CBT program to reduce recidivism risk for road crashes among adolescents and young adults: Results of a randomized controlled study and prospects☆

Sabrina Julien-Sweerts [a,*], Lucia Romo [b,c], Emilie Blot [d], Pauline Ordonneau [d], Pierre Ingrand [e], Ludovic Gicquel [d]

[a] Reims Champagne Ardenne University, C2S EA 6291, France
[b] EA 4430 Clipsyd, Paris Nanterre University, Nanterre, France
[c] Hôpital Universitaire Raymond Poincaré, Garches, France. CESP, U1018 INSERM UPS
[d] Child and Adolescent Psychiatry Department, Laborit Hospital, Poitiers, France
[e] INSERM CIC 1402, University Hospital of Poitiers, University of Poitiers, Poitiers, France

ARTICLE INFO

ABSTRACT

Road crashes are the first cause of mortality for young adults aged 18–25 years and the human factor contributes to 90–95% of events. The present study was carried out to determine the efficacy of the ECARR2 recurrence prevention program among adolescents and young adults at high risk of having a new traffic crash in the following months. A total of 288 participants having had a traffic crash that required going to the emergency room, at high risk of accident recurrence (ECARR≥5) were randomly allocated to either the intervention group ($n = 144$) or the control group ($n = 144$).

Results: revealed that the risk of recurrence was highest during the first 6 months (66% of recurrences). In per-protocol analysis population, at 6 months after inclusion, the accident recurrence rate was 14.2% ± 3.3% in the intervention group, and 23.5% ± 4.0% in the control group. The intervention had an effect per se, independently of the other predictors ($p = 0.020$). This effect was mediated by the three interaction variables: BDI, Impulsive Behavior Scale lack of perseverance, and Orientation to Happiness engagement. It was therefore through these dimensions that the intervention had an effect. In conclusion, the ECARR score predicts the risk of recurrence, risk which is the highest during the first 6 months. Finally, results confirm the predictive validity of the ECARR scale. The ECARR score had an effect on the risk of recurrence regardless of group ($p = 0.045$) and was predictive of recurrence ($p = 0.045$).

A brief psychological intervention such as ECARR2 program, offered to young people ar hight risk of having a new crash, just after the crash, seems to halve the risk of recurrence at 6 months. Future research should improve the brief psychological intervention and its access via a mobile application or few hours in high school or in a driving school given.

1. Introduction

Each year, almost 1.3 million people die in road crashes. These are the first cause of mortality for young adults aged 18–25 years [1]. Three factors have been identified as major causes: human, road environment, and vehicle. The human factor contributes to 90–95% of events [2]. Risk-taking behaviors (speed, substance abuse) inattention, inexperience, and lack of skill seem to be the main causes of this public health problem [3]. Attention deficit hyperactivity disorder (ADHD) further increases the risk of road crashes and motor vehicle injuries [4]. More surprisingly, optimism is also a risk factor, insofar as young drivers' optimism bias concerning their driving skills and accident risk perceptions, together with their tendency to perceive themselves as more skillful and less prone to driving crashes than their peers, may lead to less engagement in precautionary driving behaviors and greater engagement in more dangerous driving behaviors [5].

Even if recently some programs have been developed for children in Tanzania [6], for adolescents [7], or for adults and older individuals [8], there are very few with regard to this public health problem.

1.1. ECARR, a tool to detect the risk of recurrence

Primary prevention is important, but the recurrence rate is high: one in four adolescents who have had an accident of any type requiring emergency assistance will have a second accident within a year, and among those who have already had several accidents, the rate of recurrence is 62% [9]. "Accident of any type" includes domestic, leisure, school, occupational accidents and traffic crashes. This recurrence concerns a particular subpopulation: all indicators show that risk-taking in adolescents is frequently associated with pathological states such as depression, anxiety, suicidality, and substance use disorder [10]. One of this subpopulation's main risk factors is substance use and addictive behaviors [11]. Male and newly licensed drivers have been found to have a consistently higher risk of reoffending within 12 months [12]. In a cohort of 350 injured adolescents followed for 24 months, nearly half (45%) had a further accident requiring a visit to an emergency room [13].

Given the recurrence rate of all types of accidents among adolescents, a risk detection scale has been developed [14]. No other accident recurrence risk scale seems to exist in the scientific literature. So, research by our team led to the development of the Adolescent Risk Behavior Assessment Scale, then of a second very slightly revised version known as the Evaluation of Circumstances surrounding an Accident and the Risk of Repetition Scale (ECARR) [13]. This 12 item self questionnaire includes four items related to the circumstances of the accident (presence or absence of other people at the time of the accident, hesitation when committing, use of safety equipment, environment and and location of the accident in consistency with the activity), an item for the presence of an accident history over the past 24 month, five items investigating possible risky behaviors of the teenager (the fact of liking to drive at full speed, consuming products regularly and before the accident, being drunk, abusing during outings) and, finally, two relating to the environment (painful life events and family climate). The prospective validation study highlight that this scale has good internal and external validity, compared with the classic scales of depression, anxiety and sensation seeking, but above all has a remarkable prospective validity: a score equal to or above 5 fairly strongly predicts the recurrence of an accident within 4–9 months of the initial [13].

1.2. ECARR2, an innovative psychological program to prevent recurrence

Very few programs focused on reducing the recurrence of road accidents exist. Among them, the Reducing Youthful Dangerous Driving program uses the motivational interview method on young drivers aged 16 to 20 referred by Rhodes Island courts for traffic citation events [15]. Adolescents participated in group sessions (4 × 3 h) that used motivational interviewing methods and take part in a 3-h observation session in a trauma department to see the consequences that a road accident can have. The results showed no significant difference on recidive between the intervention group (N = 235) and control group (N = 246). However, the authors state that further research would be needed to determine whether group behavioral interventions using eg motivational interviewing could be a possible mechanism for modifying high-risk behaviors, traffic citation recidivism in young drivers.

