t*Rs (16.0
61 [95% CI 10.0-23.0]; $P < 0.001$).

62

63 **Conclusions:** *e*RW-LT allows to increase the number of referrals for LT, ensuring effective triage and
64 better appropriateness of visits.

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66 **Keywords:** Liver transplant; Telehealth; Transplant referral; Visit triage.

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72 Introduction

73

74 Rates of referral to liver transplant centers (LTCs) and accessibility to liver transplantation (LT)
75 waiting lists are low, with reported data in the literature of 5-21%¹⁻⁵ and 4-40%⁶⁻¹², respectively. The
76 reasons for the suboptimal referral rates to LCTs, which are the main cause of reduced access to
77 waiting lists, are many. The reasons for missed referrals differ by country, but distrust of transplant
78 results, even in patients with hepatocellular carcinoma (HCC) who can be successfully transplanted
79 after effective downstaging, is quite common.^{5,13} Also late referrals are frequent, even if it is currently
80 recommended that the optimal timing for initial referral to a LTC of patients with end stage liver
81 disease should be before their disease reaches the stage when their listing is actually indicated.^{14,15} This
82 is because it takes time to assess eligibility before a patient can be listed and some patients risk to
83 deteriorate rapidly to a point where they dropout from the waiting list or die before getting a
84 transplant. Suboptimal referrals to LTCs can also consist of referrals that are too early or completely
85 inappropriate, which occupy slots for first visits causing flooding of appointment schedules and delays
86 to carry out urgent visits. We felt that the suboptimal referral for LT was due, at least in part, to
87 inefficiency and difficulty in getting appointments for the first outpatient visit using traditional referral
88 methods (*t*Rs) (e.g. phone call, fax or email).

89 We have therefore developed and advertised a telemedicine tool, the *e*Referral website for referral of
90 candidates for LT (*e*RW-LT). The *e*RW-LT uses the same principle of the existing electronic referral
91 systems that had been developed in order to reduce waiting times to obtain other first specialist visit.¹⁶
92 The *e*RW-LT can be used by all general practitioners or specialists who intend to refer LT candidates
93 who need a first outpatient visit, but not in cases where a rapid evaluation through hospitalization is
94 required. A dedicated transplant hepatologist reviewer of the LTC rapidly judges online the need and
95 timing of the first transplant visit. The purpose of this study is to evaluate the effect of using *e*RW-LT
96 on the number of patients referred, on the appropriateness of the referral and on the triage and waiting
97 times for the execution of the visit.

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101 PATIENTS and METHODS

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

104 In June 2017 at the "Sapienza" University LTC, in collaboration with "Consorzio Innovo" and with the
105 "Tor Vergata" University LTC, we completed the development of the *eRW-LT* website (URL:
106 www.ereferral.it) for the first referral visit of candidates to the two above mentioned LTCs of Rome,
107 Lazio region, Italy. Starting from December 2016 until November 2017, *eRW-LT* was promoted and
108 advertised through various events and communication channels (Supplementary Methods).

109 We prospectively collected data on all referrals received for outpatient LT visits received from January
110 1, 2015 until December 31, 2019. During the entire study period we received referrals with *tRs* that
111 were not standardized and involved multiple steps mainly by telephone and by email and fax. In the
112 second half of the study, from 1 July 2017 to 31 December 2019, as an alternative to the *tRs*, it was
113 possible for the referring doctors to refer patients using *eRW-LT*. We divided the patients into three
114 groups according to the method and time of referrals: a) those referred with *tRs* before the introduction
115 of *eRW-LT* from 1 January 2015 to 30 June 2017 (old *tRs*); b) those referred with *tRs* in the same time
116 frame in which the *eRW-L* was used from 1 July 2017 to 31 December 2019 (new *tRs*) and c) those
117 referred with *eRW-LT* from 1 July 2017 to 31 December 2019.

118 The referral appropriateness was assessed prospectively by a transplant hepatologist (GCS, AM, FF,
119 MM, IL) appointed by the certification of the Italian Association for the Study of the Liver (AISF).^{18,17}
120 In the case of *eRW-LT*, the appropriateness was judged both at the time of online referral, sometimes,
121 if necessary, after exchange of information with the referring physician, and at the time of the first
122 face-to-face visit, when this was carried out. In the case of *tRs* the appropriateness was judged only at
123 the time of the first visit. Appropriateness was judged on the basis of the simultaneous presence of all
124 the following criteria: 1) availability of sufficient clinical documentation; 2) presence of an accepted
125 indication to referral for the first transplant visit^{14,15}; 3) absence of known absolute contraindications to
126 listing.

127

128 ***eReferral* website for liver transplantation**

129 The operation and technical characteristics, including the database structure, are described in Figure 1,
130 Supplementary Methods, Supplementary Figures 1, 2 and 3. Briefly, the primary care practitioner or
131 another specialist, after obtaining the patient's consent, logs in the website www.eReferral.it, is
132 informed that the use of the website is not intended for patients with a need for hospitalization and
133 submits a referral request. This includes the patient's personal and clinical data and blood tests for
134 calculating the MELD and MELDNa¹⁸ score, which are automatically calculated by the system, with
135 the date of the relative blood sampling. An automated email immediately notifies a designated
136 hepatologist transplant reviewer that a new referral has arrived and the latter responds within 24 hours.
137 The specialist reviewer can book the first visit with the right triage, or ask for further data or, in cases

138 where the visit is deemed inappropriate, redirect the patient to other specialists. To judge whether the
139 patients referred with *eRW-LT* were entitled to an urgent visit appointment, we used at least one of the
140 following criteria: 1) HCC with an up-to-seven score ≥ 5 ¹⁹; 2) HCC already downstaged or to be
141 downstaged; 3) a Lazio Region MELD score (MELD-R) >22 (Figure 1). The MELD-R score is used to
142 prioritize patients who eventually enter the regional waiting list, also considering any additional points
143 for MELD exceptions (Supplementary methods)²⁰. Triage was not an option for visits of patients
144 referred with *tRs*. The site also provides links to the most up-to-date literature on LTs and the correct
145 timing for referrals.

146

147 **Statistical analysis**

148 The normality of the data distribution was investigated by the Kolmogorov-Smirnov test. Continuous
149 variables are shown as medians (25th-75th percentile). Categorical variables are expressed as counts
150 and percentages. The Modified Charlson comorbidity index was calculated according to Volk et al. ²¹
151 The change in the referral rate due to the introduction of *eRW-LT* was evaluated by comparing the
152 number of referrals with old *tRs* with the sum of those with new *tRs* and *eRW-LT*. We compared the
153 study groups in terms of percentage and reason for inappropriateness and waiting time from the time
154 of the referral to that of the appointment given for the first visit. The comparison between old *tRs* and
155 new *tRs* was made to investigate changes related to the era, while the comparison between new *tRs*
156 and *eRW-LT* served to verify the effect of the electronic method. Continuous variables were analyzed
157 with the Mann-Whitney U test or the Student T test, as appropriate. For categorical variables,
158 intergroup differences were analyzed using the χ^2 or Fisher's exact test, as appropriate. The
159 relationship between the waiting time for the first visit and the MELD-R was evaluated with the
160 Pearson correlation coefficient. Statistical data analysis was performed using the "Statistical Social
161 Science Package (SPSS) for Windows (SPSS version 25.0, Chicago, IL, USA). Values of $P < 0.05$
162 were considered significant.

