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GROEP BIOMEDISCHE WETENSCHAPPEN

FACULTEIT BEWEGINGS- EN REVALIDATIEWETENSCHAPPEN

A multiple linear regression analysis of factors related to simulated Basic Life Support (BLS) performance with Automated External Defibrillator (AED) in Flemish Lifeguards

door Gilles Schouppe

masterproef aangeboden tot het behalen van de graad van Master of Science in de lichamelijke opvoeding en de bewegingswetenschappen

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Dr. P. Iserbyt, promotor

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Woord vooraf

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Gent, 23 mei 2014 G.L.S.S.

Situering

Deze masterproef kadert binnen de activiteiten van de onderzoeksgroep Fysieke Activiteit, Sport en Gezondheid van de Faculteit Bewegings- en Revalidatiewetenschappen aan de KU Leuven. Ze maakt deel uit van een onderzoekslijn naar innovatieve werkvormen voor het aanleren en onderhouden van Basic Life Support (BLS). BLS is een levensreddende handeling die een aantal stappen omvat die in een juiste volgorde moeten worden uitgevoerd, zoals hartmassage, beademen en het gebruik van een Automatische Externe Defibrillator (AED) (zie appendix 3). Leren reanimeren is ook een eindterm in het secundair onderwijs, binnen het kader van de realisatie van een gezonde, fitte en veilige levensstijl. Onderzoek naar effectieve werkvormen om BLS aan te leren en de identificatie van determinanten voor een goede BLS-uitvoering zijn bijgevolg ook relevant voor het secundair onderwijs.

Reanimeren en defibrilleren vormen een kernvaardigheid van Hoger Redders. Deze moeten effectief kunnen optreden in geval van verdrinking of hartproblemen in de omgeving van zwembaden. Tot op heden bestaat er geen objectieve analyse van de BLS vaardigheid met AED bij Hoger Redders in Vlaanderen. Er blijkt hieromtrent ook weinig internationale literatuur te zijn. Onderzoek hiernaar zou ons dus kunnen informeren over de reanimatievaardigheden van gediplomeerde redders, de kwaliteit van de Vlaamse redderopleiding en de effectiviteit van de jaarlijks verplichte bijscholingen.

Een eerste onderzoeksvraag in deze masterproef behandelt de kwaliteit van de reanimatie bij Vlaamse Hoger Redders. We baseren ons op de European Resuscitation Council (ERC)-richtlijnen van 2010[1]. Voorts trachten we met behulp van een regressieanalyse factoren te discrimineren die de BLS-prestatie beïnvloeden.

Referentielijst

1 Nolan JP, Soar J, Zideman DA, Biarent D, Bossaert LL, Deakin C, Koster RW, Wyllie J, Böttiger B, On behalf of the ERC Guidelines Writing Group. European Resuscitation Council Guidelines for Resuscitation 2010. Resuscitation 2010;81:1219-76.

A multiple linear regression analysis of factors related to simulated Basic Life Support (BLS) performance with Automated External Defibrillator (AED) in Flemish Lifeguards

Abstract

Background: Research investigating certified lifeguards' performance of Basic Life Support (BLS) with Automated External Defibrillator (AED) is almost non-existent.

Aim: Assessing simulated BLS/AED performance in Flemish lifeguards and identifying factors affecting this performance.

Methods: 616 (217 female and 399 male) certified Flemish lifeguards (aged 16-71 years) performed BLS with an AED on a Laerdal ResusciAnne manikin simulating an adult victim of drowning. Stepwise multiple linear regression analysis was conducted with BLS/AED performance as outcome variable and demographic data as explanatory variables.

Results: Mean BLS/AED performance for all lifeguards was 66.5%. Chest compression rate and depth adhered closely to ERC 2010 guidelines. Ventilation volume and flow rate exceeded the guidelines. A significant regression model, $F(6, 415) = 25.61$, $p < .001$, ES = .38, explained 27% of the variance in BLS performance ($R^2 = .27$). Significant predictors were age (beta = -.31, $p < .001$), years of certification (beta = -.41, $p < .001$), time on duty per year (beta = -.25, $p < .001$), practising BLS skills (beta = .11, $p = .011$), and being a professional lifeguard (beta = -.13, $p = .029$). 71% of lifeguards reported not practising BLS/AED.

Discussion: Being young, recently certified, few days of employment per year, practising BLS skills and not being a professional lifeguard are factors associated with higher BLS/AED performance.

Conclusion: Measures should be taken to prevent BLS/AED performances from decaying with age and longer certification. Refresher courses could include a formal skills test and certified lifeguards should be encouraged to practise their BLS/AED skills more often.

Key words: Education, Lifeguard, Training, CPR, BLS, AED

1. Introduction

In Flanders, public swimming pools need to be supervised by certified lifeguards who are responsible for the safety of swimmers. These certificates are supplied or approved by the Flemish Sports Agency (BLOSO). To become a certified lifeguard in Flanders one has to pass a standardized lifeguard training programme consisting of 60 hours (theory: 20 hours, practice: 40 hours) and covering five domains: (1) theory of rescue, Basic Life Support (BLS) and first care (20 hours); (2) rescue part 1 (8 hours); (3) rescue part 2 (12 hours); (4) BLS with and without oxygen delivery (14 hours); (5) first aid (6 hours). In Flanders 31,840 people currently hold a lifeguard certificate. Every year about 1,200 new lifeguards graduate and receive their certification. Only 5% of these graduates will at least once be employed as a professional lifeguard or as a student worker[1]. To stay certified, Flemish law prescribes that lifeguards should attend a refresher course at least once a year[16]. A refresher course has a standardized duration of four hours, encompassing two hours in the pool and two hours of dry practice[1]. The content of refresher courses is poorly standardized since lifeguard instructors can choose to a large extent which content will be covered and which foci are put. In general, the instructor-lifeguard ratio is 1:20. Most refresher courses are instructor-led although the instructional model is not standardized. In the swimming pool, lifeguards generally train rescue techniques based upon simulations such as the rescue of a victim of drowning. During the two hours of dry practice, lifeguards practise their BLS/AED skills on adults, children and babies with and without oxygen. First aid is also revised and practised. When lifeguards have attended refresher training, their certificate is renewed allowing them to continue their lifeguard activities. Lifeguards do not need to pass any test or exam for their certificates to be recycled.