In the face of this lack, our team, including trained behavioral psychotherapists, have created a program called ECARR2 using motivational interviewing [9].

ECARR2 is a cognitive behavioral program designed to prevent the recurrence of road traffic crashes. It is a postaccident therapeutic intervention for teenagers or young adults who have had a traffic accident that required hospitalization and who are at high risk of having another accident within 4–9 months (ECARR score ≥5). The program is aimed at drivers or road passengers, pedestrians, users of scooters and electric scooters, cyclists, and motorcyclists belonging to the sub-population with a high risk of accident recurrence.

The cognitive behavioral ECARR2 intervention developed by our team is a program based on several complementary models. It is based in part on the health action process approach [16]. This model takes account of beliefs in self-efficacy with respect to health variables, and incorporates variables such as vulnerability, perceived severity, beliefs about the consequences of behaviors, behavioral intent, and perceived self-efficacy. Health behaviors consist of two phases: motivational phase and voluntary action [17]. The program also draws on the health belief model [18], which predicts healthy or risky behaviors from factors such as cognitive scores, perceptions and beliefs, in a context where researchers are trying to understand reluctance to adopt preventive measures [19].

ECARR2 is rolled out over three sessions led by specially trained clinical psychologists, and relies on positive reinforcement, psychoeducation, motivational interviewing, cognitive restructuring, and emotional management techniques. Each session covers a different theme: risks (perception of risk, substance use, attention and concentration), others (illbeing, family and social relations), and

emotions (expression and regulation of negative emotions, impulsivity, empathy, etc.). The goal is to enable adolescents and young adults to recognize the conditions favoring fresh road crashes. The program also helps young people to better understand these risk factors and to find solutions and/or techniques to reduce the negative impact of their risky behaviors [20].

1.3. The present study

The present study was carried out to determine the efficacy of the innovative ECARR2 recurrence prevention program among adolescents and young adults with a high risk of having a new traffic crash (ECARR≥5). The main criterion was the recurrence or nonrecurrence of a road crash within 12 months of inclusion. Secondary criteria were the timing of accident recurrence and the influence of psychopathological dimensions on the risk of recurrence. More precisely, we expect an increased frequency of crash recidivism in the six months following a first traffic accident in participants at risk of recidivism, which would justify actions to prevent early recidivism and correlations between the scores of the dimensions of impulsivity, depression, and attention, in particular, and variations in the frequency of traffic crash recidivism among at-risk adolescents and young adults.
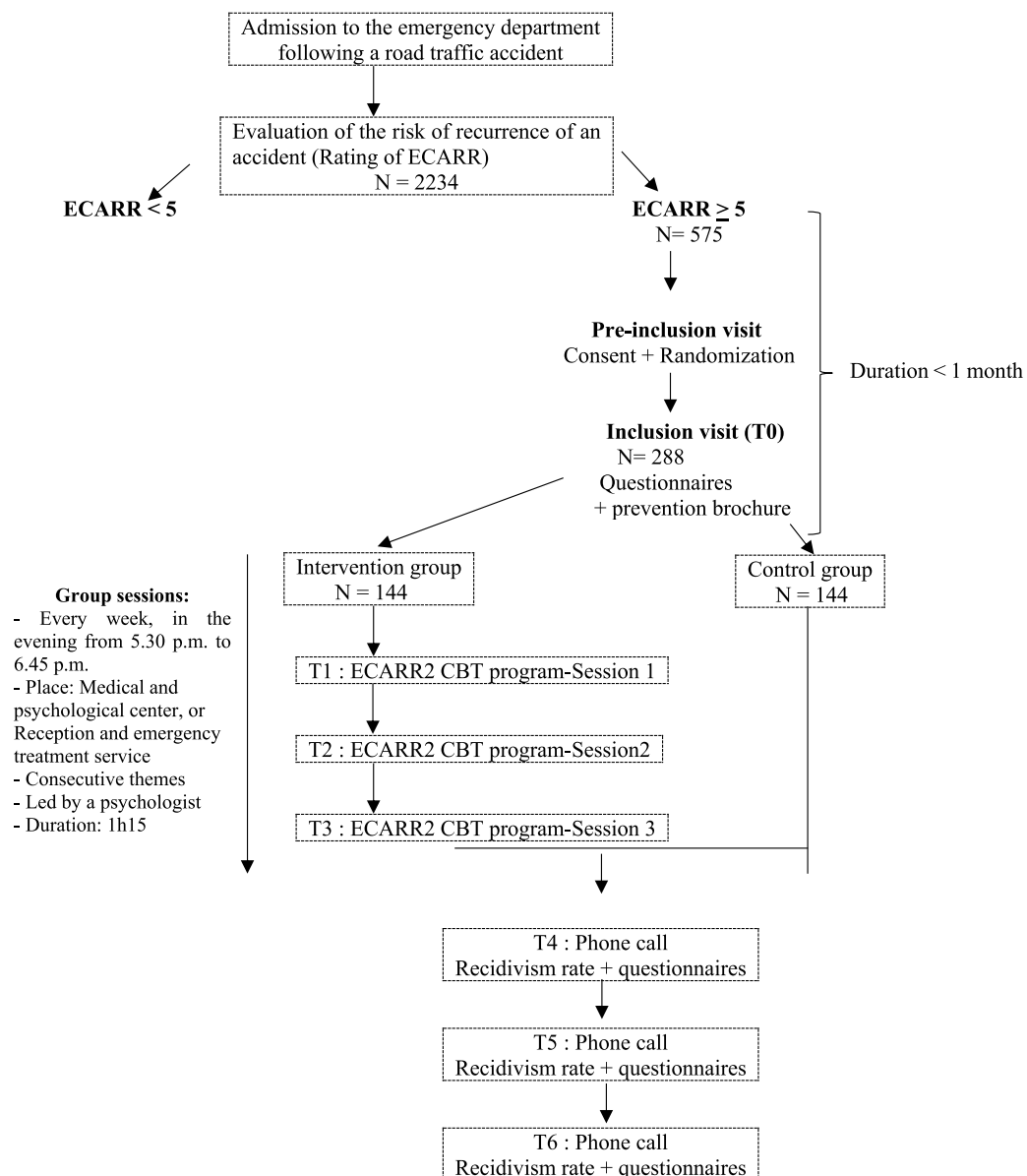
Fig. 1. Study design
N.B: T4 = 3 months after the end of ECARR2 CBT program; T5 = 6 months after the end of ECARR2 CBT program; T6 = 12 months after the end of ECARR2 CBT program.

