Effectiveness of Cardiopulmonary Resuscitation at the Workplace

Lorenzo Bellini[1], Nazzareno Fagoni[2], Aida Andreassi[3], Giuseppe Maria Sechi[3], Rodolfo Bonora[3], Giuseppe Stirparo[1,3]*

[1]Faculty of Medicine, School of Public Health – University of Vita-Salute San Raffaele, Milan, Italy
[2]Dipartimento di Medicina Molecolare e Traslazionale, Università di Brescia, Brescia, Italy
[3]Agenzia Regionale Emergenza Urgenza, AREU, Milan, Italy

Abstract

Background: *Out-of-Hospital Cardiac Arrest (OHCA) is a medical emergency whose chances of survival can be increased by rapid Cardiopulmonary Resuscitation (CPR) and early use of Public Access Defibrillators (PAD). Basic Life Support (BLS) training became mandatory in Italy to spread knowledge of resuscitation maneuvers in the workplace. Basic Life Support (BLS) training became mandatory according to the DL 81/2008 law. To improve the level of cardioprotection in the workplace, the national law DL 116/2021 increased the number of places required to be provided with PADs. The study highlights the possibility of a Return to spontaneous circulation in OHCA in the workplace.* **Methods:** *A multivariate logistic regression model was fitted to the data to extrapolate associations between ROSC and the dependent variables. The associations' robustness was evaluated through sensitivity analysis.* **Results:** *The chance to receive CPR (OR 2.3; 95% CI:1.8-2.9), PAD (OR 7.2; 95% CI:4.9-10.7), and achieve Return to spontaneous circulation (ROSC) (crude OR 2.2; 95% CI:1.7-3.0, adjusted OR 1.6; 95% CI:1.2-2.2) is higher in the workplace compared to all other places.* **Conclusion:** *The workplace could be considered cardioprotective, although further research is necessary to understand the causes of missed CPRs and identify the best places to increase BLS and defibrillation training to help policymakers implement correct programming on the activation of PAD projects.*

1. Introduction

Out-of-Hospital Cardiac Arrest (OHCA) is the cessation of cardiac mechanical activity, confirmed by the absence of circulation signs in an out-of-hospital setting. The survival rate is less than 10%. Therefore, it is globally considered a health emergency and affects 40 to 170 people per 100,000 per year, or just over 350,000 per year in Europe and the United States [1, 2]. Emergency Medical System (EMS) resuscitation is attempted in approximately 50-60% of EMS-assisted cases. However, a substantial underestimation of the phenomenon is likely [3-9]. Furthermore, 1% of OHCAs occurred in the workplace, with differences in occupation, work environment, and health surveillance levels [10]. In Italy, OHCA is responsible for 60-70% of all causes of cardiovascular death [11, 12], and 5% of cardiac arrests occur during work, 70 workers a week [13]. The first act to improve OHCA workplace safety was introduced in 2008 with Legislative Decree 81. The law obligates the employers to identify the first

aid responder, a worker who is supposed to undergo mandatory training [14]. With the 116/2021 standard of August 4, the automatic external defibrillator (AED) is also recommended in the workplace [15]. Regarding cardiopulmonary resuscitation, timeliness and efficacy is recognized as a crucial link in the chain of survival from cardiac arrest [16, 17]. Both the time of arrival and the level of training offered by the rescuer affect the outcome of Cardiopulmonary Resuscitation (CPR) [18-21]. A 50% survival rate can be achieved when bystanders intervene to provide CPR with automated external defibrillators (AEDs). To increase bystander intervention, laypeople should undergo CPR training, and Public Access Defibrillators (PAD) should be widely disseminated [23-26].

This is especially important when considering that the recent COVID-19 [27] pandemic had a meaningful impact on CPR training practice [15] and profoundly changed the EMS system [28-30], even changing the work policy [31]. In addition, it has been shown that early defibrillation, when made available in the workplace, is a primary need and desirable standard for improving workers' and citizens' survival rates after cardiac arrest [32-37].