Drowning is a major cause of death worldwide. Every year 150,000 people die as a victim of drowning[2]. In Flanders, no data are available on the number neither of drowning accidents nor on the number of people having cardiac arrests in swimming pools. In addition, little is known about the quality of BLS performance of certified Flemish lifeguards. Even internationally there is little literature regarding the BLS performance level of lifeguards. When BLS is applied correctly and shortly after drowning or cardiac arrest, chances of survival increase two to threefold[2]. Since certified lifeguards only need to attend one refresher course a year to stay certified, one could question the quality of their BLS performance. Studies in BLS generally report poor retention[3, 4, 5, 10]. Some research demonstrated that BLS performance reached a pre-training (i.e. beginner's) level one year following training[5]. One could therefore argue that, if lifeguards do not engage in self- or group training of BLS and AED, performance of these skills at refresher courses will be poor.

In this study, lifeguards' simulated BLS/AED performance was assessed at refresher courses. The simulated scenario was that of an adult victim of drowning. Prior to the BLS/AED assessment, lifeguards filled in a demographic questionnaire. Research shows that demographic factors can significantly influence BLS performance. Moran et al. (2012) found younger and inexperienced lifeguards performed better than older lifeguards at the preliminary checking of a patient and females were more accurate than males in their ventilation skills, especially with regard to correct tidal volumes[6]. De Vries et al. even proved there is a significant relation between the age and the experience of a lifeguard[15]. We sought to answer the following research questions: (1) what is the quality of the BLS/AED performance of Flemish

lifeguards?, and (2) which factors affect this performance As such specific solutions could be provided to improve both the pre and in-service training of lifeguards.

2. Methods

2.1. Sample and selection procedure

In all 5 Flemish provinces (West Flanders, East Flanders, Flemish Brabant, Antwerp and Limburg) ten lifeguard refresher courses were randomly selected using an online randomisation tool (http://www.randomizer.org/form.htm) constituting an estimated 1,000 lifeguards at 50 refresher courses. Lifeguards are free to choose where to attend a refresher course. Due to drop out, the analysed sample consisted of 616 (217 female and 399 male) certified Flemish lifeguards (aged 16-71 years). Informed consent was obtained from the lifeguards, lifeguard instructors, and organisations responsible for refresher courses such as the Flemish Sports Agency (BLOSO) and the Flemish Institute for Sports Management and Recreational Policy (ISB). Lifeguard instructors were asked not to inform lifeguards of the upcoming tests.

2.2. Research procedure

At all refresher courses, lifeguards were randomly assigned a number using an online randomisation tool (http://www.randomizer.org/form.htm). These numbers were used by research assistants to determine the order in which lifeguards entered the testing room. First, lifeguards filled in a questionnaire involving demographic data as well as questions concerning the lifeguard's training routines and perceived skills (see appendix 4). Upon completion of the questionnaire, a research assistant read aloud the following standardized instruction: *"Please demonstrate the Basic Life Support procedure of an adult victim of drowning from beginning to end. You can ask questions regarding the victim's condition or you can ask for assistance, but I cannot tell you what to do. An Automated External Defibrillator is nearby. It is important that you continue the BLS procedure until I tell you to stop."* A Laerdal ResusciAnne manikin in the room represented the adult victim of drowning. When lifeguards completed three compression-ventilation cycles, the research assistant handed over the AED to the lifeguard. This action was standardized for all assessments. The simulation was stopped after the subject completed an additional compression-ventilation cycle after arrival of the AED. The subjects were then asked two standardized questions: "How long would you perform BLS/AED when you are alone with a drowned person prior to calling for help?", and "How long would you continue BLS/AED in a real life situation?" The correct answer to the first question was "one minute" whereas the answer to the second question consisted of three items, namely (1) until professional rescuers take over; (2) till you become exhausted; or (3) until the victim starts breathing normally. These questions and their answers were based on the European Resuscitation Council (ERC) guidelines[7].

2.3. BLS/AED procedure

According to the ERC 2010 guidelines[7] for BLS and AED, the performance of BLS/AED on an adult victim of drowning consists of following steps: (1) safe approach; (2) check responsiveness by shaking gently and shouting loudly; (3) shout for help; (4) open airway; (5) check for breathing; (6) send someone

for AED and call 112; (7) provide five initial ventilations; (8) perform compression-ventilations cycles with a 30:2 ratio; (9) activate AED upon its arrival; (10) attach electrodes; (11) plug in electrodes; (12) check visually and verbally during AED analysis; (13) push the shock button while checking the environment of the victim visually and verbally; (14) do not lean over victim; (15) continue cardiopulmonary resuscitation (CPR) in a 30:2 ratio (see appendix 3).