163

164 **RESULTS**

165

166 *Effect of the introduction of the electronic referral website on referral rates and the appropriateness* 167 *of the first visit*

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169 Since the introduction of the *eRW-LT*, the total number of referrals, the sum of those with *eRW-LT*
170 ($n=99$) and new *tRs* ($n=96$), was 195, corresponding to an increase of 17.4% compared to the 161
171 candidates referred with old *tRs* throughout the first era of the study. Furthermore, compared to the last

172 12 months before the introduction of *eRW-LT*, the average increase in subsequent semesters up to the
173 end of the study was 34.5% (Figure 2). Table 1 shows patient demographic and clinical variables.
174 Patients referred with old *tRs*, compared to those referred more recently with new *tRs*, had fewer
175 comorbidities. Patients referred with *eRW-LT* had higher comorbidities, MELD, MELDNa and
176 MELD-R scores and were referred more frequently by gastroenterologists / hepatologists than patients
177 referred with old *tRs*. No difference was present between patients referred with *eRW-LT* and new *tRs*.
178 Among patients ≥ 65 years of age, those referred with *eRW-LT* had at least five comorbidities in 5
179 cases, while none had such a high number in the new *tRs* group.
180 Considering patients referred by *eRW-LT*, 11 out of 99 (11.1%) were found to be inappropriate,
181 judged online by the designated LTC specialist and the appointment for the visit was not scheduled,
182 rapidly redirecting patients to other therapies (Supplementary table 1). Among the 88 remaining
183 patients referred with *eRW-LT*, at the time of the first visit the latter was judged inappropriate by the
184 transplant hepatologist in 5 cases (5.1% of the total referred with *eRW-LT*) (Supplementary Table 2).
185 Regarding patients referred using *tRs*, all visits were scheduled and judged inappropriate at the time of
186 the first visit in 65/161 (40.4%) and 42/96 (43.8%) cases with old *tRs* and with new *tRs*, respectively.
187 As shown in Figure 3, the difference in the distribution of appropriateness using *eRW-LT* versus *tRs*
188 from both periods was highly significant ($P < 0.0001$). As regards the frequency of causes of
189 inappropriateness (Supplementary table 3): a) in those referred with the new *tRs*, compared to those
190 referred with the old *tRs*, the contraindications were higher and the incomplete clinical documentation
191 was lower; b) in those referred with *eRW-LT*, compared to those of the same period referred with new
192 *tRs*, the contraindications were lower and the lack of an accepted indication for referral was higher.
193 With *eRW-LT* the incompleteness of clinical documentation was absent.

194

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

197 All visits related to referrals obtained with old *tRs* and with new *tRs* were booked for the first available
198 appointment without following any triage criteria. Among the 83 patients referred with *eRW-LT* who
199 obtained the appointment for the first visit and this was judged appropriate by the transplant specialist,
200 the latter defined 18 (21.7%) as urgent and planned to be overbooked. The remaining 65 (78.3%) visits
201 were scheduled as first available. As shown in Figure 4, median waiting time in days between referral
202 date and first appropriate visit appointment was significantly shorter for urgent visits referred with
203 *eRW-LT* (5.0 [95% CI 4.8-9.3]) compared to non-urgent visits sent with the same system (17.0 [95%
204 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
205 new *tRs* (16.0 [95% CI 10.0-23.0]; $P < 0.001$).

206 Finally, we found a negative correlation between MELD-R, the score used to prioritize patients they
207 eventually enter the waiting list, and the time frame between the referral date and the first visit
208 appointment, only for patients referred using *eRW-LT* ($r = -0.412$, $P < 0.0001$), but not for patients
209 referred with *tRs* (Supplementary Figure 3). Although the introduction of *eRW-LT* increased the
210 percentage of referred patients who were then evaluated for transplantation, it had no impact on listing
211 and transplant rates (Supplementary table 4).

212

213

214 **DISCUSSION**

215

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

230 As for the 88 patients referred with *eRW-LT* for whom the first outpatient visit was booked and
231 carried out, we had two further favorable effects of our system: a percentage of inappropriateness
232 judged at the time of the first visit much lower than that of *tRs* and the reduction of the waiting time
233 for the first visit in urgent cases. In fact, the transplant hepatologist judged inappropriate only 5 (5.7%)
234 first visits booked with *eRW-LT*, but as many as 40.4% and 43.8% of those booked with *tRs*, during
235 the first and the second period of the study, respectively. Again, the reason for the few inappropriate
236 visits with *eRW-LT* was mostly compensated liver disease, which rapidly had improved after the
237 referral. Contraindications as a cause of inappropriateness were reduced, thanks to the educational
238 links on *eRW-LT* and the online interaction with the transplant hepatologist, despite the patients in the
239 second period of the study having more comorbidities.

240 With *eRW-LT*, out of 83 appropriately referred patients, 18 (21.7%) were judged urgent and obtained
241 an appointment for the first overbooked visit. In this way, their waiting time for the first visit was
242 significantly shorter than in patients referred with *tRs*, for which it was not possible to do a triage
243 because the clinical data available were insufficient or even absent. Conversely, *eRW-LT* requires the
244 referring physician to enter the minimum clinical documentation necessary to judge the urgency of the
245 referral. With *eRW-LT*, but not with *tRs*, we found an inverse correlation between the waiting time
246 from the referral date to the appointment date for the first visit and the MELD-R score which is used to
247 prioritize patients in waiting list.²⁰ This is desirable since, even among patients who start transplant
248 evaluation as outpatient, some have such advanced disease that they are at risk of not reaching the
249 transplant due to complications. These patients represent a fair number considering that the patients
250 who had started the evaluation of the transplant during a hospitalization during the study period, and
251 who were not included in the study, were only 35% of the total patients considered for transplantation
252 (data not shown).

253 Other studies have described the use of telemedicine in the field of evaluation before LT. Two studies
254 from the Richmond VA LTC, as part of the Specialty Care Access Network - Extension of Community
255 Healthcare Outcomes (SCAN-ECHO), reported that all 91 patients referred with an electronic system
256 were admitted to the first face-to-face visit at the transplant center²² and that electronically completing
257 the entire pre-LT assessment led to a substantial reduction in time from referral to initial evaluation by
258 a hepatologist and placement on the LT waitlist.²³ SCAN-ECHO physicians are part of a specific
259 educational program within the VA system, are liver disease experts and can either complete a full
260 workup and submit a referral or request an initial triage through electronic consult. This type of
261 electronic referral counseling from gastroenterologists / hepatologists was also adopted in another
262 study by the Houston / El Paso group.²⁴ In contrast, in our present study only 39% of patients were
263 referred by gastroenterologists / hepatologists and this may explain the difference in our results
264 compared to those obtained with the SCAN-ECHO system in terms of appropriateness and effect on
265 listing. Even though our study was done before the COVID-19 pandemic, the use of our *eRW-LT*
266 system, like other telemedicine technologies that reduce the risk of viral transmission, has the
267 advantages of applicability, convenience, cost effectiveness and is even more advisable and useful
268 during the COVID-19 pandemic and for the future.²⁵ However, we believe that when the referring
269 physicians are also non-gastroenterologists / hepatologists and the distance between the LTC and the
270 patients' place of residence is not too great, as in our study, patients should undergo their first and
271 subsequent visits in face-to-face mode and complete the pre-listing assessment at the LTC.

272 The novelty of our study is therefore that *eRW-LT* can be used quickly and easily even by referring
273 physicians who are not experts in liver disease, who are asked for the essential information to judge

274 the appropriateness and triage of the first visit. Furthermore, the system has an educational value for
275 the links present on the site and for the interactions with transplanted hepatologists.