The present study highlights the difference in OHCA management by laypeople in the workplace and other settings in the Lombardy Region. All rescues of OHCAs in the Lombardy region are managed by AREU (Agenzia Regionale Emergenza Urgenza), which coordinates all medical emergencies in out-of-hospital settings [31]. All data are cataloged in EM-MA (emergency medical system), the regional emergency mission registers.

2. Methods

This is a retrospective observational cohort study. The study was conducted following the principles of the Helsinki declaration and was approved by the AREU Data Protection Officer in November 2021 (reference number: 5.2021).

2.1. Data Registry

The Lombardy AREU headquarters register provided data. The data was analyzed using the

SAS-AREU portal and R (version 4.1.2). The portal contains all data regarding emergency calls, and the scenarios involving OHCA were selected. The ambulance crew is trained to recognize cardiac arrest as the absence of consciousness to verbal and tactile stimulus and the absence of breathing. This is enough to start Basic Life Support manoeuvres by rescuers while bystanders begin external chest compression under the guidance of healthcare personnel through 112. The medical team evaluates possible causes of cardiac arrest if an advanced vehicle with a doctor on board is sent to the event.

We analyzed all OHCAs in the Lombardy region register from the 1st of January 2019 to the 31st of December 2019. The selection criteria were age (from 18 to 67 years), non-cancer in medical history, no signs of death (i.e., rigor mortis), and no traumatic events (details in Figure 1).

2.2. Statistical Analysis

The categorical variables are presented as number and percentage, the continuous variables are presented as averages and standard deviation (SD). The categorical variables were analysed by means of χ^2 test, and the relative odds ratios (OR) and 95% Confidence Intervals (95% CI) were provided. Continuous variables were tested for normality by means of the Kolmogorov-Smirnov test, and the analysis was performed by Z-test for two population means.

Differences were considered significant when $p<0.05$. A logistic regression analysis was conducted in R to investigate the roles of different variables which may influence the chance of achieving a Return to Spontaneous Circulation (ROSC) in OHCAs. The robustness of the associations between the independent variables "CPR practice" and "Place" and the dependent variable "ROSC" was tested by means of a sensitivity analysis. The relative E-Values were calculated [38].

3. Results

Figure 1 shows a diagram of the OHCAs included in the analysis. Of 12140 OHCAs, only 3308 (27.2%) occurred in subjects of working age
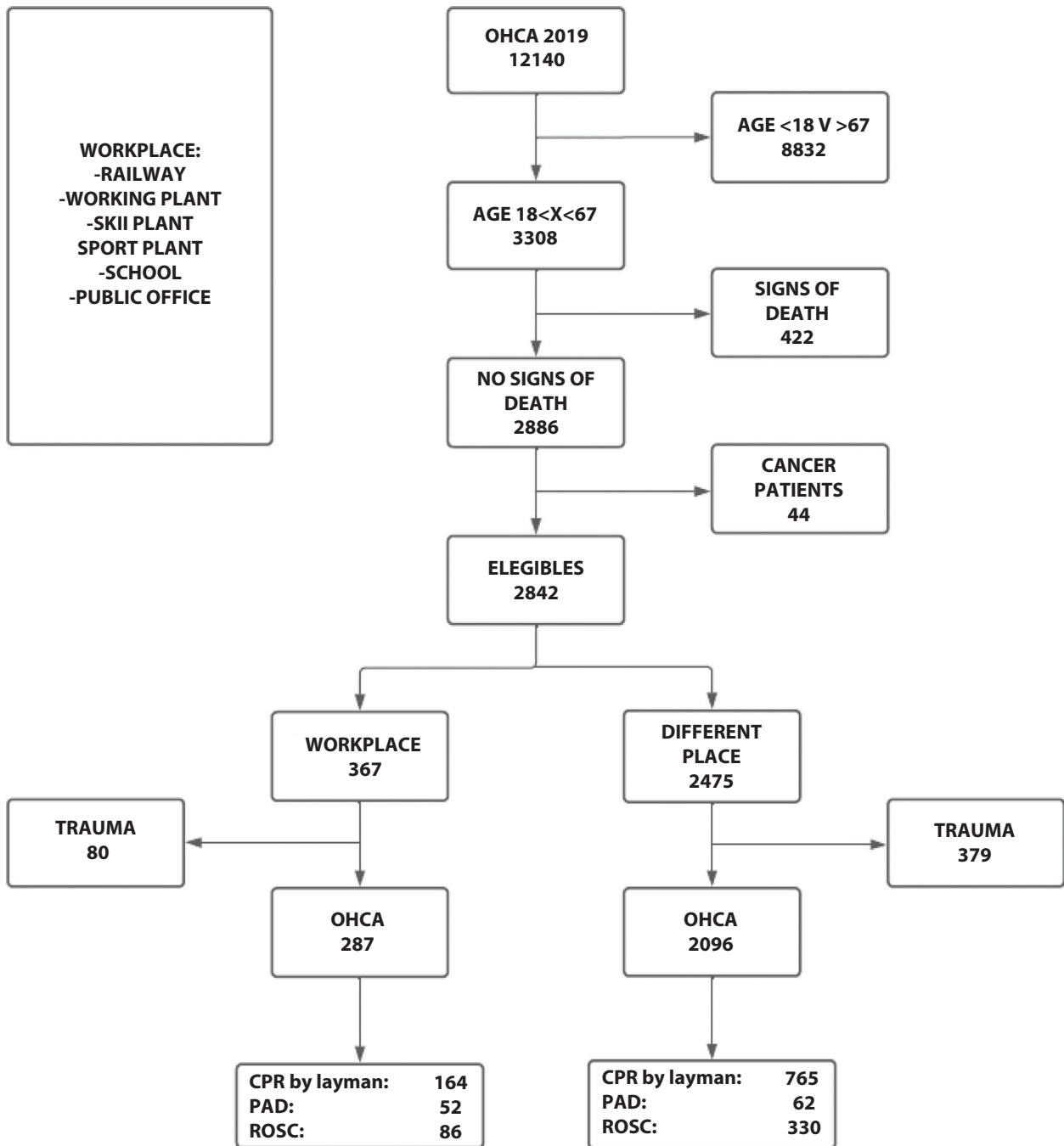
Figure 1. OHCA diagram.