2.4. Data collection

All BLS/AED assessments were videotaped and performed on a Laerdal ResusciAnne Manikin (Laerdal Medical, Vilvoorde) connected to a laptop computer. The following CPR variables were retained using the PC SkillReporting Software: ventilation volume, ventilation flow rate, compression depth, compression rate, duty cycle (i.e. ratio between time performing CPR to total time) and compressions with correct hand placement. In addition, the following BLS skills were qualitatively assessed by two trained observers: safe approach; check responsiveness by shaking and shouting; shout for help; open airway; look, listen and feel; call 112; initial ventilations; switching on AED, attaching pads, checking during analysis, checking during shock and continuing 30:2 sequence. Both CPR data from the manikin and BLS data from the observers were entered into a scoring system based on the Cardiff Test[8]. Individuals' BLS performance scores ranged between 24 and 102 points (see appendix 5). For reasons of clarity, this score was converted into a percentage of the maximum BLS score and served together with CPR variables as the primary outcomes of this study.

The demographic questionnaire inquired age, sex, place of refresher course, place of residence, place of employment, being a professional lifeguard or student worker, lifeguard context (i.e. combining the role of lifeguard with teaching/coaching), other obtained lifeguard certificates, year of certification, time of employment per year as lifeguard, practice of BLS skills, time of practising BLS skills, self-reported knowledge and skill of BLS (see appendix 4). The self-reported knowledge of BLS and self-reported skill in BLS were scored based on a Likert format from 1 (very bad) to 5 (very good). Significant predictor variables served as the secondary outcomes of this study.

2.5. Data analysis

All data were analyzed using version 19.0 of SPSS (SPSS Inc., Chicago, IL, USA). CPR variables were reported using means and standard deviations. Their quality was assessed through comparison with the ERC 2010 guidelines[7]. A stepwise multiple linear regression analysis was computed with BLS performance (expressed as a percentage) as the dependent variable, and the following variables as explanatory variables: sex, age, professionally employed as lifeguard, student worker, context in which the subject works as a lifeguard, other lifeguard certifications, years of certification, how many days a year on duty as a lifeguard, practice of BLS skills. Predictor variables such as age, years of certification, and time on duty per year were expressed in their absolute values. All other variables were codes as categorical data. Sample size analysis revealed that 333 subjects would be needed for a multiple linear regression including ten predictors, a desired power of .80, an alpha-level of .05, and an estimated effect size (ES, Cohen's f^2) of .05.

3. Results

A total of 50 refresher courses constituting 1,000 participants were randomly selected for participation in this study over the course of the academic year 2012-2013. Nineteen refresher courses dropped out of the study because they were cancelled (n = 9), or no informed consent was received from the lifeguard instructor (n = 6), or because organizational problems prevented a valid BLS assessment (e.g. when the refresher course started with a powerpoint of BLS making it impossible to perform objective assessments) (n = 4). All refresher courses in this sample were open to all certified lifeguards, and were heterogeneous concerning participants' gender, age, and professional occupation. In total, 616 (217 female, 399 male) certified Flemish lifeguards (aged 16-71 years) were assessed at 35 refresher courses.

Intrarater reliability for observational data as measured by Cohen's kappa was .90 for rater A and .92 for rater B. Interrater reliability was .89. All reliability measurements were based on 40% of the total sample. A null model was computed to investigate variance in BLS performances between the five provinces. The explained variance was .048, which was not considered meaningful.

3.1. Analysis of BLS/CPR performance with AED

Average BLS/AED performance was 66.5% (SD 10.7, range 39-100) for all lifeguards. Comparison with ERC 2010 guidelines showed that on average, lifeguards overinflated the manikin (M = 848 ml) and exceeded the recommended flow rate (M = 1148 ml/sec) (see Table 1). Average compression rate (M = 116/min) met the ERC 2010 guidelines[7] whereas compression depth (M = 48 mm) and duty cycle (M = 46%) adhered closely to the standards. On average, it took subjects 23 seconds to switch on the AED and 62 seconds to deliver the first shock.

Table 1: Cardiopulmonary resuscitation (CPR) and AED performance of Flemish lifeguards (n= 616).

	Guideline Target	**Mean (SD)**		**Min**	**Max**
Ventilation volume (ml)	499–601	848	(305)	0	1765
Ventilation flow rate (ml/sec)	499–601	1106	(606)	0	4048
Compressions with correct hand placement (%)	N/A*	74	(37)	0	100
Compression depth (mm)	50–60	48	(9)	0	60
Compression rate (min^{-1})	100-120	116	(17)	0	173
Duty cycle (%)	50	46	(6)	0	63
Time from arrival AED to switching ON (sec)	N/A*	23	(19)	2	120
Time from arrival AED to first shock (sec)	N/A*	62	(20)	31	201

* Not Applicable

3.2. Regression analysis

Stepwise multiple linear regression analysis built a significant model, $F(6, 415) = 25.61$, $p < .001$, ES = .38, explaining 27% of the variance in BLS performance ($R^2 = .27$). Analysis of variance inflation factors (VIFs) did not demonstrate multicollinearity between factors. No violations of linearity were detected. Significant predictors were age (beta = -.31, $p < .001$), year of certification (beta = .41, $p < .001$), time on duty per year (beta = -.25, $p < .001$), practising BLS skills (beta = .11, $p = .011$), and being a professional lifeguard (beta = -.13, $p = .029$) (see Table 2).

Table 2: Multiple linear regression analysis of factors associated with simulated BLS/AED performance in Flemish lifeguards.

	Standardized	**95% CI**		**p**
	Beta	**Lower**	**Upper**	
Age	-.31	-.41	-.16	< .001
Year of certification	.41	-.30	-.66	< .001
Time on duty per year	-.25	-.03	-.01	< .001
Practice of BLS and AED skills	.11	-0.18	.40	.011
Being a professional lifeguard	-.13	-0.42	0.16	.029

3.3.Demographics

Table 3 presents demographic data and the corresponding average BLS score. Data show that the youngest age group achieves higher BLS/AED performances compared to older age groups (70.8% vs. 63.1%). Also for certification, subjects certified before 2000 achieve lower scores than subjects who were recently certified (60.8% vs. 70.2%). Average BLS performances seem to decline with extended time on duty. Subjects being on duty between 8-30 days per year achieve higher BLS performances compared to subjects with more time on duty. Lifeguards who practise their BLS skills score slightly better than their peers (67.6% vs. 66.2%). Finally, professional lifeguards achieve a lower BLS score than student workers (65.3% vs. 72.3%). Those who reported to have a very bad knowledge and skill of BLS/AED perform also worse than those who reported to be very good (45.5% vs. 80.0% for knowledge and 58.6% vs. 77.6% for skill).