2. Materials and methods

Ethical approval

The study was approved by an institutional review board (CPP Ouest III; protocol no. 15.06.29, ID RCB no. 2014-A00894-43 — HPS).

2.1. Study design

We conducted a multicenter (12 centers) randomized controlled research with two parallel arms.

Inclusions started on January 20, 2016 in 12 emergency rooms. Participants in the final sample were recruited in eight hospitals: Poitiers, Châtellerault, Limoges, Nantes, Angers, La Roche-sur-Yon, Les Sables d'Olonne, and Tours. Inclusions ended on July 31, 2018. Fig. 1 illustrates the study design.

2.2. Inclusion and exclusion criteria

Inclusion criteria were age 14–25 years, admission to emergency room following a road crash (first or *n*th episode) either as a driver (motor vehicle, two wheels) or pedestrian, good command of the French language, high risk of having a new traffic crash in the following months (ECARR $\geq$ 5), agreement to participate in the study (informed consent was obtained during the passage to the hospital emergency room after the participant had read and understood the information letter), and social security cover. Exclusion criteria were manic or hypomanic episode, schizophrenia, severe somatic pathology, under legal guardianship or curatorship, and participation in another program.

2.3. Instruments

Sociodemographic data and trait variables (personality trait, impulsivity, optimism …) were only collected at T0. State variables (depression, anxiety …) were measured at T0 (inclusion), T4 (three months after the ECARR2 CBT program), T5 (six months after the ECARR2 CBT program), T6 (twelve months after the ECARR2 CBT program).

2.3.1. Sociodemographic data

This first self-assessment questionnaire was divided into two parts. The first part contained five items collecting participants' sociodemographic data: sex, age, marital status, marital status's parents (separated or not), current schooling (type:general, technological or professional and level) and/or professional activity. The second part contained 25 items probing meaningful events in the participant's life.

2.3.2. Risk of recurrence measure

ECARR, scale containing 12 items rated 0 or 1, was used to measure the risk of recurrence [13]. An ECARR score between 0 and 12 is calculated by summing responses to the 12 items. An ECARR score equal to or greater than 5 fairly strongly predicts the occurrence of a second accidents within 4–9 months of the first one [13].

2.3.3. Psychopathology scales

The Beck Anxiety Scale is a 21-item self-report scale that measures participants' level of anxiety [21]. The Beck Depression Inventory (BDI) is a 13-item self-assessment tool used to identify possible signs of depression and to measure their severity [22]. Substance abuse was measured with the Cannabis Abuse Screening Test, a 6-item scale that screens for cannabis use disorders among adolescents and young adults [23], and the Alcohol Use Disorders Identification Test, which contains three questions about heavy drinking and/or active alcohol abuse or dependence [24]. Impulsivity was measured with the Impulsive Behavior Scale, which has five dimensions: negative urgency (i.e., tendency to act rashly under extreme negative emotions), positive urgency (i.e., tendency to act rashly in positive emotional states), lack of premeditation (i.e., tendency to act without thinking), lack of perseverance (i.e., inability to remain focused on a task), and sensation seeking (i.e., tendency to seek out novel and thrilling experiences) [25–27].

The McLean Screening Instrument for Borderline Personality Disorder was used to screen for borderline personality disorder (BPD). This yes/no brief self-report questionnaire, derived from the BPD module of the Diagnostic Interview for DSM-IV Personality Disorders, contains 10 items: one item for each DSM-IV-TR BPD criterion except for paranoia/dissociation (2 items) [28].

ADHD was measured with the World Health Organization Adult ADHD Self-Report Scale [29], while pessimism and happiness were measured with the self-report Hopelessness Scale [22] and French version [30] of the Orientation To Happiness [31]. According to the theoretical framework underlying the latter, happiness is a combination of pleasure, meaning, and engagement [31]. The Brief COPE was used to measure coping skills in a given situation. This 28-item self-assessment instrument assesses how well individuals deal with new situations in terms of their coping strategies. There are 14 two-item subscales: self-distraction, active coping, denial, substance use, use of emotional support, use of instrumental support, behavioral disengagement, venting, positive reframing, planning, humor, acceptance, religion, and self-blame [32]. A four factor structure was recently validated: seeking social support (Items 5, 7, 9, 10, 14, 18, 19, and 27), problem solving (Items 2, 13, 20, and 24), avoidance (Items 1, 3, 4, 6, 12, 15, 17, 21, 22, and 25), and positive thinking (Items 8, 11, 16, 23, 26, and 28) [33]. Finally, the Mini International Neuropsychiatric Interview was administered to screen

participants for the main psychiatric disorders [34]. This brief and valid structured clinical interview enables researchers to assess the 17 most common psychiatric disorders in DSM-IV. It is a short but accurate structured psychiatric interview for multicenter clinical trials and epidemiology studies [35].