(18-67); 422 cadaveric subjects were excluded as they presented evident signs of death (rigor mortis, decapitation, etc.). Of the remaining 2,886 eligible subjects, 44 subjects diagnosed with cancer in medical history were excluded.

Out of the total, 2,842 (23.0%) subjects were defined as eligible for the analysis, 367 (12.9%) OHCAs took place in the workplace, and 2,475 in a different place (87.1%). According to national law, the following locations were identified as workplaces

Table 1. Main characteristics of the subjects with Out of Hospital Cardiac Arrest (OHCA) stratified by place of occurrence.

	Workplace (287 subjects)	No workplace (2,096 subjects)	p
Females*	44 (15.33%)	597 (28.48%)	p<0.00001
Average years (SD)§	52±10.2	55.2±9.9	p<0.00001
Hospitalized by EMS	60 (21%)	356 (17%)	p>0.05
CPR	164 (57.14%)	765 (36.49%)	p<0.0001
PAD	52 (18.11%)	62 (2.95%)	p<0.0001
ROSC	86 (29.96%)	330 (15.74%)	p<0.0001

Chi-square significant at p<0.05.
§ Z-test for two population means significant at p<0.05.
CPR: Cardiopulmonary Resuscitation).
PAD: Public Accee Defibrillators.
ROSC: Return to Spontaneous Circulation.

requiring employees to be trained in BLS practice: railway facilities, working plants, ski plants, sports plants, schools, and public offices [14]. Eighty OHCAs in the workplace and 379 in other places were excluded because they occurred due to trauma. Trauma-related OHCAs are more frequent in the workplace than other places, OR 2.8 (C.I. 95% 1.8-4.3) p<0.0001.

The total of acute cardiological OHCAs (excluding traumatic ones) is 2,383, of which 287 (12.04%) happened in the workplace and 2,096 (87.96%) took place elsewhere.