Table 3a: Overview of lifeguard demographics with their mean BLS performance percentage and standard deviation (SD)

	Category	N (%)		Mean BLS percentage	SD
Sex	Male	399	(64.8)	66.4	15.6
	Female	217	(35.2)	66.8	16.2
Province of refresher course	West Flanders	118	(19.2)	69.4	10.9
	East Flanders	108	(17.5)	66.2	9.6
	Flemish Brabant	179	(29.1)	60.4	24.7
	Antwerp	178	(28.9)	69.5	11.0
	Limburg	33	(5.4)	66.3	9.4
Age	16-25	305	(49.5)	70.8	16.9
	26-30	86	(14.0)	66.8	11.0
	31-35	59	(9.6)	60.7	16.9
	36-40	41	(6.7)	62.9	7.8
	41-45	46	(7.5)	63.7	13.4
	46-50	40	(6.5)	62.0	14.6
	51-55	27	(4.4)	58.1	16.6
	56-60	7	(1.1)	53.6	27.0
	>60	5	(.8)	63.1	8.2
Employment	Professional lifeguard	164	(26.6)	65.3	16.1
	Student	202	(32.8)	72.3	13.8
	Neither	250	(40.6)	68.8	14.9
Time on duty per year	Never	54	(8.8)	63.8	14.8
	1-7 days	21	(3.4)	62.1	22.2
	8-31 days	112	(18.2)	72.8	13.2
	32-62 days	70	(11.4)	64.8	15.1
	63- 183 days	48	(7.8)	67.9	11.0
	184-365 days	141	(22.9)	63.6	17.4
	Unknown	170	(27.6)	65.8	15.6
Lifeguard context[a]	Teacher	27	(4.4)	57.7	22.0
	Lifeguard/swim coach	399	(64.8)	68.2	15.2
	Combination of previous	20	(3.2)	62.4	24.2
	Other	47	(7.6)	60.8	18.1
	Unknown	123	(20.0)	66.3	13.4
Total		616		66.5	15.8

a Different context i.e. as police man or in the military

Table 3b: Overview of lifeguard demographics with their mean BLS performance percentage and standard deviation (SD)

	Category	N (%)		Mean BLS percentage	SD
Other lifeguard certificate[b]	Yes	98	(15.9)	66.1	16.2
	No	516	(83.8)	66.6	15.8
	Unknown	2	(.3)	65.0	9.5
Year of receiving lifeguard certificate	2006-2012	360	(58.4)	70.2	16.0
	2000-2005	106	(17.2)	64.1	11.9
	1995-1999	49	(8.0)	60.8	14.0
	1990-1994	38	(6.2)	61.7	11.3
	1985-1989	9	(1.5)	61.1	9.6
	1980-1984	14	(2.3)	56.5	15.2
	<1980	14	(2.3)	60.1	9.9
	Unknown	26	(4.2)	62.1	12.6
Practise of BLS skills	Yes	165	(26.8)	67.6	18.9
	No	439	(71.3)	66.2	14.4
	Unknown	12	(1.9)	61.4	16.7
Self-reported knowledge of BLS	Very Bad	9	(1.5)	45.5	23.2
	Bad	58	(9.4)	65.9	12.9
	Neutral	270	(43.8)	64.3	14.6
	Good	257	(41.7)	68.3	16.8
	Very good	22	(3.6)	80.0	10.9
Self-reported skill in BLS	Very Bad	7	(1.1)	58.6	9.3
	Bad	62	(10.1)	64.3	15.1
	Neutral	290	(47.1)	65.5	13.6
	Good	242	(39.3)	67.9	18.4
	Very good	15	(2.4)	77.6	11.0
Total		616		66.5	15.8

b Other i.e. sea lifeguard, open water lifeguard

4. Discussion

The first research question concerned the general quality of BLS/AED performance of Flemish lifeguards. The study shows lifeguards in Flanders achieved an overall mean BLS/AED performance of 66.5% (SD=15.8%). Previous research showed that laymen, introduced to BLS without AED, achieved BLS scores averaging 71 and 81% after one lesson. Two weeks following the learning phase, their BLS performance was still above 70% and thus higher compared to the results in our study[9]. Assuming that lifeguards' BLS/AED performance was much higher at the time of their certification, results from our study seem to support research indicating a significant decay of skill[5, 10]. Furthermore our study shows the

longer it has been since certification, the worse the lifeguards' performance. This confirms skill decay as well.

Comparison with ERC 2010 guidelines showed that on average, lifeguards overinflated the manikin (M = 848 ml) and exceeded the recommended flow rate (M= 1148 ml/sec). Average compression rate (M= 116/min) met the ERC 2010 guidelines whereas compression depth (M= 48 mm) and duty cycle (M= 46%) adhered closely to the standards. In their study, Moran and Webber determined that 87% of the tested lifeguards ventilated a higher volume rate (M = 937 ml) than prescribed in the guidelines, and 31% ventilated more than 1,000 ml which heightens the possibility of gastric insufflation[6, 7]. A mere 3% of the tested subjects ventilated not enough (i.e. < 500ml), and only 9% maintained an adequate volume. When ventilation skills were analysed based on age or years of experience of the lifeguards, no significant differences were found. However, their analysis based on gender did show some significant results: male test subjects overventilated more than female subjects. About 4% of the variability within the ventilation volume could be explained based on gender.