2.4. Statistical analysis

Two populations were defined for the analysis. For the primary analysis, the modified intention-to-treat (ITT) population comprised all randomized patients whose records were sufficient to evaluate accident recurrence, including those with major deviations. The per-protocol (PP) population excluded any patients in the ITT population with major deviations from the study protocol.

Descriptive statistics included means and standard deviations for quantitative variables, and frequencies and percentages for categorical variables. Characteristics were compared between groups of patients using the nonparametric Wilcoxon-Mann-Whitney test. The main criterion (i.e., accident recurrence) was defined as the first occurrence of an accident following inclusion. Cumulative incidence curves were produced using Kaplan-Meier estimates, and compared using the logrank test, with estimation of hazard ratios in relation to the intervention received.

Factors related to accident recurrence were analyzed separately for each randomized group, by comparing the characteristics of participants with and without recurrence. Multivariate logistic regression analysis was based on preselected variables with an individual significance level below 0.20 (stepwise ascending selection retained variables with a p value < 0.05). To identify variables related to a modification of effect according to the intervention received, we tested interactions between the effect of any variable and the effect of the intervention, and included significant interaction terms in the final model, along with the main effects. To make them easier to interpret, the results of both logistic models are provided (i.e., with and without intervention).

The significance threshold was set at $p < 0.05$ for all tests. All analyses were performed using SAS statistical software version 9.4 (SAS Institute, Cary NC, USA).
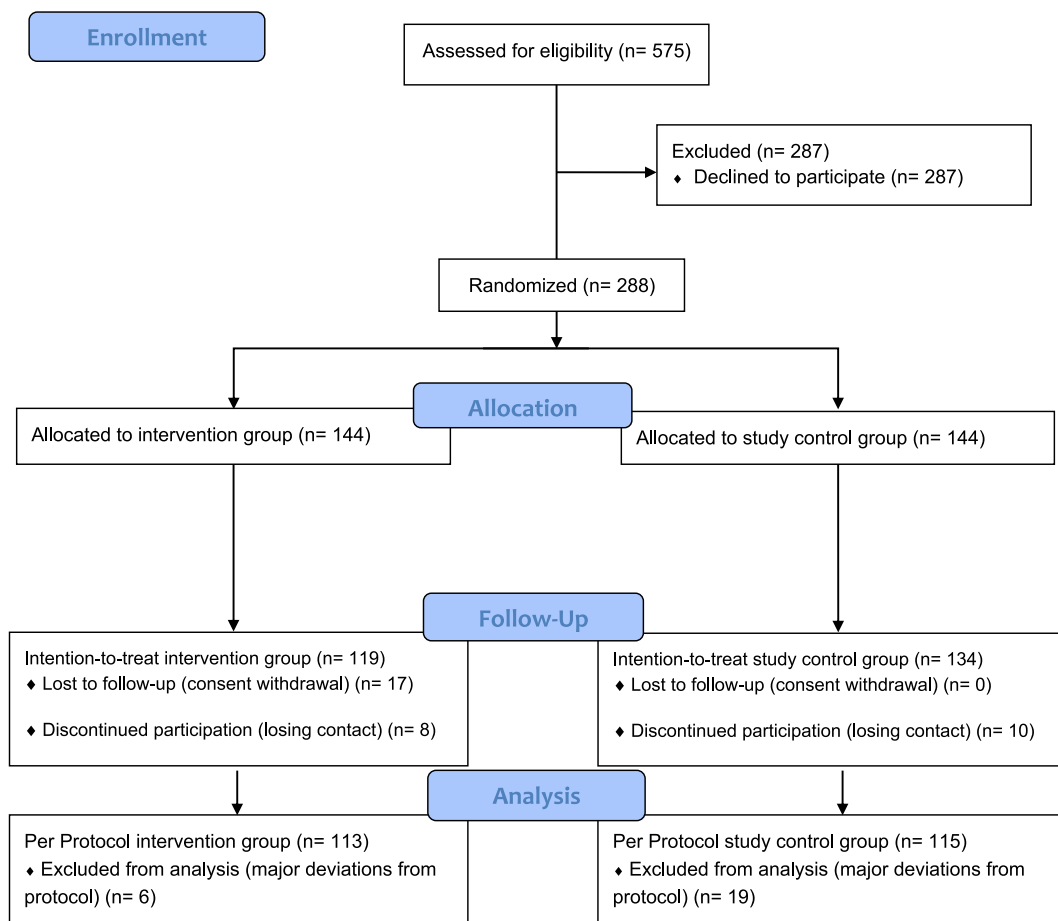

Enrollment

Assessed for eligibility (n= 575)

Excluded (n= 287)
♦ Declined to participate (n= 287)

Randomized (n= 288)

Allocation

Allocated to intervention group (n= 144)

Allocated to study control group (n= 144)

Follow-Up

Intention-to-treat intervention group (n= 119)
♦ Lost to follow-up (consent withdrawal) (n= 17)

♦ Discontinued participation (losing contact) (n= 8)

Intention-to-treat study control group (n= 134)
♦ Lost to follow-up (consent withdrawal) (n= 0)

♦ Discontinued participation (losing contact) (n= 10)

Analysis

Per Protocol intervention group (n= 113)
♦ Excluded from analysis (major deviations from protocol) (n= 6)

Per Protocol study control group (n= 115)
♦ Excluded from analysis (major deviations from protocol) (n= 19)

Fig. 2. ECARR2 flow diagram.