In Table 1, the main characteristics of the OHCAs occurred in the workplace and other settings are compared. The proportion of females and the average age were significantly lower at the workplace, whereas a higher percentage of subjects received CPR, used PAD and achieved ROSC. (Crude ORs 2.3, 95%CI 1.8-2.9, 7.2, 95%CI 4.9-10.7 2.2, 95% CI:1.7-3.0 respectively). Furthermore, we observed an increase in the chance of having ROSC in the working place (30% vs. 16%). The proportion of subjects hospitalized by EMS did not differ between the settings (21% in the workplace vs. 17% in other settings).

To verify if there is a relationship between Sex, Age, and Minutes to the first vehicle on the scene, CPR practice, PAD use, ACLS practice, Place, and ROSC, we conducted a logistic regression analysis. The independent variables included in the model were Sex (0=Female), Age (years), Minutes to the

Table 2. Effects of predictor variables on ROSC chance (multivariate logistic regression).

Predictor variable	Estimated Odds Ratio	95%CI
Sex	0.73	(0.58-0.93)
Age	0.97	(0.96-0.98)
Minutes to the first Vehicle	0.92	(0.90-0.95)
CPR practice	1.69	(1.34-2.13)
PAD use	1.26	(0.99-1.59)
ACLS practice	2.56	(1.97-3.34)
Workplace	1.66	(1.23-2.24)

first vehicle (continuous), CPR practice (0=no practice), ACLS practice (0=no practice), and Place (0=not a workplace).

Adjusted Odds ratios for all predictor variables are reported in Table 2. The chance of Return to Spontaneous Circulation (ROSC) was lower in males and decreased with age, increasing minutes to the first vehicle. CPR and ACLS practices were positively associated with ROSC and having OHCA in the workplace compared to other settings.

We also investigated the relationship between the predictor variable PAD use and the predictor variable CPR practice in order to evaluate independence, owing to the fact that PAD is rarely used without CPR. A chi-square test of independence was performed to examine the relation between CPR

practice and PAD use. The relation between these variables was significant, $\chi 2$ (1, N= 2383)=149.1571 (with Yates correction), p<0.00001. People who were rescued with PAD use almost always underwent CPR practice. The results may account for the lack of significance of OR for the predictor variable PAD use in our logistic model.

The strength of the associations between CPR practice and Place and the dependant variable ROSC was investigated by means of sensitivity analysis. The calculated E-Values are reported in Supplementary Figure 1.

The observed odds ratios of 1.69 and 1.66 (CPR practice and Place) could be explained by an unmeasured confounder that was associated with both the treatment and the outcome by a risk ratio of 2.77 and 2.71-fold each, respectively, above and beyond the measured confounders, but weaker confounding could not do so; the confidence interval could be moved to include the null by an unmeasured confounder that was associated with both the treatment and the outcome by a risk ratio of 2.01 and 1.76-fold each, respectively, above and beyond the measured confounders, but weaker confounding could not do so.

4. Discussion

Our findings showed a higher chance (+66%, adjusted OR 1.6, 95%CI 1.2-2.2) of achieving ROSC and a higher probability of receiving CPR (57.14% vs. 36.49%) in the workplace compared with other settings. Similar findings emerged from the studies of Baldi et al. [39] and Marino et al. [5], who detected a 90% increase in ROSC chance in the workplace (computed on all OHCAs in the Pavia province and Canton Ticino from 2015 to 2017) and a 56.25% probability of receiving CPR on the workplace (on 32 OHCAs occurring in the workplace), respectively.

The higher probability of receiving ROSC proves that the workplace could be considered a cardioprotective place. On the other hand, although the probability of receiving PCR is higher than in other settings, we cannot consider it entirely satisfactory considering the mandatory training of lay people in the workplace established by Legislative Decree 81 2008. This finding underlines the need for further

research to investigate the causes of missed CPR execution in the workplace.

Through a logistic regression model, we also examined the roles of different predictive variables associated with the chance of achieving ROSC. Male sex reduced the chance of achieving ROSC by about 26%. This percentage is somewhat in line with the findings of Bakran et al. [23], who report a 34% increase in OHCA mortality in a retrospective study of 1,440 male patients resuscitated between 2011 and 2017 in Istra, Croatia.