Performing BLS without ventilation errors is a complicated task. Batcheller et al. found that only 1.7% of the ventilations and 3.5% of the chest compressions were successful after classroom instruction [11]. The ventilation limits were exceeded which was explained by the fact that the ventilation technique was wrongfully thought since Iserbyt et al. have identified overinflation and low percentages of ventilations without errors as challenges for the instruction of BLS[10, 12, 13].

A conclusion that could be drawn from the study of Moran et al. was that male subjects compressed deeper and faster than their female counterparts[6]. Supplementary work of Moran and colleagues stated that the current knowledge of BLS in employed lifeguards in New Zealand is low[14]. 30% of the lifeguards did not know how to perform effective ventilations even though they all had attended a refresher course earlier that year. In order to find solutions for the improvement of lifeguards' BLS/AED skills we ran a regression analysis to identify significant predictor variables.

A significant regression model explained 27% of the variance in BLS/AED performance. Results highlighted five variables as significant: age, years of certification, time on duty per year, practising BLS skills and being a professional lifeguard. It appears that older age, longer certification of the lifeguard, more time on duty per year, not practising BLS skills and being a professional lifeguard negatively affected BLS performance. Two of the predictors, age and years of certification, imply younger and thus less experienced lifeguards to achieve higher BLS/AED performances than older and experienced lifeguards. Research of De Vries et al. demonstrated inexperienced lifeguards outperformed experienced lifeguards in every aspect of the BLS performance, except for compression depth where experienced lifeguards performed better (i.e. deeper compression) than younger lifeguards. A significant relation was confirmed between the age of the lifeguards and their experience[15]. The similarity between these results and the ones in our research is remarkable, as one would expect it to be the other way round. Two possible explanations could be put forward: (1) the retention of the BLS skills and knowledge is substandard, (2) older lifeguards were taught different protocols of performing BLS. Because of a lack of yearly lifeguard tests, it could be that older lifeguards still stick to their previously taught BLS techniques. Either way the Flemish law[16] could be modified in requiring lifeguards to pass a yearly test to maintain their knowledge and skills at a higher level. A problem with current refresher courses is that mere participation is

sufficient for the renewal of their certificate, which enables them to continue their professional activities. A yearly BLS test could easily be implemented within the refresher courses. Before and/or after this test, feedback could be provided to the lifeguards to ensure higher performance.

In addition to these results, practising BLS skills was also a significant predictor in the BLS performance. This seems rational, as one has to perform the skills regularly to master the knowledge, attitudes and skills of being a lifeguard[17]. Remarkably 71.3% reported to never practise their BLS skills. This is another argument to implement a yearly BLS test. This could ensure lifeguards would practise more. Individual training of the BLS skills is recommended but this could be organised by the managers of the swimming pools. Nevertheless the study of Moran et al. showed that skills, as compared to knowledge, are not significant in the training of lifeguards[14]. In contrast to our study, training BLS skills was not found significant. The reason could be that if a lifeguard keeps training BLS skills wrongly, the training will be ineffective. Batcheller et al. report mastering BLS skills is a complex process[18]. As such, feedback is the key to perfectly mastering BLS performance. A supplementary explanation for these results could be that data on knowledge and skill variables in this study were based on self-reports, which are subject to response bias. An objective measurement of these variables and the possible relations with other factors is something to be examined in future research.

In contrast to what would be expected from previous research, gender was not a significant predictor of BLS performance[14, 15]. This could be due to the fact that our research included not only CPR variables, which are more affected by physical characteristics such as strength and endurance, but integrated all fifteen BLS/AED handlings as prescribed by the ERC guidelines. Some variables are important to mention because of their non-significance in the regression model, such as the context of employment or the amount of hours spent on training BLS. Finally, it is counterintuitive that lifeguards who hold other lifeguard certificates (e.g. certificate of diver-lifeguard, surf lifeguard) did not lead to a significant predictor variable in the regression model.

This study has some limitations. An equal distribution of refresher courses across the five provinces was not achieved since Limburg was underrepresented in the sample. Furthermore more male than female subjects participated and the youngest and inexperienced group was overrepresented. Although a limitation, we believe this represents the actual active lifeguard population in Flanders. Certain data, such as how often the lifeguards practised their BLS skills and knowledge, were tested through self-evaluation and could be biased. A corner stone of this research is that we were able to examine 616 active lifeguards. That is 16.06% of all Flemish lifeguards coming to a refresher course[1]. Moreover this study used both qualitative and quantitative data and we measured with both objective and subjective instruments. Additionally numerous variables were used to determine the overall BLS performance percentage.

We advise further research to determine whether or not a yearly test, giving feedback on BLS performances to lifeguards and coaching their individual, on site training to maintain retention of their knowledge and skills. Data on drowning or cardiac arrests in pools should be collected and made accessible for the general public, as information on this topic is limited.

5. Conclusion

The goal of this research was to assess the quality of BLS/AED performance and identifying factors predicting this performance in Flemish lifeguards. Results showed lifeguards scored a mean 66.5% on the BLS performance with AED on a drowned victim. Regression analysis identified age, years of certification, time on duty per year, the practising of BLS skills and being a professional lifeguard as significant predictor variables. These results provide essential information for increasing the effectiveness of lifeguard training courses and in-service training. A yearly assessment, giving accurate feedback on their BLS performance and guided practice at the lifeguard's site of employment are recommended. This could improve the BLS performances of Flemish lifeguards.