3. Results

3.1. Participants

Of the 2234 patients who completed the ECARR, 575 were eligible (Figs. 1 and 2). A total of 288 participants were randomly allocated to either the intervention group ($n = 144$) or the control group ($n = 144$).

Table 1 summarizes participants' characteristics and accident status.

Participants were mainly men, aged slightly over 20 years (20.4–20.6 years). It was their very first accident in only 28.5% of cases. Participants included following an accident were mostly drivers (70.8–78.5%) followed by cyclists (11.8–18.8%). Victims of crashes as passengers represented 8.3–9%. There was a higher proportion of pedestrians in the control group (12.5%) than in the intervention group (4.9%).

Table 2 summarizes the psychological characteristics of the ITT and PP analysis populations at T0. The randomized intervention and control groups were homogeneous on all the variables.

3.2. Accident recurrence in intention-to-treat and per-protocol analysis populations (Figs. 3 and 4)

In ITT, at 6 months after inclusion, the accident recurrence rate was 13.7% ± 3.2% in the intervention group, and 21.6% ± 3.8% in the control group. At 1 year after inclusion, the accident recurrence rate was 22.3% ± 4.4% in the intervention group, and 36.0% ± 4.4% in the control group. In PP, at 6 months after inclusion, the accident recurrence rate was 14.2% ± 3.3% in the intervention group, and 23.5% ± 4.0% in the control group. At 1 year after inclusion, the accident recurrence rate was 22.1% ± 3.9% in the intervention group, and 37.8% ± 4.6% in the control group..

3.3. Univariate analyses

Table 3 summarizes the results of the univariate analyses.

The score on the problem solving dimension of the Brief COPE was significantly higher for participants in the intervention group who had no recurrence of accidents ($p = 0.026$), whereas in the control group, it was higher for participants who had a recurrence. Scores on the avoidance and positive thinking dimensions were significantly higher for participants who had recurrences than those who did not, but only in the control group. Regarding the Impulsive Behavior Scale, the score on the lack of premeditation dimension was significantly higher for participants who had recurrences than for those who did not, but only in the intervention group ($p = 0.011$). The score on the lack of perseverance dimension was also significantly higher among repeat offenders in the intervention group, while the opposite result was observed in the control group. Finally, regarding the sensation seeking dimension, a significant difference was observed, but only within the control group, where participants who relapsed had higher scores than those who did not. As for the univariate analyses, there were significant differences in both groups concerning the engagement dimension of the Orientation to Happiness scale, as the score was significantly higher for participants with no recurrences in the intervention group, while the opposite result was observed in the control group.

3.4. Multivariate analyses

Table 3 summarizes the results of the multivariate analyses, which revealed several significant results.

The ECARR score had an effect on the risk of recurrence regardless of group ($p = 0.045$). In addition, the ECARR score was predictive of recurrence ($p = 0.045$).

3.5. Effect of intervention

The intervention had an effect per se, independently of the other predictors ($p = 0.020$). This effect was mediated by the three
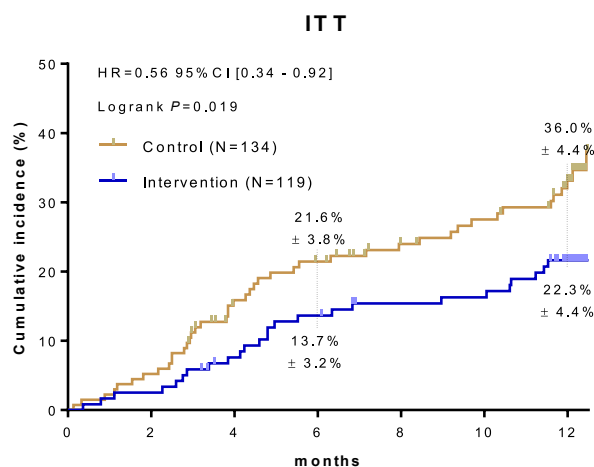
Table 1

Characteristics and accident status of participants in intention-to-treat and per-protocol analysis populations.

	Intention-to-treat		Per-protocol	
	Intervention $n = 144$	Control $n = 144$	Intervention $n = 113$	Control $n = 117$
Male/Female ratio	94/50	89/55	74/39	68/49
Mean age in years ±SD	20.4 ± 2.5	20.6 ± 2.4	20.5 ± 2.4	20.7 ± 2.5
First accident	41 (28.5%)	41 (28.5%)	34 (30.1%)	34 (29.1%)
Status				
Driver	113 (78.5%)	102 (70.8%)	89 (78.8%)	83 (70.9%)
Passenger	12 (8.3%)	13 (9.0%)	9 (8.0%)	9 (7.7%)
Cyclist	27 (18.8%)	17 (11.8%)	22 (19.5%)	16 (13.7%)
Skateboarder	1 (0.7%)	3 (2.1%)	1 (0.8%)	3 (2.6%)
Pedestrian	7 (4.9%)	18 (12.5%)	5 (4.4%)	15 (12.8%)
Other	6 (4.2%)	12 (8.3%)	5 (4.4%)	11 (9.4%)

Table 2
Psychological characteristics of intention-to-treat and per-protocol analysis populations at T0.