Increasing age was associated with a decreased probability of achieving ROSC of 2.7% every year, highlighting that the efficacy of rescue manoeuvres decrease in older people. ACLS was found to have the most decisive impact on ROSC, increasing the probability of achieving it by 156%. This can be linked to the role of the ACLS crew's medical and nurse personnel, underlining the EMS's importance. CPR was found to be effective, too, increasing the chance of achieving ROSC by 69%. Interestingly, the associations were reasonably robust to potential confounding, according to the interpretations suggested by Tyler and Peng [38].

These results are also relevant for emergency training. They confirm the impact of Legislative Decree 81 2008 and support Law No. 116, passed on August 4, 2021. Having trained operators in the workplace increases the chance of achieving ROSC in agreement with strategies suggested by K. Bakran et al. [23]. Furthermore, the trained operator for emergency shows high satisfaction during the course and for the emergency skill learned, as shown in previous research [40]. However, our research has several limitations, i) the central operator of the AREU collected all data, and some data could have gone missing during the emergency. ii) we did not know if the layman who performed CPR was the first responder. Therefore, we can only suppose the impact of mandatory training.

5. Conclusion

The workplace is safer regarding OHCA outcomes than other places. We highlighted a higher chance to receive CPR, PAD use, and achieve ROSC, which could partly be explained by the

mandatory BLS training introduced in companies. Future regulations regarding OHCA could consider including training programs in other settings, with a greater commitment towards placing PADs in other places, always with public access. In fact, from our analysis, it emerges that workplaces are just a small percentage of places where OHCA occurs. However, further analyses are necessary to identify the best place to increase basic life support and defibrillation training to help policymakers implement correct programming to activate PAD projects.

Supplementary Material: Figure S1: Sensitivity Analysis of the associations between specific predictive variables and the dependent variable.

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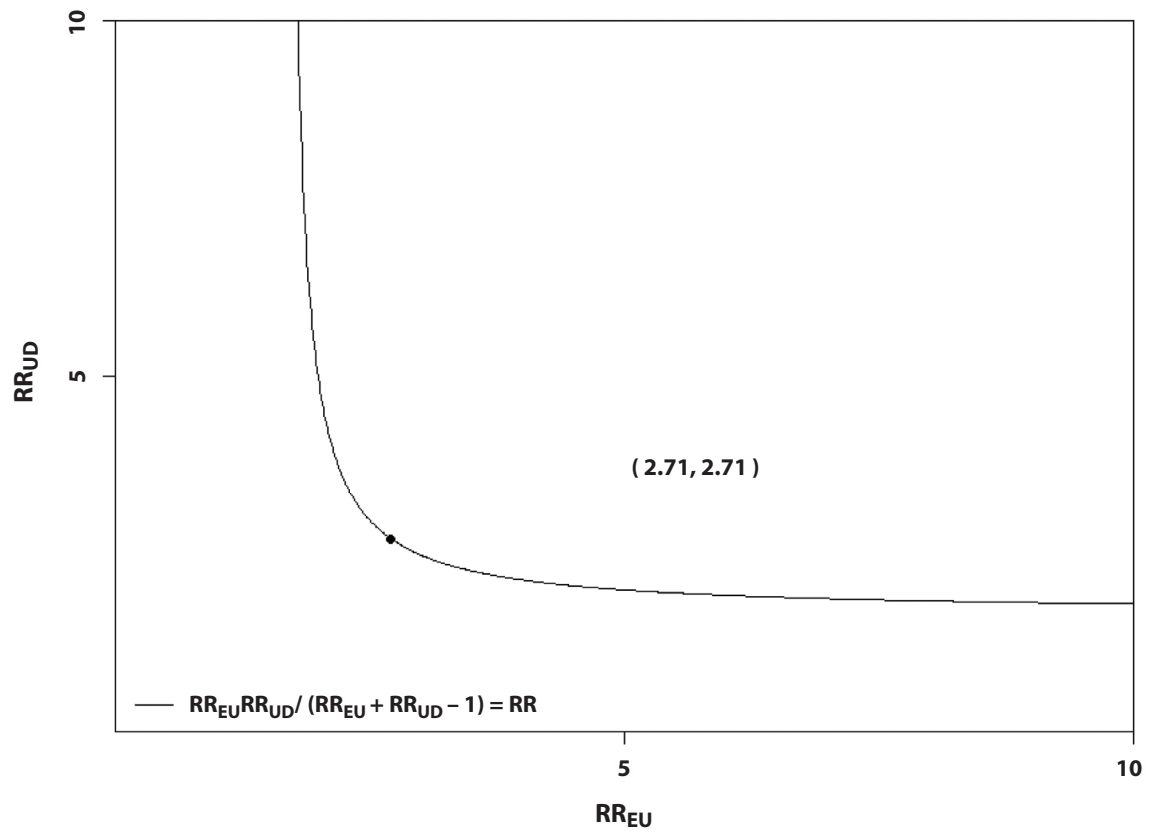19. Aeby D, Staeger P, Dami F. How to improve automated external defibrillator placement for out-of-hospital