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7. Appendices

Appendix 1 – Populaire samenvatting

Tot op heden bestaat er geen objectieve analyse van de reanimatiekwaliteit met AED bij Vlaamse Hoger Redders. Onderzoek hiernaar kan ons veel vertellen over de reanimatievaardigheid van gediplomeerde redders, de kwaliteit van de Vlaamse reddersopleiding en de effectiviteit van de jaarlijks verplichte bijscholingen.

Het doel van deze studie is om de reanimatievaardigheden van de redders in kaart te brengen. Een totaal van 616 proefpersonen (16-71 jaar; 399 mannen, 217 vrouwen), van over heel Vlaanderen, werd getest op hun reanimatievaardigheden. Demografische gegevens werden verzameld aan de hand van een vragenlijst.

Per persoon werd een totale reanimatiescore berekend. Gebruik makend van een stapsgewijze multipele lineaire regressieanalyse werden de variabelen 'leeftijd', 'jaar van behalen reddersdiploma', 'tijd aan het werk per jaar', 'oefenen van de BLS vaardigheden' en 'al dan niet een professionele Hoger Redder zijn', significant bevonden. Deze variabelen verklaarden 27% van de variantie in de totale BLS score.

De studie toont aan dat jonge onervaren redders die niet veel per jaar oefenen, beter reanimeren. Een jaarlijks examen invoeren op de bijscholingen, feedback leveren over de reanimatievaardigheden en individuele trainingen van redders coachen gedurende het jaar zouden een verbetering van deze resultaten kunnen teweegbrengen.

Appendix 2 – Richtlijnen journal

Resuscitation

Guide for Authors

An interdisciplinary journal for the dissemination of clinical and basic science research relating to cardiopulmonary resuscitation.

RESUSCITATION Guide for Authors *Resuscitation* is a monthly interdisciplinary medical journal and is the official journal of the European Resuscitation Council. The papers published deal with the aetiology, pathophysiology and prevention of cardiac arrest, resuscitation training, clinical resuscitation, and experimental resuscitation research although papers relating to animal studies will be published only if they are of exceptional interest and related directly to clinical cardiopulmonary resuscitation. Papers relating to trauma are published occasionally but the majority of these concern specifically traumatic cardiac arrest. Review articles and Letters to the Editor, particularly relating to articles previously published in Resuscitation, are welcome. We no longer publish case reports as papers but a case of exceptional interest and originality may be considered for publication if submitted in the form of a letter to the editor.

Editorial policy The originality of content of papers submitted and the quality of the work on which they are based is the prime consideration of the editors. The paper should deal with original material, neither previously published nor being considered for publication elsewhere, except in special circumstances agreed with the Editor-in-Chief. A small number of papers are randomly selected for plagiarism software checking. Most papers are assigned to an editor and sent for peer review; papers may be returned to authors as accepted, for reconsideration after revision, or rejection. The reviewers name may or may not be revealed to the author(s), depending on the reviewer's preference. The decision of the Editor-in-Chief regarding acceptance or rejection is final. Papers that are not within the scope of the journal or are far below the standard for publication in *Resuscitation* will be rejected by the Editors without obtaining peer review. Papers that simply describe a clinical trial protocol will be rejected. Resuscitation operates a word limit for all articles as detailed in the table below. Manuscripts will be returned to the author if the word count is exceeded.

WORD LIMIT (excluding abstract and references)