	Intention-to-treat			Per-protocol		
	Intervention $n = 144$	Control $n = 144$	p	Intervention $n = 113$	Control $n = 117$	p
ECARR	6.2 ± 1.5	6.3 ± 1.6	0.27	6.2 ± 1.4	6.2 ± 1.5	0.70
BAS	8.4 ± 8.0	10.2 ± 9.0	0.090	8.5 ± 7.8	10.4 ± 9.1	0.11
BDI	5.2 ± 4.5	5.7 ± 5.4	0.71	5.2 ± 4.2	5.6 ± 5.5	0.80
H	4.5 ± 3.2	5.1 ± 3.4	0.10	4.6 ± 3.2	5.1 ± 3.5	0.18
MSI-BPD	3.9 ± 2.6	4.1 ± 2.8	0.42	3.9 ± 2.6	4.1 ± 2.8	0.79
BCS						
BCS-Support	31.5 ± 19.0	30.8 ± 18.2	0.85	33.3 ± 18.8	30.9 ± 18.5	0.35
BCS-PRBsolving	47.0 ± 24.6	49.1 ± 24.5	0.42	46.5 ± 24.0	48.8 ± 23.3	0.41
BCS-Avoidance	26.4 ± 13.1	28.4 ± 12.6	0.13	27.0 ± 13.2	28.0 ± 12.7	0.49
BCS-Positive	51.2 ± 22.9	51.5 ± 21.8	0.95	50.2 ± 23.1	51.6 ± 22.1	0.70
AUDIT	5.6 ± 2.6	5.9 ± 2.6	0.33	5.7 ± 2.5	5.7 ± 2.4	0.97
CAST	1.6 ± 2.0	1.9 ± 2.0	0.34	1.5 ± 1.9	1.7 ± 2.0	0.42
UPPS						
UPPS-NegURG	10.4 ± 3.0	10.2 ± 2.8	0.75	10.4 ± 3.0	10.1 ± 2.8	0.43
UPPS-PosURG	11.8 ± 2.3	11.5 ± 2.1	0.21	11.8 ± 2.2	11.5 ± 2.1	0.15
UPPS-PREM	8.7 ± 2.7	8.8 ± 2.4	0.39	8.8 ± 2.7	8.8 ± 2.4	0.92
UPPS-PERS	7.1 ± 2.3	7.2 ± 2.2	0.79	7.3 ± 2.2	7.2 ± 2.2	0.76
UPPS-SENS	11.3 ± 2.8	11.8 ± 2.6	0.13	11.2 ± 2.7	11.8 ± 2.6	0.14
ASRS	2.6 ± 1.6	2.9 ± 1.5	0.097	2.7 ± 1.6	3.0 ± 1.5	0.25
OTH						
OTH-Meaning	3.9 ± 1.2	3.8 ± 1.2	0.82	3.9 ± 1.2	3.9 ± 1.1	0.87
OTH-Pleasure	5.1 ± 1.1	5.0 ± 1.1	0.31	5.0 ± 1.1	5.0 ± 1.1	0.71
OTH-ENGA	4.3 ± 1.1	4.3 ± 1.0	0.85	4.3 ± 1.0	4.3 ± 1.0	0.83

Note. BAS = Beck Anxiety Scale; BDI = Beck Depression Inventory; H = Hopelessness Scale; MSI-BPD = McLean Screening Instrument for Borderline Personality Disorder; BCS = Brief COPE with four dimensions: Support (seeking social support), PRBsolving (problem solving), Avoidance, and Positive (positive thinking); AUDIT = Alcohol Use Disorders Identification Test; CAST = Cannabis Abuse Screening Test; UPPS = Impulsive Behavior Scale with five dimensions: NegURG (negative urgency), PosURG (positive urgency), PREM (lack of premeditation), PERS (lack of perseverance), and SENS (sensation seeking); ASRS = Adult ADHD Self-Report Scale; OTH = Orientation to Happiness with three dimensions: Meaning, Pleasure, and ENGA (engagement).

Fig. 3. Accident recurrence in intention-to-treat (ITT) analysis population.

interaction variables: BDI, Impulsive Behavior Scale lack of perseverance, and Orientation to Happiness engagement. It was therefore through these dimensions that the intervention had an effect.

4. Discussion

Results revealed that the risk of recurrence was highest during the first 6 months (66% of recurrences). It is therefore essential to intervene as early as possible. Participants started the ECARR2 program as soon as they had been discharged from hospital. Moreover, these results show that there were twice as many recurrences of accidents in the control group as in the intervention group, even though the two groups were homogeneous at inclusion. A brief therapeutic intervention after an accident leading to hospitalization therefore seems to halve the risk of recurrence at 6 months.
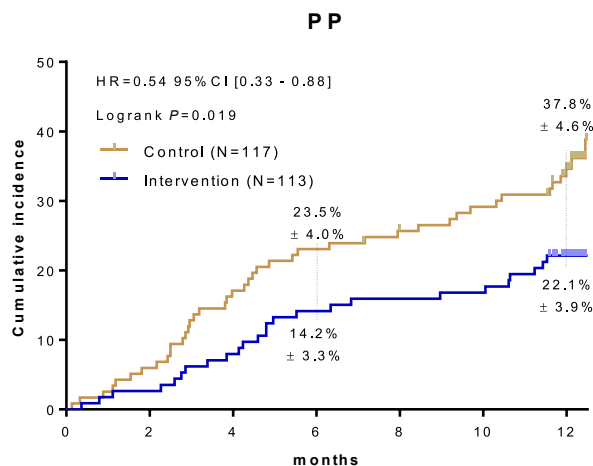
Fig. 4. Accident recurrence in per-protocol (PP) analysis population.