276 The study has some limitations: it is an observational study, patients were not randomized to either
277 method of referral and the study was conducted in only two LTCs. Furthermore, since there are no data
278 on referrals to other Italian LTCs, we cannot say with certainty whether the increase in referrals in our
279 study was a true increase driven by convenience of using *eRW-LT* or a reflection of increased referrals
280 nationwide. However, the introduction of *eRW-LT* seems to have contributed significantly as, at
281 national level, new registrations on the waiting list had increased in 2017 but then in 2018 had dropped
282 to slightly lower values than in 2016.²⁶ In our study, on the other hand, we had the peak of referrals
283 starting from the second half of 2017 until the end of 2018. The increase in referrals therefore, at least
284 in part, was due to the training events we implemented, to the educational links on the site and the
285 characteristics of *eRW-LT* such as the ease of obtaining an appointment quickly, the possibility of co-
286 management of the patient by the referring physician together with the transplant hepatologist and the
287 fact that all contacts between the two doctors are tracked for legal purposes. Finally, the introduction
288 of *eRW-LT* did not lead to an increase in listings and transplants performed. The latter is expected due
289 to the limited number of donors. The failure to increase the patients listed could be explained by the
290 fact that the patients referred in the second part of the study, and in particular the older ones referred
291 with *eRW-LT*, had more comorbidities, leading to an increase in excluded patients.

292 In summary, our results show the usefulness of an electronic referral system to obtain the first LT
293 evaluation outpatient visit for candidates with end stage liver disease. The introduction of our
294 telemedicine tool was associated with an increase in the number of referrals, a reduction in
295 inappropriate visits and waiting times to obtain the first visit, as well as a triage of the latter according
296 to the severity of the patients. Further studies are needed to confirm our data in other countries and in
297 the field of other organ transplants such as kidney transplants where the problem of suboptimal referral
298 exists.²⁷

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

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

	9	0 (0.0)	0 (0.0)	1 (1.0)			
	Long distance from home to the LTC (outside the Lazio Region), n (%)	31 (19.3)	18 (18.8)	13 (13.1)	0.201	0.283	0.921
Referring physician	Specialty gastroenterology/hepatology, n (%)	55 (34.2)	37 (38.5)	46 (46.5)	0.048	0.263	0.479

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386

387 Data are expressed as median and interquartile range or as proportions.

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389 *eRW-LT*: electronic referral website for LT; HCC: hepatocellular carcinoma; LTC: LT center;

390 MELD: model for end-stage liver disease; MELD-R: regional model for end-stage liver disease; old

391 *tR*: traditional referral in the older era; new *tR*: traditional referral in the most recent era.

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396 **Figure legends**

397

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

400

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

403

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

406

407 **Figure 4.** Box plots of the time elapsed between the referral date and the one for which the first
408 visit was booked in all visits referred with traditional methods (*tRs*) and in those booked with *eRW-*
409 *LT*, also divided into urgent and non-urgent subgroups, and according to appropriateness.410 *** P<0.001 and ** P<0.01 vs urgent visits referred with *eRW-LT*

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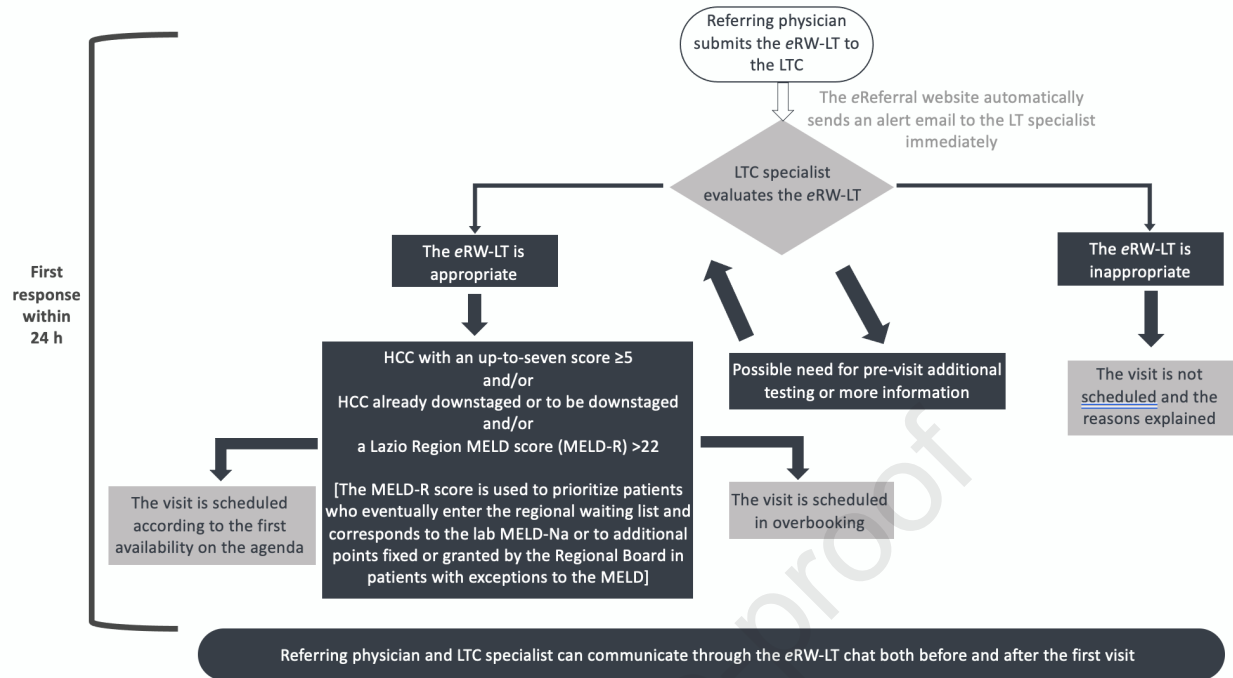
Table 1. Patient demographic and clinical variables and specialty of the referring physician according to the referral system and study era

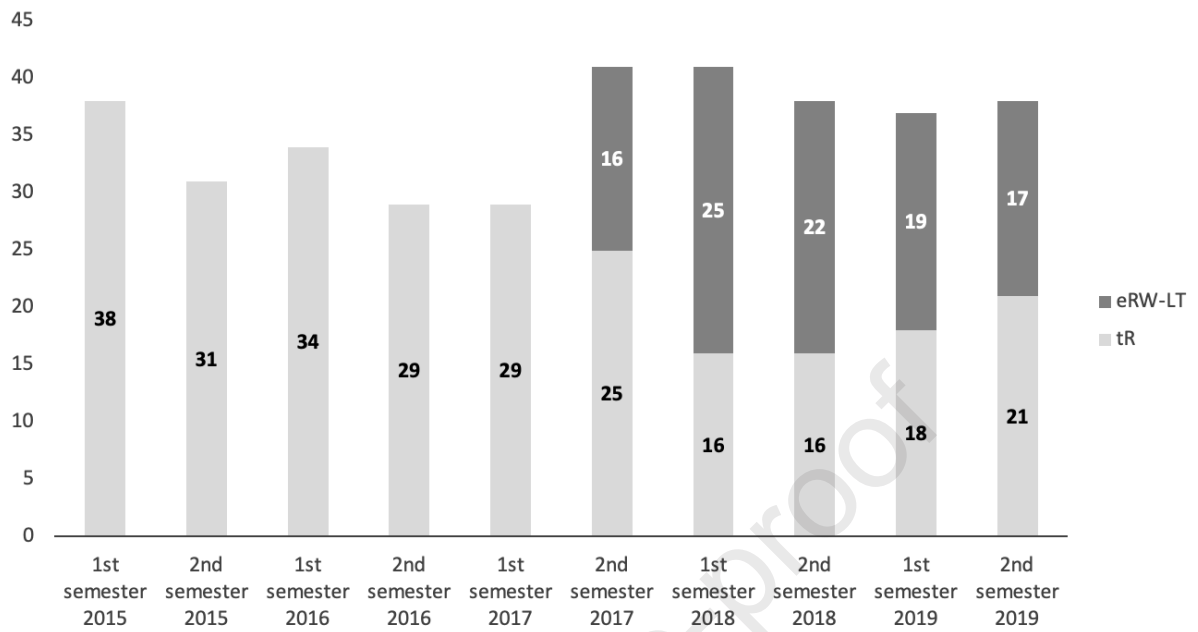
		old tR n= 161	new tR n= 96	eRW-LT n=99	P value old tR vs eRW- LT	P value new tR vs eRW- LT	P value old tR vs new tR
Patient	Age (years)	56 (51-61)	55 (48-61)	56 (49-63)	0.698	0.450	0.580
	Sex male, n (%)	129 (80.1)	69 (71.9)	77 (77.8)	0.651	0.342	0.128
	Etiology, n (%)				0.095	0.437	0.453
	Alcohol	47 (29.2)	33 (34.4)	38 (38.4)			
	Virus	51 (31.7)	22 (22.9)	17 (17.2)			
	Alcohol+Virus	22 (13.7)	14 (14.6)	19 (19.2)			
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2	10 (6.2)	22 (22.9)	19 (19.2)				
3	2 (1.2)	7 (7.3)	6 (6.1)				
4	0 (0.0)	4 (4.2)	7 (7.1)				
5	1 (0.6)	3 (3.1)	1 (1.0)				
6	1 (0.6)	2 (2.1)	3 (3.0)				
7	0 (0.0)	0 (0.0)	1 (1.0)				
8	0 (0.0)	0 (0.0)	1 (1.0)				