Original Paper* 3000

Short Paper* 1500

Review* 4000

Commentary and Concepts* 2000

Editorial 1200

Letter to Editor 500

TABLES/ILLUSTRATION LIMIT

Original Paper* 6

Short Paper* 3

Review* 8

Commentary and Concepts* 3

Editorial 1

Letter to Editor 1

REFERENCE LIMIT

Original Paper* 40

Short Paper* 20

Review* 75

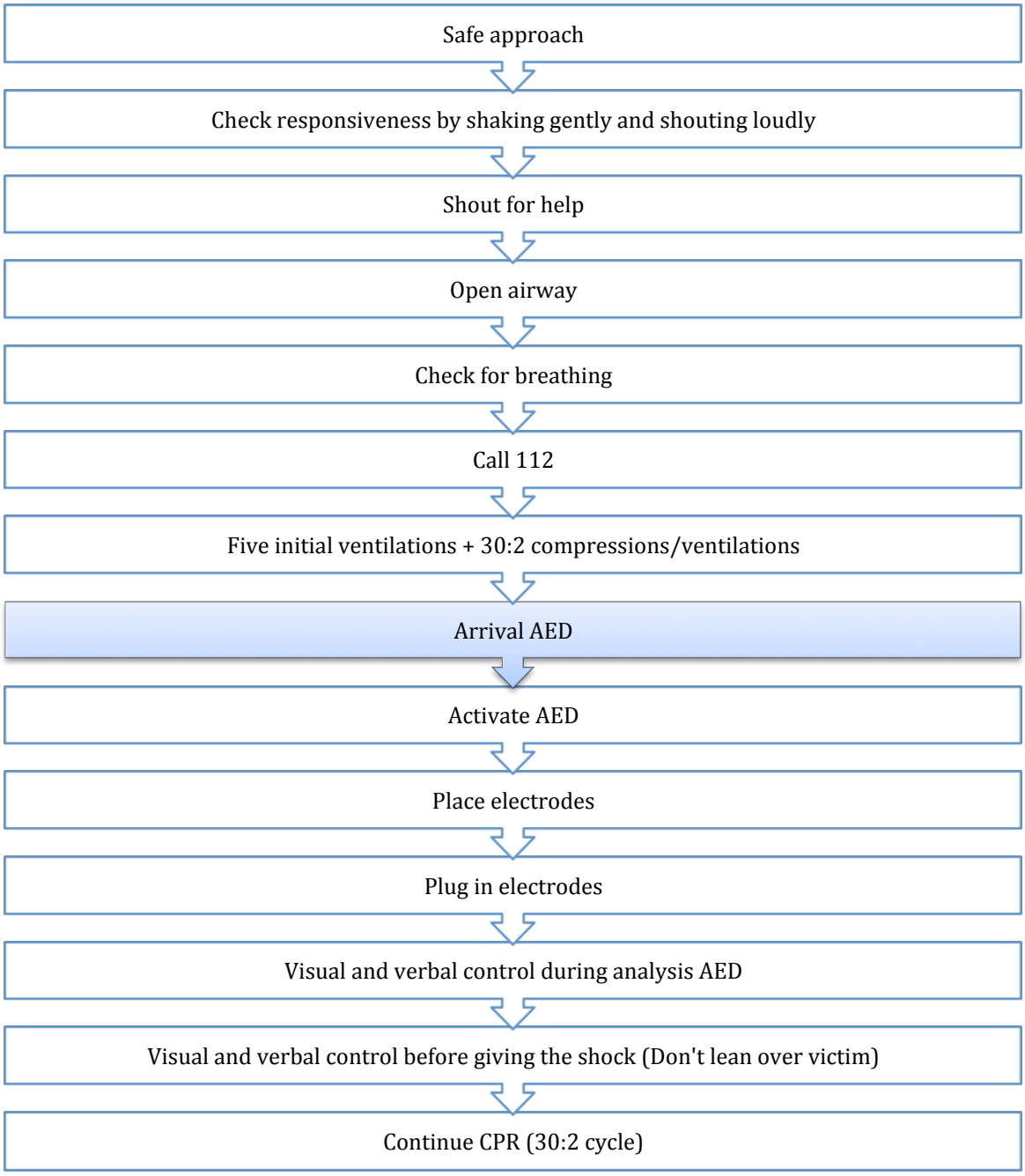
Commentary and Concepts* 20

Editorial 30

Letter to Editor 5 *option for supplementary on line materials

Guide for Authors These guidelines generally follow the 'Uniform Requirements for Manuscripts Submitted to Biomedical Journals' The complete document appears at http://www.icmje.org These instructions for authors can also be found on http://www.elsevier.com/wps/find/journaldescription.cws_home/505959/description#description

Appendix 3 – European Resuscitation Council 2010 guidelines on Basic Life Support with use of an Automated External Defibrillator (AED)



Appendix 4 – Vragenlijst studie Hoger Redder

Vragenlijst Studie HR

Deze vragenlijst wordt anoniem verwerkt

Ik ben een MAN/ VROUW

Mijn leeftijd: ..... jaar

Plaats bijscholing: .....

Woonplaats: .....

Plaats(en) waar u Redder bent: .....

Ik ben een beroepsredder: JA / NEE

Ik ben een jobstudent: JA / NEE

Ik ben redder in volgende context:

1. Leraar 2. Redder/trainer in zwembad 3. Ander: ……..

Andere reddersdiploma's (Redder aan Zee, Duiker-Redder,...): .....

Het jaar waarin u het diploma Hoger Redder behaalde? .....

Probeer zo nauwkeurig mogelijk uit te drukken hoeveel tijd u per jaar aan het werk bent als redder of de functie van redder combineert met die van lesgever/leraar:

..... dagen per jaar	..... maanden per jaar	Het hele jaar door (beroepsredder)	Ander: .....

Oefent u regelmatig uw reanimatievaardigheden? JA / NEE

Probeer zo nauwkeurig mogelijk uit te drukken hoeveel tijd u besteedt aan het oefenen van uw reanimatievaardigheden:

..... uren per week	..... dagen per maand	..... dagen per jaar	Ander(bv. enkel op reddersbijscholing):.....

Mijn kennis over de reanimatie van een drenkeling vind ik:

1. Zeer slecht 2. Slecht 3. Neutraal 4. Goed 5. Zeer goed

Mijn vaardigheid in de reanimatie van een drenkeling vind ik:

1. Zeer slecht 2. Slecht 3. Neutraal 4. Goed 5. Zeer goed

Lifeguard Study 2012

I. Scoring vragenlijst (groen in Excel-sheet)

Ik ben een MAN/ VROUW

1. MAN
2. VROUW

Mijn leeftijd: ..... jaar

1. 17-25
2. 26-30
3. 31-35
4. 36-40
5. 41-45
6. 46-50
7. 51-55
8. 56-60
8. >60

Plaats bijscholing: .....

1. West-Vlaanderen
2. Oost-Vlaanderen
3. Vlaams-Brabant
4. Antwerpen
5. Limburg
6. Brussel

Woonplaats: .....

1. West-Vlaanderen
2. Oost-Vlaanderen
3. Vlaams-Brabant
4. Antwerpen
5. Limburg
6. Brussel

Plaats(en) waar u Redder bent: .....

1. West-Vlaanderen
2. Oost-Vlaanderen
3. Vlaams-Brabant
4. Antwerpen
5. Limburg
6. Brussel

7. Nergens

Ik ben een beroepsredder: JA / NEE

1. JA 2. NEE

Ik ben een jobstudent: JA / NEE

1. JA 2. NEE

Ik ben redder in volgende context

1. Leraar 2. Redder/trainer in zwembad
3. Ander…….. 4. Combinatie van voorgaande

Andere reddersdiploma's (Redder aan Zee, Duiker-Redder,…): ……

1. Redder aan Zee 2. Duiker-Redder
3. Openwater Redder 4. Combinatie 1-3
5. Ander en Noteer

Het jaar waarin u het diploma Hoger Redder behaalde? ……

1. 2006-2012 2. 2000-2005
3. 1995-1999 4. 1990-1994
5. 1985-1989 6. 1980-1984
7. < 1980