Results concerning the problem solving, avoidance and lack of premeditation dimensions were consistent with the conceptual model developed by D'Zurilla and colleagues (2004), which distinguishes between *effective* problem solving (constructive and confident attitude toward problems, and ability to approach problems rationally and systematically) and *maladaptative* problem solving (defeatist or catastrophizing attitudes, passively waiting for problems to resolve (avoidant style), or acting impulsively without thinking through possible consequences and alternative solutions (lack of premeditation)) [36,37]. Having better problem-solving skills would help youth overcome personal problems [37] and might allow them to step back from their first accident, to reduce the risk of recidivism.

Positive thinking includes three Brief COPE subscales: acceptance, positive reinterpretation, and humor. While acceptance of the situation seems to be an effective strategy for reducing the risk of recidivism, this may not be the case for humor and positive reframing. Many drivers perceive their risk of having a motor vehicle crash to be lower than that of other drivers, and also perceive their driving ability to be better. This so-called *comparative optimism* may prevent them from adopting safe driving behaviors and/or mitigate their perceptions of negative outcomes [38]. Unlike comparative optimism, which is an optimism bias, *dispositional optimism* is associated with the adoption of healthy behaviors [39]. While this may allow us to better understand the positive association between the engagement dimension of the Orientation to Happiness scale and fewer recurrences in the intervention group, it does not explain the opposite phenomenon. One possible explanation is that it is the competitive nature of engagement in an activity that brings pleasure and which, in addition, can increase the feeling of personal effectiveness [40]. Finally, unlike other studies, we failed to find an association between gender, substance abuse or ADHD and risk of recidivism. Whereas in a recent study, drivers who reported more ADHD symptoms also reported greater traffic risk-taking [41], we found no association in our study between probable ADHD and recidivism ($p = 0.55$ for the intervention group and $p = 0.25$ for the control group). Similarly, numerous studies have shown an association between alcohol and/or cannabis consumption and risk of accident [42,43]. These differences in results can be explained by the fact that our sample was composed exclusively of participants who had already had at least one road accident resulting in hospitalization. To be clear, in our study, for participants who had already had a road accident, there was no association between the risk of having a new road accident within 1 year and either gender, alcohol and cannabis use, or ADHD.

The ECARR score had an effect on the risk of recurrence regardless of group and was predictive of recurrence. This result highlights the relevance of screening individuals who have had a first road accident resulting in hospitalization for the risk of recurrence. The ECARR is a rapid detection scale with proven psychometric qualities [13,14].

The BDI score did not predict recidivism, but there was an effect that depended on group, in that the lower the BDI score, the more effective the intervention. In fact, recidivism was lower in the intervention group than in the control group, even for participants with a relatively high BDI score. Similarly, regarding the lack of perseverance dimension of the Impulsive Behavior Scale, for participants in the intervention group, the lower the score on this dimension, the more effective the intervention. In the control group, a lower score on this dimension was associated with recidivism. In other words, recidivism was lower in the intervention group than in the control group, even for participants with a relatively high score on the lack of perseverance dimension.

Although the engagement dimension of the Orientation to Happiness Scale did not predict recurrence, there was an effect, depending on group. More specifically, the intervention was more effective if participants had a high score on this dimension.

These results are consistent with a recent study that showed that measures of mental health scores at age 17 years were not predictive of subsequent road traffic crashes, after adjusting for measures of driving-risk activities [44]. However, poor mental health, particularly a state of depression or high anxiety, may determine recidivism in youth over the longer term.

Regarding the negative urgency dimension of the Impulsive Behavior Scale, its effect on recidivism was the same whether or not there was an intervention. Attentional capacities and working memory play important roles in the prediction of impulsivity. ECARR2 is not primarily a cognitive intervention, so it is not surprising that we did not observe an effect of this dimension [45].

The score on the sensation seeking dimension of the Impulsive Behavior Scale had an effect on recidivism regardless of group. There

Table 3

Mean (± standard deviation) psychological characteristics and recurrence status in intervention and control analysis populations.