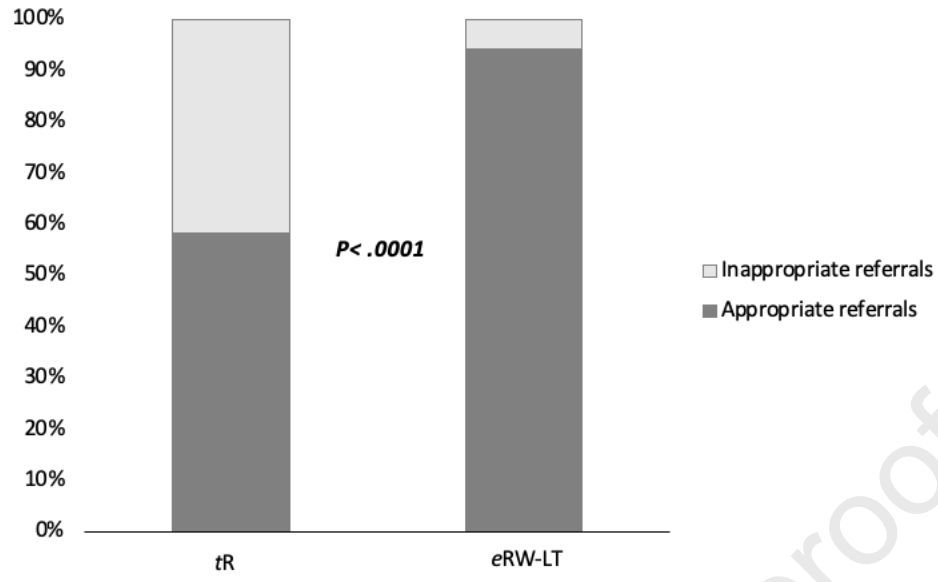
	9	0 (0.0)	0 (0.0)	1 (1.0)			
	Long distance from home to the LTC (outside the Lazio Region), n (%)	31 (19.3)	18 (18.8)	13 (13.1)	0.201	0.283	0.921
Referring physician	Specialty gastroenterology/hepatology, n (%)	55 (34.2)	37 (38.5)	46 (46.5)	0.048	0.263	0.479

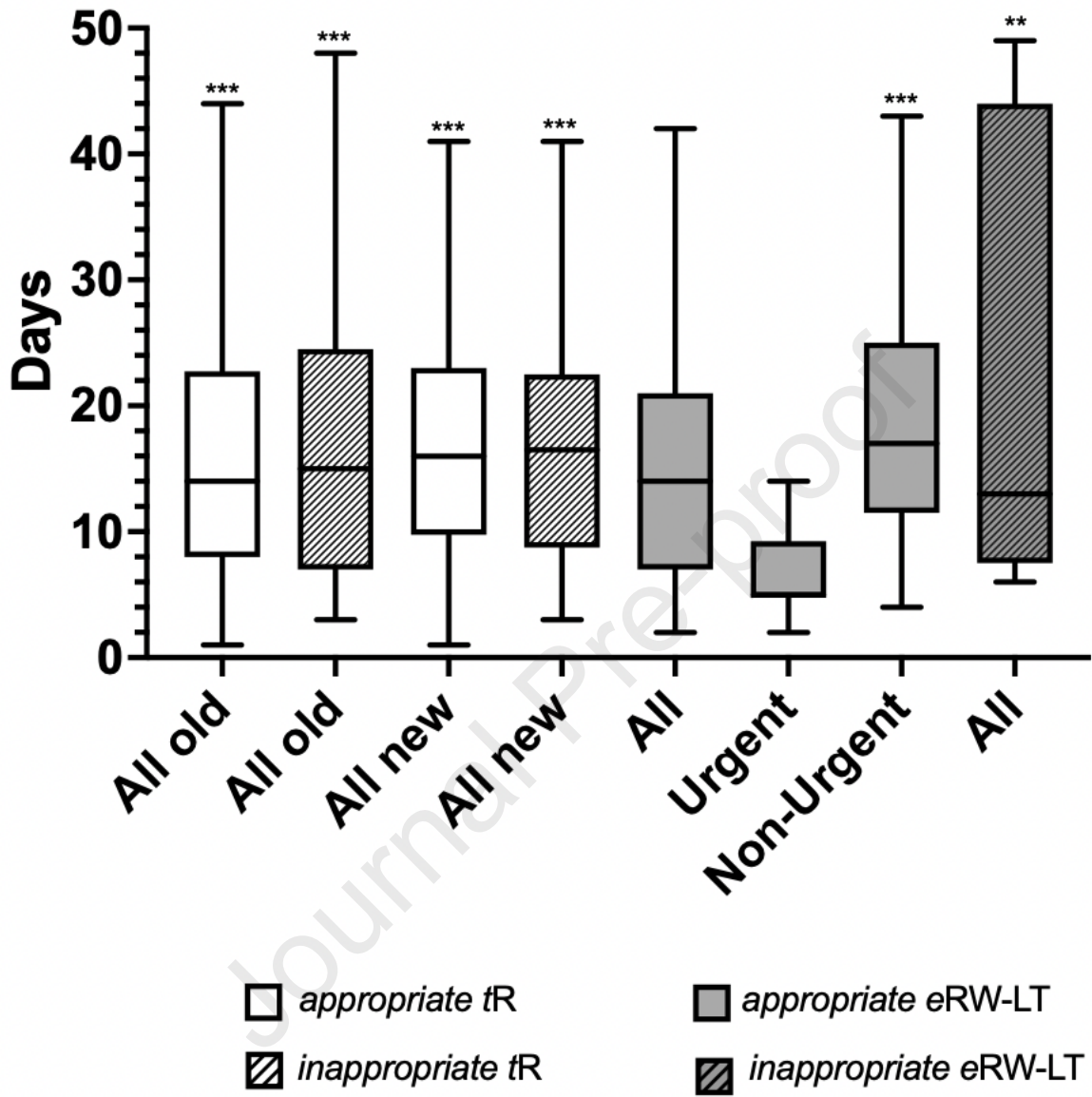
Data are expressed as median and interquartile range or as proportions.

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.