Probeer zo nauwkeurig mogelijk uit te drukken hoeveel tijd u per jaar aan het werk bent als redder of de functie van redder combineert met die van lesgever/leraar:

……. dagen per jaar	…….. maanden per jaar	Het hele jaar door (beroepsredder)	Ander: ……

1. Nooit
2. 1-7 dagen
3. 7 dagen – 1 maand
4. 1-2 maanden
5. Een half jaar (bv. 50% redder)
6. Hele jaar door (bv. 100% redder)
7. Gekoppeld aan leraar zijn
8. Gekoppeld aan andere (bv. zwemlessen, clubs)

Oefent u regelmatig uw reanimatievaardigheden? JA / NEE

1. JA
2. NEE

Probeer zo nauwkeurig mogelijk uit te drukken hoeveel tijd u besteedt aan het oefenen van uw reanimatievaardigheden:

..... uren per week	..... dagen per maand	..... dagen per jaar	Ander (bv. alleen tijdens de reddersbijscholing): .....

1. Nooit
2. Wekelijks
3. Maandelijks
4. Minder dan maandelijks

Mijn kennis over de reanimatie van een drenkeling vind ik:

1. Zeer slecht 2. Slecht 3. Neutraal 4. Goed 5. Zeer goed

Nummer naargelang antwoord

Mijn vaardigheid in de reanimatie van een drenkeling vind ik:

1. Zeer slecht 2. Slecht 3. Neutraal 4. Goed 5. Zeer goed

Nummer naargelang antwoord

Appendix 6 – Assessment of BLS performance

II. Assessment of Basic Life Support performance

Scenario: Resuscitation of an adult drowning victim with AED.

1. Safe approach (OBSERVATIE)

2. Performed
1. Not performed

2. Check consciousness (OBSERVATIE)

A. By shaking gently at shoulders

3. Performed
2. Not performed
1. Performed potentially dangerous

B. By shouting aloud

2. Performed
1. Not performed

3. Shout for help (OBSERVATIE)

2. Performed
1. Not performed

4. Check breathing (OBSERVATIE)

A. Opening airway

4. As instructed on task cards
3. Other and effective
2. Visibly attempted
1. Not performed

B. Look, listen, feel

B1. Actions

4. Correct
3. Not correct
2. Not effective
1. Not performed

B2. Time

4. 8-12 seconds
3. 1-7 seconds
2. >12 seconds
1. Not performed

5. Call 112

3. Performed
2. Called unspecified help
1. Not performed

6. Amount of initial ventilations (OBSERVATIE)

5. 5
4. 1-4
3. >5
2. Attempted
1. Not performed

7. Chest compressions (SOFTWARE)

A. Total amount of compressions after three cycles

4. 85-95
3. >95
2. 1-84
1. Not performed

B. Average compression depth (mm) **(SOFTWARE)**

5. 50 or >50
4. 40-49
3. 19-39
2. 1-18
1. Not performed

*C. Compressions with correct hand position (%)***(SOFTWARE)**

6. 100
5. 85-99
4. 70-84
3. 55-69
2. <55
1. Not attempted

D. Average compression rate (rate/min) **(SOFTWARE)**

6. 90-110
5. 109-120
4. 80-89
3. >120
2. <80
1. Not performed

8. Ventilation (SOFTWARE)

A. Total amount of ventilations after three cycles

7. 11
6. 7-10
5. 4-6
4. 1-3
3. >11
2. Attempted
1. Not performed

B. Average ventilation volume (ml) **(SOFTWARE)**

7. 500-600
6. 300-499
5. 600-800
4. 1-299
3. >800
2. Attempted
1. Not performed

C. Ventilation: compression ratio **(SOFTWARE)**

6. 3 : 30 (3 : 28-32)
5. 2 : 30 (of 2 : 28-32)
4. Other
3. Compression only
2. Ventilation only
1. No ventilation nor compression

8. Switching on AED

2. Performed
1. Not performed

9. Plugging Electrodes onto AED after being prompted by AED

3. Performed
2. First plugged, next switched on
1. Not plugged in

10. Correct attachment of AED electrode Pads (OBSERVATIE)

7. Both electrodes completely in areas
6. One completely in area and one crossing the border of the area
5. Both electrodes crossing the border of the area
4. One electrode completely in area and one completely outside area
3. One electrode crossing the border of area and one completely outside the area
2. Both electrodes outside the area
1. Electrodes not attached or not plugged onto AED

11. During AED analysis, visual and verbal checks by Lifeguard (OBSERVATIE)

3. Performed (verbal AND visual check)
2. Incorrect (only verbal OR visual check)
1. Not performed

12. Shock button pushed as directed and shock safety (OBSERVATIE)

4. Performed: Verbal AND visual check and no eye contact with shock button when pushed
3. Not performed: Verbal OR visual check during administration of shock
2. No visual or verbal check during administration of shock
1. Shock button not pushed

13. <u>Not</u> leaning over the victim when pushing the shock button (OBSERVATIE)

2. Performed
1. Not performed

14. Continue with resuscitation when prompted by AED (OBSERVATIE)

3. Yes: 30/2 sequence
2. Yes: other sequence
1. Not performed

15. How long do you resuscitate a victim of drowning before leaving the victim to get help? (oral question)

2. 1 minute (or 3 x 30/2)
1. Other

16. Continue with resuscitation (oral question)

4. 3 items correct
3. 2 items correct
2. 1 item correct
1. No item correct

17. Performed all BLS items (OBSERVATIE)

2. Yes
1. No

18. Performed all items in the correct sequence (OBSERVATIE)

2. Yes
1. No

Total Basic Life Support score (1-18): range 24-102 points

Time from 'arrival of defibrillator' to first shock [sec]
Time from arrival of AED to switching ON [sec]