	Intervention			Control			Multivariate Logistic Regression		
							Without intervention	With intervention	
	No recurrence $n = 88$	Recurrence $n = 25$	Univariate p	No recurrence $n = 72$	Recurrence $n = 43$	Univariate p	p	Effect p	Interaction p
Age in years	20.6 ± 2.4	20.1 ± 2.5	0.38	20.8 ± 2.6	20.5 ± 2.5	0.57			
ECARR	6.3 ± 1.4	5.9 ± 1.4	0.40	6.3 ± 1.5	6.1 ± 1.4	0.75	0.045	0.045	–
BAS	8.6 ± 8.0	8.0 ± 6.9	0.80	9.7 ± 7.3	11.5 ± 11.5	0.93			
BDI	5.4 ± 4.2	4.7 ± 4.2	0.45	5.0 ± 5.1	6.7 ± 6.1	0.19		0.98	0.023
H	4.6 ± 3.2	4.6 ± 3.5	0.89	4.9 ± 3.4	5.6 ± 3.7	0.24			
MSI-BPD	3.9 ± 2.5	4.0 ± 2.6	0.93	3.7 ± 2.6	4.7 ± 3.1	0.074			
BCS									
BCS-Support	33.0 ± 19.1	34.5 ± 18.2	0.60	31.9 ± 19.2	29.1 ± 17.4	0.31			
BCS-PRBsolving	49.3 ± 24.3	36.5 ± 20.4	**0.026**	45.4 ± 24.3	54.5 ± 20.5	**0.039**			
BCS-Avoidance	27.6 ± 13.7	24.9 ± 11.0	0.44	25.5 ± 11.4	32.2 ± 13.6	**0.017**			
BCS-Positive	50.4 ± 23.6	49.8 ± 21.7	0.86	48.3 ± 22.2	57.2 ± 21.1	**0.042**			
AUDIT	5.6 ± 2.5	5.9 ± 2.3	0.75	5.6 ± 2.4	5.9 ± 2.6	0.66			
CAST	1.4 ± 1.9	1.6 ± 2.0	0.80	1.6 ± 1.9	1.8 ± 2.1	0.64			
UPPS									
UPPS-NegURG	10.2 ± 2.9	11.4 ± 3.2	0.12	9.9 ± 2.7	10.3 ± 3.0	0.39	0.043		
UPPS-PosURG	11.6 ± 2.2	12.8 ± 1.8	0.065	11.2 ± 2.1	11.8 ± 1.9	0.19			
UPPS-PREM	8.4 ± 2.6	10.0 ± 2.6	**0.011**	8.9 ± 2.3	8.5 ± 2.5	0,40			
UPPS-PERS	7.0 ± 2.0	8.1 ± 2.6	**0,040**	7.6 ± 2.3	6.6 ± 2.0	**0,032**		0,95	0,006
UPPS-SENS	10.9 ± 2.7	12.2 ± 2.7	0,053	11.3 ± 2.6	12.6 ± 2.4	**0,007**	0001	0,002	–
ASRS	2.7 ± 1.6	2.9 ± 1.5	0,55	2.8 ± 1.4	3.2 ± 1.6	0,25			
OTH									
OTH-Meaning	4.0 ± 1.2	3.8 ± 1.3	0,55	3.8 ± 1.1	4.1 ± 1.1	0,28			
OTH-Pleasure	5.0 ± 1.1	5.1 ± 1.0	0,93	4.9 ± 1.1	5.2 ± 1.0	0,29			
OTH-ENGA	4.4 ± 1.1	3.8 ± 0.9	**0.017**	4.1 ± 1.0	4.6 ± 0.9	**0.021**		0.73	0.003
Intervention effect							0.020	0.45	

Note. BAS = Beck Anxiety Scale; BDI = Beck Depression Inventory; H = Hopelessness Scale; MSI-BPD = McLean Screening Instrument for Borderline Personality Disorder; BCS = Brief COPE with four dimensions: Support (seeking social support), PRBsolving (problem solving), Avoidance, and Positive (positive thinking); AUDIT = Alcohol Use Disorders Identification Test; CAST = Cannabis Abuse Screening Test; UPPS = Impulsive Behavior Scale with five dimensions: NegURG (negative urgency), PosURG (positive urgency), PREM (lack of premeditation), PERS (lack of perseverance), and SENS (sensation seeking); ASRS = Adult ADHD Self-Report Scale; OTH = Orientation to Happiness with three dimensions: Meaning, Pleasure, and ENGA (engagement).

have already been studies on the implications for the prevention of risky driving behaviors in high-risk young adults. The sensation seeking dimension may well be a very important clinical determinant or screening tool for identifying these individuals [46]. Sensation seeking has been found to be significantly correlated with all four subcategories of dangerous driving behavior: negative cognitive/emotional driving, aggressive driving, risky driving, and drunk driving [47].

These results suggestthat the effectiveness of our brief intervention can be explained by an improvement in depressive symptomatology, a decrease in impulsivity, an increase in the ability to complete a task, and an increase in optimism. A recent study found that for youth with depression, the risk of road crashes varied according to the status of their antidepressant medication, but this was not the case for young people with ADHD [48]. Thus, acting on depressive symptoms may reduce the risk of accident recurrence.

Moreover, studies have shown that a brief intervention focusing on impulsivity is a promising strategy for preventing risky behaviors among novice drivers, as findings indicate a significant impact on road safety over a 4-year period [49–51]. Finally, the most optimistic individuals appear to have greater resilience, which may mean that they are better able to adapt to stressful or traumatic events, with a lower risk of relapse [52].

5. Limitations

Our study had two main limitations. First, it was carried out in centers located in the central and western regions of France, and was therefore not representative of every region of the country. Second, the group interventions mostly involved either small groups or individual participants. Future research should attempt to make this interventional program more accessible (app, videoconference …) and to observe whether a brief remote psychological intervention can have the same effect. In addition, to have more scientific impact on the public authorities, it would be relevant to focus on a more specific population: young adults between 18 and 25 who have had a first road accident as drivers (car, two-wheeler, bicycles, scooter).

6. Practical relevance and perspectives

This study highlights the importance of detecting as early as possible the risk of having a new traffic crash among adolescents and young adults. The ECARR tool predicts this risk. The risk of having a new traffic crash is highest during the 6 months following the first accident. Passing this brief 12-item self-assessment scale in emergency room could be the first step in prevention for adolescents and young adults who have had a road accident. Moreover, the ECARR 2 program offered after an accident leading to hospitalization therefore seems to halve the risk of recurrence at 6 months. Brief psychological care for high-risk adolescents and young adults could be the second stage of prevention. Future research should improve the ECARR2 program based in particular on the dimensions found here to be associated with this risk: depression, impulsivity and engagement to happiness. Finally, access to this brief intervention must be increased, whether it be via a mobile application, for a few hours at high school, or for a few hours in a driving school.

Author contribution statement

1 - Conceived and designed the experiments.
2 - Performed the experiments.
3 - Analyzed and interpreted the data.
4 - Contributed reagents, materials, analysis tools or data.
5 - Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

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