1 SUPPLEMENTARY METHODS

2

3 PATIENTS and METHODS

4

5 In June 2017 at the "Sapienza" University liver transplant center (LTC), in collaboration with
6 "Consorzio Innovo" and with the "Tor Vergata" University LTC, we completed the development of
7 the *eRW-LT* website (URL: www.ereferral.it) for the outpatient referral of liver transplant (LT)
8 candidates to the two above mentioned LTCs of Rome, Lazio region, Italy. Starting from December
9 2016 until November 2017, *eRW-LT* was promoted and advertised in the annual meetings of the Lazio
10 regional sections of the Italian Federation of Societies of Diseases of the Digestive System and of the
11 Federation of Associations of Internist Hospital Doctors, in two specific residential courses organized
12 at Sapienza and Tor Vergata Universities, which also included an online training course and through
13 an interview held by two of the authors (GCS and AM) in a daily newspaper dedicated to medical
14 doctors. On all these occasions, the issues of the sub-optimal referral for LT and the recommendations
15 for a correct referral were also illustrated. The Lazio Regional Transplant Center, the Professional
16 Order of Medical Doctors of Rome, The Italian Federation of Family Doctors and the Lazio Regional
17 Council were also involved to advertise the project.

18 We prospectively collected data on all referrals received for outpatient LT visits received from January
19 1, 2015 until December 31, 2019. During the entire study period we received referrals with traditional
20 methods (*tRs*) that were not standardized and involved multiple steps mainly by telephone and by
21 email and fax. In the second half of the study, from 1 July 2017 to 31 December 2019, as an alternative
22 to the *tRs*, it was possible for the referring doctors to send patients with electronic referral using *eRW-*
23 *LT*. We divided the patients into three groups according to the method and time of referrals: a) those
24 referred with *tRs* before the introduction of *eRW-LT* from 1 January 2015 to 30 June 2017 (old *tRs*);
25 b) those referred with *tRs* in the same time frame in which the *eRW-L* was used from 1 July 2017 to
26 31 December 2019 (new *tRs*) and c) those referred with *eRW-LT* from 1 July 2017 to 31 December
27 2019.

28 The referral appropriateness was assessed prospectively by a transplant hepatologist (GCS, AM, FF,
29 MM, IL) appointed by the certification of the Italian Association for the Study of the Liver (AISF)¹⁷.
30 In the case of *eRW-LT*, the appropriateness was judged both at the time of online referral, sometimes,
31 if necessary, after exchange of information with the referring physician, and at the time of the first
32 face-to-face visit, when this was carried out. In the case of *tRs*, all requested visits have been
33 performed and their appropriateness was judged at the time of the visit. All judgments of
34 appropriateness were subsequently checked blindly by a transplant hepatologist belonging to the LTC

35 other than the one where the referral was sent (FF and MM), who agreed 100% with the initial
36 judgments. Appropriateness was judged on the basis of the simultaneous presence of all the following
37 criteria: 1) availability of sufficient clinical documentation; 2) presence of an accepted indication to
38 referral for the first transplant visit^{14,15}; 3) absence of known absolute contraindications to listing.

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

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

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

54 We have prospectively collected data on all consecutive traditional referrals (tRs) from January 1st
55 2017, 6 months before the start of using eRW-LT, until December 31st 2019, and all electronic
56 referrals using eRW-LT from June 1st 2017 until December 31st 2019.

57 The referral appropriateness was assessed by a transplant hepatologist (GCS, AM, FF, MM, IL)
58 appointed by the certification of the Italian Association for the Study of the Liver (AISF)¹⁸. In the
59 case of eRW-LT, the appropriateness was judged both at the time of online referral, sometimes, if
60 necessary, after exchange of information with the referring physician, and at the time of the first face-
61 to-face visit, when this was carried out. In the case of tRs, all requested visits have been performed and
62 their appropriateness was judged at the time of the visit. All judgments of appropriateness were
63 subsequently checked blindly by a transplant hepatologist belonging to the LTC other than the one
64 where the referral was sent (FF and MM), who agreed 100% with the initial judgments.
65 Appropriateness was judged on the basis of the following criteria: 1) availability of sufficient clinical
66 documentation (i.e. blood sampling with data needed for the MELDNa score calculation); 2) presence
67 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 ¹⁹; 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 score²⁰. 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 Board²¹. 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 MELDNa score¹⁸, 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 eRWT 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

103 a brief history of the patient and the indication for LT in free text format. An automated email
104 immediately notifies a designated transplant hepatologist reviewer that a new referral has arrived, and
105 the latter responds within 24 hours to each referral request. The transplant hepatologist reviewer uses
106 the eRW-LT system to communicate with the referring physician to obtain additional patient
107 information if necessary. Whenever the two doctors receive a communication from the other on the
108 site, an automated email immediately alerts them to enter the site to respond. The specialist reviewer
109 can already schedule an appointment for the first visit with the right triage at the first response, if
110 deemed appropriate. Alternatively, an iterative communication begins between the two doctors if the
111 clinical documentation is judged to be implemented by the specialist reviewer. In this way, too early
112 referrals are avoided and, once the communication is completed, the specialist reviewer can schedule
113 an appointment with the right timing based on the urgency or, in cases where the visit is deemed
114 inappropriate, redirect the patient to other specialists. A further utility of the eRW-LT is educational.
115 In fact, the site provides links to the most up-to-date literature on transplantation and referral for
116 referring doctors. To judge whether the patients referred with eRW-LT were entitled to an urgent visit
117 appointment, we used at least one of the following criteria: 1) HCC with an up-to-seven score ≥ 5 ¹⁹; 2)
118 HCC already downstaged or to be downstaged; 3) a Lazio Region MELD score (MELD-R) >22
119 (Figure 1). The MELD-R score is used to prioritize patients who eventually enter the regional waiting
120 list, also considering any additional points for MELD exceptions²⁰. The MELD-R score corresponds
121 to the MELDNa score or, for patients in whom the transplant indication is an exception to the MELD
122 system, the MELD-R was defined by additional points fixed or granted by the Regional Board²⁰. For
123 example, for patients with HCC, if the laboratory MELDNa score was less than 18, the MELD-R at
124 registration was 18, otherwise they were listed with a MELD-R corresponding to their MELDNa score.
125 Triage was not an option for visits of patients referred with tRs.

126 ~~The website was developed using the Debian Server (v 7.0 and its latest updated versions) as operating~~
127 ~~system and LAMP as web service stack, which include the use of: the Linux operating system, the~~
128 ~~Apache HTTP Server, the MySQL relational database management system (RDBMS), and the~~
129 ~~hypertext preprocessor scripting language. The operation of the eRW-LT is described in **Figure 1**.~~
130 ~~Briefly, the primary care practitioner or another specialist, after obtaining the patient's consent, submits~~
131 ~~a referral request through eRW-LT, available on the website www.eReferral.it. The referring physician~~
132 ~~logs in and is informed that the use of the website is not intended for patients who require expedite~~
133 ~~inpatient evaluation for severe acute hepatitis, acute liver failure, acute on chronic liver failure or a~~
134 ~~MELDNa score greater than 30. The referring physician can choose the Center via a drop-down menu~~
135 ~~that changes randomly each time the order in which the LTCs appear. Then he is asked to enter the~~
136 ~~patient's personal data and the blood tests for calculating the MELD and MELDNa score, which are~~

137 automatically calculated by the system, with the date of the relative blood sampling. In the event that
138 these blood tests had not been performed on the same date, or were dated prior to 30 days before the
139 referral, an automated alert for the referring physician appears on eRWT to request a new blood
140 sample. The referring physician can also attach reports of other analyzes and radiological and
141 endoscopic examinations and can write a message to the specialist with a brief history of the patient
142 and the indication for LT in free text format. An automated email immediately notifies a designated
143 transplant hepatologist reviewer that a new referral has arrived, and the latter responds within 24 hours
144 to each referral request. The transplant hepatologist reviewer uses the eRW-LT system to communicate
145 with the referring physician to obtain additional patient information if necessary. Whenever the two
146 doctors receive a communication from the other on the site, an automated email immediately alerts
147 them to enter the site to respond. The specialist reviewer can already schedule an appointment for the
148 first visit with the right triage at the first response, if deemed appropriate. Alternatively, an iterative
149 communication begins between the two doctors if the clinical documentation is judged to be
150 implemented by the specialist reviewer, or thanks to some automated steps of the eRW-LT system that
151 allow to verify the completeness and recent execution of laboratory and imaging tests. In this way, too
152 early referrals are avoided and, once the communication is completed, the specialist reviewer can
153 schedule an appointment with the right timing based on the urgency or, in cases where the visit is
154 deemed inappropriate, redirect the patient to other specialists. A further utility of the eRW-LT is
155 educational. In fact, the site provides links to the most up to date literature on transplantation and
156 referral for referring doctors.