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APPENDIX

Supplementary Figure 1: Sensitivity Analysis of the associations between specific predictive variables and the dependent variable.
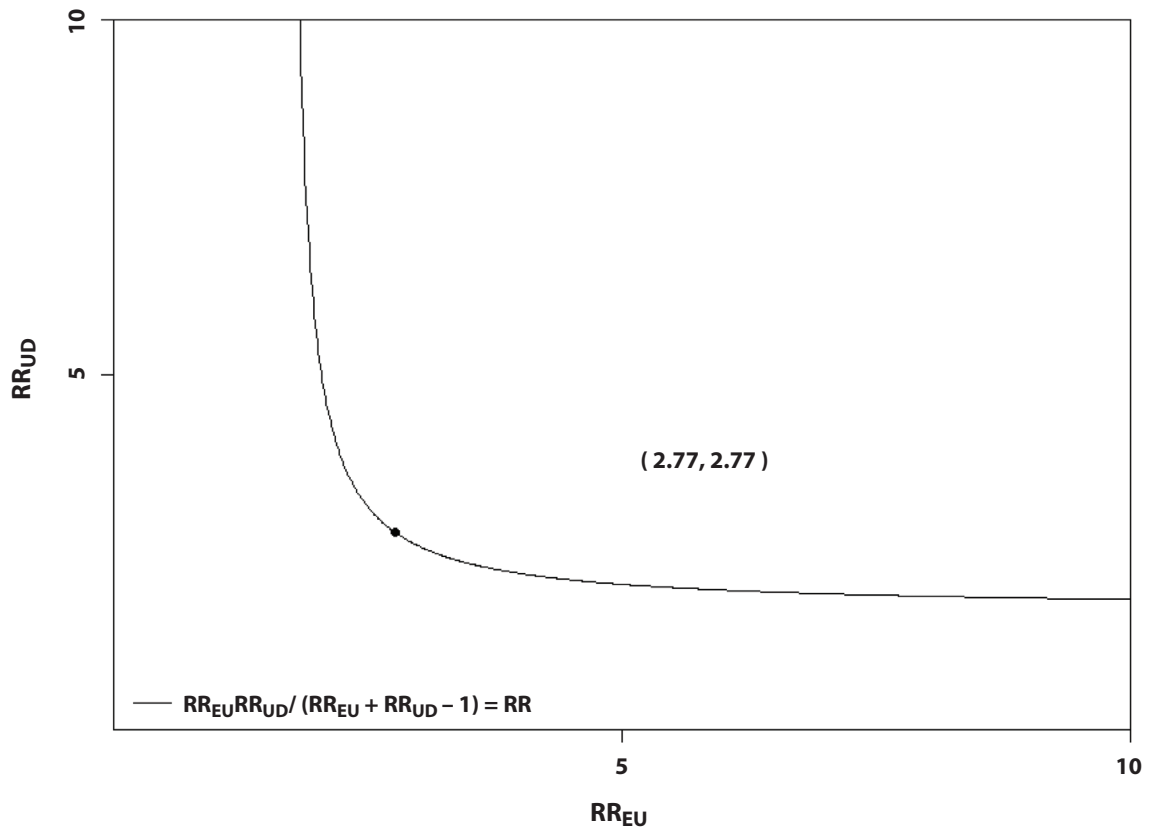
"CPR" Odds-Ratio Sensitivity Analysis.

"Place" Odds–Ratio Sensitivity Analysis.