157

158 **Supplementary Figure 1.** Structured query language (SQL) of the eRW-LT software. Note that the
159 blood tests required for the calculation of the MELD and MELDNa scores (see the end of this Figure)
160 are entered in the "CREATE TABLE` bridgePatientScreenings" area of the general SQL.

161

```

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,

```

```

`fkScreening` int(10) NOT NULL,
`fkPatientDetails` int(255) NOT NULL,
`value` varchar(50) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
`date` date NOT NULL,
`fkScreeningScanning` int(255) NULL DEFAULT NULL,
`dialysis` int(1) NULL DEFAULT NULL,
PRIMARY KEY (`idBridgePatientScreening`) USING BTREE,
INDEX `fkPatientDetails`(`fkPatientDetails`) USING BTREE,
INDEX `fkScreening`(`fkScreening`) USING BTREE,
INDEX `fkScreeningScanning`(`fkScreeningScanning`) USING BTREE
) ENGINE = InnoDB AUTO_INCREMENT = 1934 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,

```

```

`fkProvince` int(255) NOT NULL,
`name` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NOT NULL,
PRIMARY KEY (`idCity`) USING BTREE,
INDEX `fkProvince`(`fkProvince`) USING BTREE
) ENGINE = InnoDB CHARACTER SET = utf8 COLLATE = utf8_general_ci ROW_FORMAT = Dynamic;

```

```

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` (
  `idDettaglioDsr` 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 (`idDettaglioDsr`) 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,
```

```

`email` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
`nationality` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
`spokenLanguage` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
`exemptionCode` varchar(255) CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
`notes` text CHARACTER SET utf8 COLLATE utf8_general_ci NULL DEFAULT NULL,
`active` tinyint(1) NOT NULL DEFAULT 1,
`deleted` tinyint(1) NOT NULL DEFAULT 0,
PRIMARY KEY (`idPatientDetails`) USING BTREE
) ENGINE = InnoDB AUTO_INCREMENT = 474 CHARACTER SET = utf8 COLLATE = utf8_general_ci
ROW_FORMAT = Dynamic;

```

```

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 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 `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;

```



```

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 AUTO_INCREMENT = 255 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 `bridgeAltroEsamePaziente_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 `dsrDetails` ADD CONSTRAINT `dettaglioDsr_ibfk_1` FOREIGN KEY (`fkUser`) REFERENCES
`users` (`idUser`) ON DELETE CASCADE ON UPDATE CASCADE;
```

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

```
ALTER TABLE `extentionCirrhosis` ADD CONSTRAINT `extraCirrosi_ibfk_1` FOREIGN KEY
(`fkPatientClinicalDetails`) REFERENCES `patientClinicalDetails` (`idClinicalPatientDetails`) ON DELETE
CASCADE ON UPDATE CASCADE;
```

```
ALTER TABLE `login` ADD CONSTRAINT `login_ibfk_1` FOREIGN KEY (`fkUser`) REFERENCES `users` (`fkUser`)
ON DELETE CASCADE ON UPDATE CASCADE;
```

```
ALTER TABLE `patientClinicalDetails` ADD CONSTRAINT `dettaglioClinicoPaziente_ibfk_1` FOREIGN KEY
(`fkPatientDetails`) REFERENCES `patientDetails` (`idPatientDetails`) ON DELETE CASCADE ON UPDATE
CASCADE;
```

```
ALTER TABLE `referral` ADD CONSTRAINT `referral_ibfk_1` FOREIGN KEY (`fkUser`) REFERENCES `users`
(`idUser`) ON DELETE CASCADE ON UPDATE CASCADE;
```

```
ALTER TABLE `referral` ADD CONSTRAINT `referral_ibfk_2` FOREIGN KEY (`fkDsr`) REFERENCES `users`
(`idUser`) ON DELETE CASCADE ON UPDATE CASCADE;
```

```
ALTER TABLE `referral` ADD CONSTRAINT `referral_ibfk_3` FOREIGN KEY (`fkReferralState`) REFERENCES
`referralState` (`idReferralState`) ON DELETE NO ACTION ON UPDATE CASCADE;
```

```
ALTER TABLE `referral` ADD CONSTRAINT `referral_ibfk_4` FOREIGN KEY (`fkTransplantCenter`) REFERENCES
`transplantCenter` (`idTransplantCenter`) ON DELETE CASCADE ON UPDATE CASCADE;
```

```
ALTER TABLE `referral` ADD CONSTRAINT `referral_ibfk_5` FOREIGN KEY (`fkPatientDetails`) REFERENCES
`patientDetails` (`idPatientDetails`) ON DELETE CASCADE ON UPDATE CASCADE;
```

```
ALTER TABLE `users` ADD CONSTRAINT `utenti_ibfk_1` FOREIGN KEY (`fkRole`) REFERENCES `roles` (`idRole`)
ON DELETE CASCADE ON UPDATE CASCADE;
```

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```
INSERT INTO `screenings`(`idScreening`, `name`) VALUES (1, 'BILIRUBIN');
```

```
INSERT INTO `screenings`(`idScreening`, `name`) VALUES (2, 'INR');
```

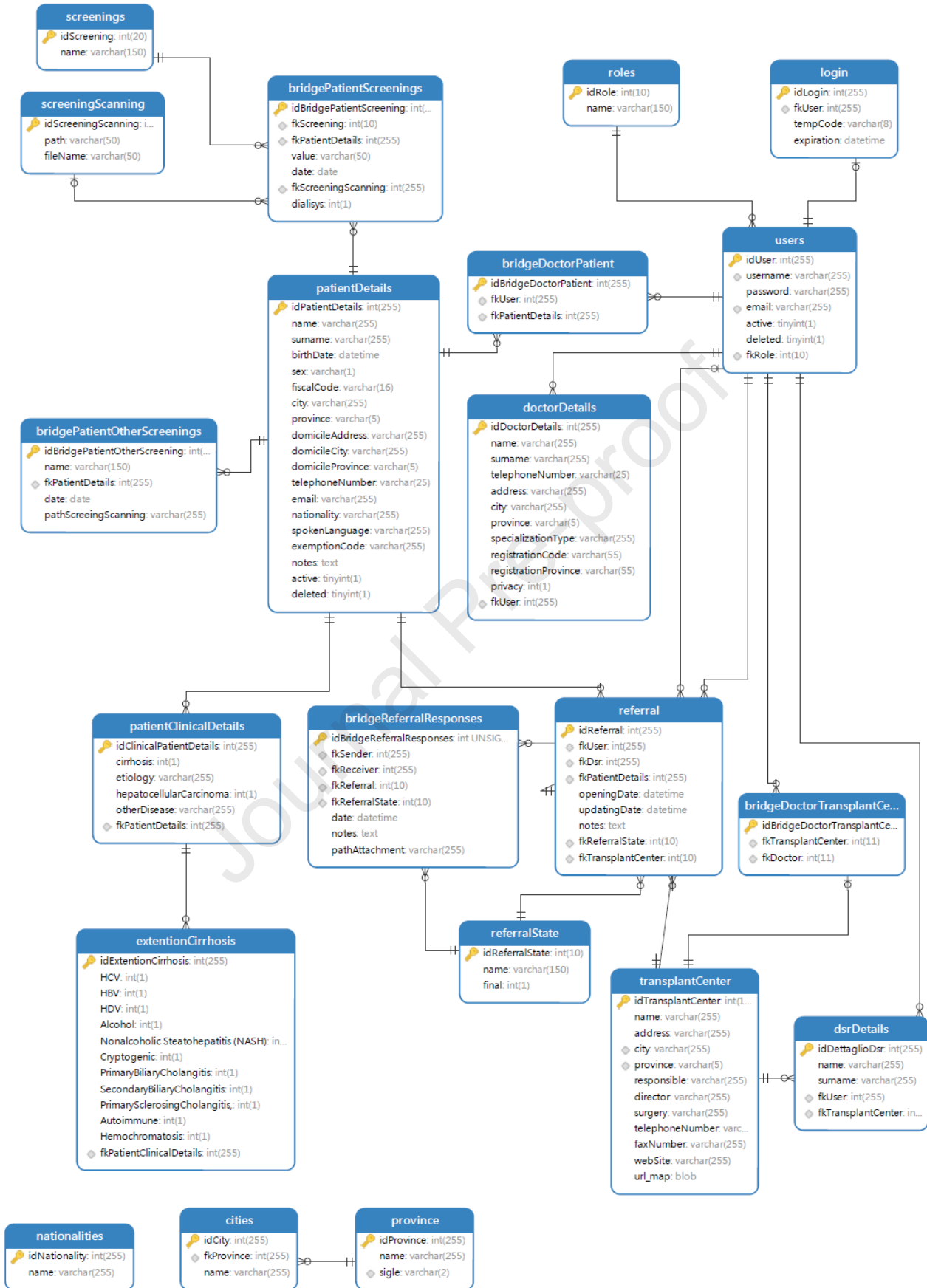
```
INSERT INTO `screenings`(`idScreening`, `name`) VALUES (3, 'CREATININE');
```

```
INSERT INTO `screenings`(`idScreening`, `name`) VALUES (4, 'SODIUM');
```

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184 **Supplementary Figure 2.** Graphic representation of the Structured Query Language (SQL) of the
185 *eRW-LT* software. Each box represents a table, while the lines indicate the fields present in the table,
186 which will contain the data entered through the software. The lines that connect the various boxes
187 represent the relationships between the tables.

188



193
 194 **Supplementary Figure 3.** Screenshots of the eRW-LT referral procedure illustrating the main steps of
 195 its operation (English translations are provided)

196

A Home page at www.eReferral.it and login procedure of the referring physician

The web portal for the doctor who wants to send a patient for hepatological evaluation of suitability for liver transplantation

Attention, system suitable only for elective transplantation! For cases in which the consultation must take place immediately (acute liver failure), contact your referral transplant center

Sign in

Quick and easy to use
Privacy / Guidelines

Reset password

197

198

B

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

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

Per effettuare l'accesso al sistema inserire il seguente codice di accesso temporaneo:
Il codice di accesso sarà attivo fino al . alle ore 19:34:00

Inserisci il codice temporaneo ricevuto via mail.

Accedi

Annulla

Log in

Cancel

199

C

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

Invio di eReferral

Centro di Trapianti

Seleziona Centro di Trapianto

Nota

Annulla ✕

Invia ✓

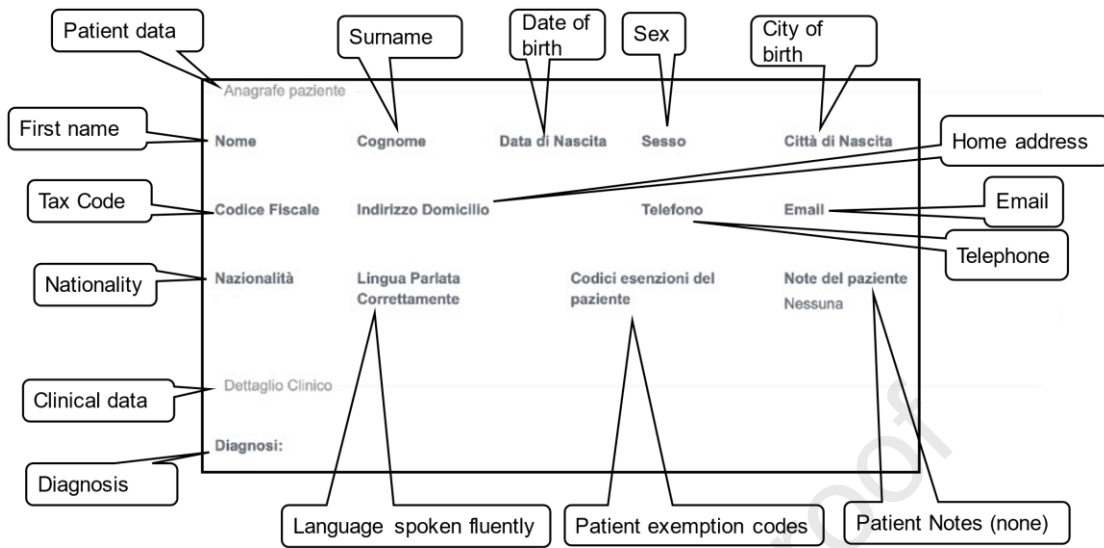
Send

Cancel

200

D

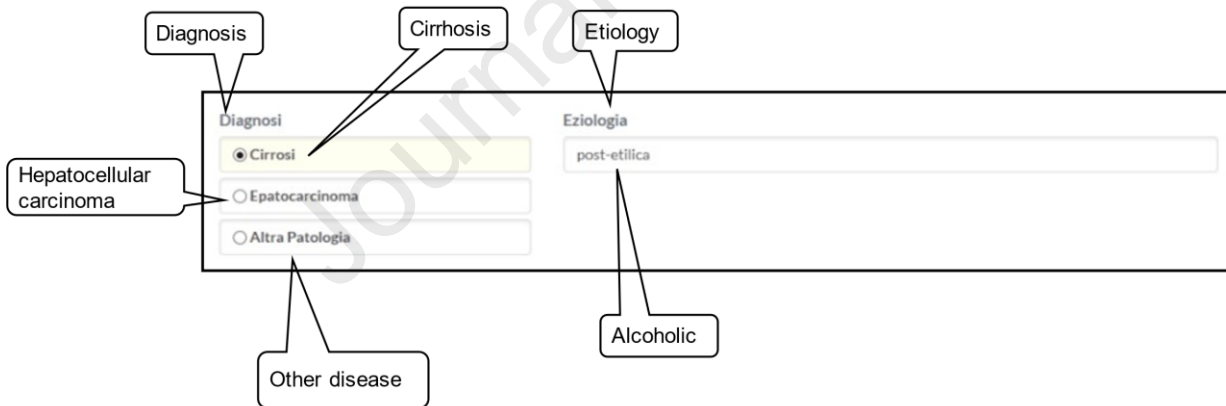
The referring physician enters the patient's mandatory demographics and diagnosis



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E

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



202

F

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

Tipo Valore	Valore	Data	Scansione
BILIRUBINEMIA	2.43 mg/dL	11/09/2018	-
CREATININEMIA	0.83 mg/dL	11/09/2018	-
INR	1.39	11/09/2018	-
SODIEMIA	132 mEq/L	11/09/2018	-

Vista da 1 a 4 di 4 elementi

MELD e MELDNa calcolati

MELD	13.5	MELD-Na	18.8
------	------	---------	------

203

G

The referring physician can upload additional exams

Tipo Esame	Data	Scansione
TC ADDOME CON MDC	mar 28, 2018	Vedere Scansione

Vista da 1 a 1 di 1 elementi

204

H

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

Answered February 13, 2018 at 8:43:01 AM
Sent by:

waiting for the updated blood tests for MELD- Na

Risposta del 13/02/2018 08:43:31
Inviata da:
Stato: IN ATTESA DI RISPOSTA

In attesa degli esami per il MELD-Na aggiornati

Status: AWAITING RESPONSE

Answered February 12, 2018 at 6:05:52 PM
Sent by:

Risposta del 12/02/2018 18:05:52
Inviata da:
Stato: PAZIENTE TEMPORANEAMENTE NON IDONEO

Gli esami del sangue bilirubina, creatinina, INR e sodio inseriti nel sistema sono troppo vecchie dev ono esser ripetuti ed inviati al più presto

the blood tests for bilirubin, creatinine, INR and sodium entered in the system are too old and must be repeated and sent again as soon as possible

Status: PATIENT TEMPORARILY NOT ELIGIBLE

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227 SUPPLEMENTARY RESULTS

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

230

	Reason for inappropriateness
Patient 1	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 <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
Patient 2	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 <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
Patient 3	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 <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
Patient 4	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
Patient 5	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 <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
Patient 6	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
Patient 7	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 <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
Patient 8	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 <10 with no HCC or other MELD exceptions. The patient was referred to the
	Reason for inappropriateness
Patient 12	Absence of an accepted indication to referral for the first transplant visit Cirrhosis” outpatient service in the same hospital of Liver Transplant Center
Patient 9	(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 service Contraindication: The patient had a diagnosis of HCC with portal vein invasion, the patient was referred to “Hepatocellular carcinoma” outpatient
Patient 10	visit, the MELD score was 8. Contraindication: The patient was 76 years old with multiple comorbidities,
Patient 13	Absence of an accepted indication to referral for the first transplant visit the patient was referred to “Cirrhosis” outpatient service in the same hospital of Liver Transplant Center
Patient 11	(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. 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 <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

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240 **Supplementary table 2. Reasons for inappropriateness judged at the time of the first face-to-face**
241 **visit of the five patients who had been referred by eRW-LT**

	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 <i>eRW-LT</i>
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.

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255 **Supplementary table 3. Specialization of the referring physician and reasons for**
 256 **inappropriateness of referrals of patients who had been referred with traditional methods**
 257 **judged at the time of the first visit according to the study era, and of those who had been**
 258 **referred with *eRW-LT* judged both at the time of the referral and at the first visit.**

259

260

		Inappropriate old <i>t</i>Rs judged at first visit n=65	Inappropriate new <i>t</i>Rs judged at first visit n=42	Inappropriate <i>e</i>RW-LT judged at referral or at first visit n=16	<i>P</i> value old <i>t</i>Rs vs <i>e</i>RW-LT	<i>P</i> value new <i>t</i>Rs vs <i>e</i>RW-LT	<i>P</i> value old <i>t</i>Rs vs new <i>t</i>R
Reasons for inappropriateness	Absence of an accepted indication to referral for the first transplant visit (Early referral), n (%)	20 (30.8)	9 (21.4)	10 (62.5)	0.0019	0.0106	<0.0001
	Contraindications, n (%)	19 (29.2)	31 (74.0)	6 (37.5)			
	Incomplete clinical documentation, n (%)	26 (40.0)	2 (4.8)	0 (0)			
Referring physician	Specialty gastroenterology/hepatology, n (%)	12 (18.5)	12 (28.6)	3 (18.8)	1.000	0.552	0.243

261 *e*RW-LT: electronic referral website for liver transplantation; MELD: model for end-stage liver
 262 disease; old *t*Rs: traditional referral methods in the older era; new *t*Rs: traditional referral methods
 263 in the most recent era.
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283 **Supplementary table 4. Distribution with respect to the total number of referred patients of**
 284 **those subsequently placed on the waiting list and those transplanted according to the referral**
 285 **system and study era.**
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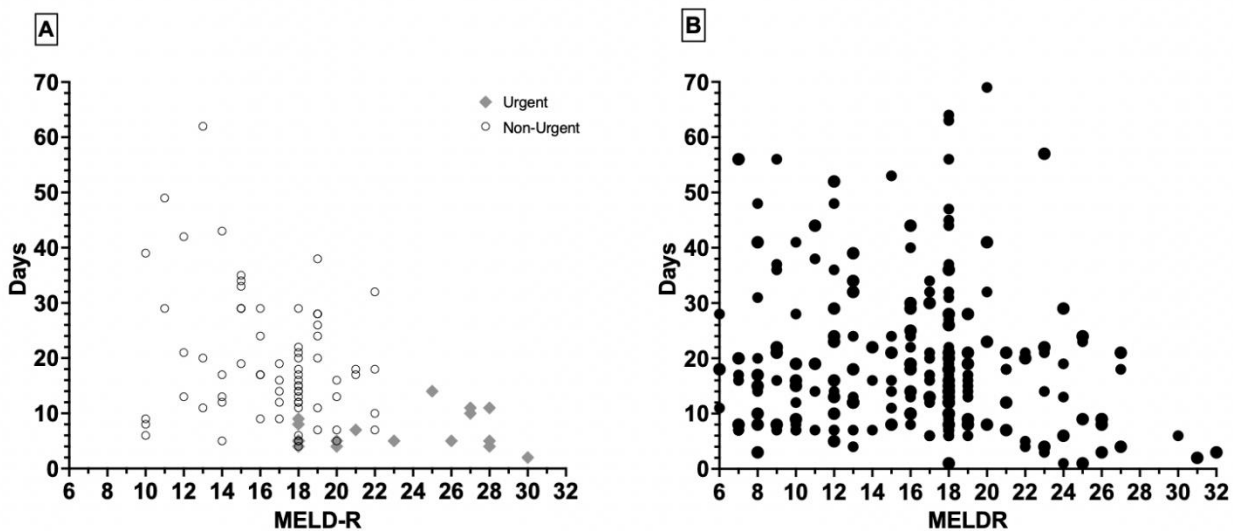
	old <i>tR</i>	new <i>tR</i>	<i>eRW-LT</i>	new <i>tRs</i> plus <i>eRW-LT</i>	<i>P value</i> old <i>tRs</i> vs <i>eRW-LT</i>	<i>P value</i> new <i>tRs</i> vs <i>eRW-LT</i>	<i>P value</i> old <i>tRs</i> vs new <i>tR</i>	<i>P value</i> old <i>tRs</i> vs new <i>tR</i> plus <i>eRW-LT</i>
Patients referred, n	161	96	99	195				
Patients evaluated, n (%)	96 (59.6)	54 (56.3)	83 (83.8)	137 (70.3)	<0.0001	<0.0001	0.689	0.047
Patients listed, n (%)	56 (34.8)	24 (25.0)	30 (30.3)	54 (27.7)	0.543	0.502	0.134	0.185
Patients transplanted, n (%)	42 (26.1)	15 (15.6)	21 (21.2)	36 (18.5)	0.458	0.413	0.072	0.109

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 288 *eRW-LT*: electronic referral website for liver transplantation; MELD: model for end-stage liver
 289 disease; old *tRs*: traditional referral methods in the older era; new *tRs*: traditional referral methods
 290 in the most recent era.
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294 **Supplementary Figure 4. Panel A:** scatter plots showing that, using *eRW-LT*, the time between the
 295 date of referral and the date the first transplant visit was booked is negatively correlated with each
 296 patient's MELD-R ($r = -0.412$, $P < 0.0001$). Empty circles refer to non-urgent visits and filled diamonds
 297 refer to urgent visits. **Panel B:** scatter plots showing that, using traditional referral methods (*tRs*), the
 298 time between the date of the referral and the date the first transplant visit was booked did not correlate
 299 with each patient's MELD-R.



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"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