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Undergraduate nursing students' acquisition and retention of CPR knowledge and skills

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Summary The ability to respond quickly and effectively to a cardiac arrest situation rests on nurses being competent in the emergency life-saving procedure of cardiopulmonary resuscitation (CPR). The aim of this study was to investigate the extent to which Irish nursing students acquire and retain CPR cognitive knowledge and psychomotor skills following CPR training. A quasi-experimental time series design was used. A pre-test, CPR training programme, post-test, and re-test were conducted. CPR knowledge was assessed by a multiple-choice assessment and psychomotor skills were assessed by observing CPR performance on a Resusci-Anne skill-meter manikin. The findings showed an acquisition in nurses' CPR knowledge and psychomotor performance following a 4 h CPR training programme. Despite this, at no point in this study, did any nurse pass the CPR skills assessment. A deterioration in both CPR knowledge and skills was found 10 weeks following CPR training. However, students' knowledge and skills were improved over their pre-training scores, which clearly indicated a positive retention in CPR cognitive knowledge and psychomotor skills. The study findings present strong evidence to support the critical role of CPR training in ensuring that nursing students progress to competent and confident responders in the event of a cardiac related emergency.

Introduction

Cardiovascular disease (CVD) is a critical issue for Irish health care practitioners as it is the leading cause of premature mortality in Ireland, accounting for over 40% of all deaths annually (Central Statistics Office, 2004). Approximately 11,000 people die from CVD every year and it is estimated that 6000 of these deaths are from a sudden cardiac arrest (Irish Heart Foundation (IHF) (2004a)). Almost half of cardiac deaths occur in the hospital environment and nurses are frequently first responders (Yakel, 1989). Cardiopulmonary resuscitation (CPR) is a critical component of basic life support and the established first line of response to a cardiac arrest in the interim before defibrillation and advanced life support are available (AHA, 2001).

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CPR has the potential to save lives in other life threatening emergencies such as stroke, respiratory arrest, trauma, drowning and airway obstruction (AHA, 2001). CPR is associated with survival and has the potential to prevent sudden death (Moser and Coleman, 1992). Thus, nurses' competency in CPR is a critical factor in determining successful patient outcomes from a cardiac arrest.

The Irish Heart Foundation (IHF) is affiliated to the American Heart Association (AHA) and follows their resuscitation guidelines (IHF, 2004b). These guidelines recommend that all hospital staff with patient contact should have regular resuscitation training (AHA, 2001). However, in Ireland, there is no regulatory mandate for registered nurses to attend CPR instruction or re-certification programmes. This situation is unique and therefore, it is conceivable, that nurses may be receiving the majority of their CPR training during the early stages of an educational programme. The purpose of this study was to investigate the degree to which nursing students acquire and retain CPR knowledge and skills following CPR training.

While this subject has been studied before, it remains unexplored within the Irish context and particularly within the student nurse population. Given the unique Irish situation, the current study is timely and will bridge this gap in the literature by investigating whether student nurses acquire and retain CPR knowledge and skills following CPR training.

Literature review

CPR competency is defined as having a cognitive knowledge domain and a psychomotor skills domain in order that practitioners will be able to perform CPR in a cardiac arrest situation (Broomfield, 1996). This study further defines CPR competency as encompassing both the acquisition and retention of CPR cognitive knowledge and psychomotor skills.

Despite the fact that nurses' ability to perform CPR may well be a critical determinant of patient survival from a cardiac arrest (Devlin, 1999; Hemming et al., 2003), evidence is compelling to suggest that registered nurses across continents lack competence in the performance of CPR (Broomfield, 1996; Devlin, 1999). Similarly, nursing students are also reported to lack CPR competency (Moule and Knight, 1997; Badger and Rawstorne, 1998). The reality of these findings is a cause for concern. If nurses as first responders to a cardiac arrest patient are not competent in the life-saving procedure of CPR, then, the patient is undoubtedly at risk of not having optimal chances of survival.

The literature is clear that the composite skill of CPR cannot be acquired or retained easily by nurses (Handley and Handley, 2003). Studies report different levels of competency in individual CPR skill components, that vary dramatically along a continuum from 0% to 100% (Greig et al., 1996; Devlin, 1999). There is consistency that the core CPR skill 'performing chest compressions' was ranked lowest in the psychomotor skills (Greig et al., 1996; Devlin, 1999). These findings are perhaps not surprising as CPR is a complex task and nurses are required to remember and perform up to 50 psychomotor skills (Flint et al., 1993; Wollard et al., 2004).

CPR retention is defined as retaining the capacity to perform CPR effectively at a certain point in time after CPR training (Greig et al., 1996). The retention of CPR knowledge and skills is a key factor in determining CPR competence (Broomfield, 1996). However, there is universal evidence to suggest that CPR knowledge and skills are poorly retained across populations (Broomfield, 1996; Moule and Knight, 1997; Handley and Handley, 2003). Moser and Coleman (1992) carried out a seminal review of studies on CPR retention over a 9-year span (1980–1989) and reported poor CPR skills retention.

While there are a number of factors associated with CPR competency, one critical factor is CPR instruction (Hemming et al., 2003; Wollard et al., 2004). The function of CPR instruction is to ensure that nurses not only acquire CPR knowledge and skills, but that they also retain this knowledge and skills to be able to respond competently and confidently to a life-threatening cardiac arrest situation (Broomfield, 1996).

The development of knowledge and skills is an essential component of professional development in nurse education programmes (Bullock, 2000). Undoubtedly, public expectation is high that nurses will be competent to perform CPR in the event of a cardiac arrest (Barrett and Squire, 2004). The issue of nurses' CPR competency remains unexplored within the Irish context. With no evidence regarding Irish nursing students' competency in CPR knowledge and skills, it is reasonable to assume that the findings reported in this literature review may also be applicable to them.

Research questions

This study investigated:

1. The extent to which nursing students attending CPR training acquire the knowledge and skills necessary to perform effective CPR?

2. The extent to which nursing students attending CPR training retain the knowledge and skills necessary to perform effective CPR?

Methods

The population consisted of all General nursing students within the second year cohort of a three-year undergraduate nursing Diploma programme in the Republic of Ireland ($n = 55$). The study setting was one Irish general teaching hospital and 18 students were randomly selected from this convenience group. The age profile of students ranged from 18 to 37 years, with 72.2% ($n = 13$) under 23 years and 27.8% ($n = 5$) over 23 years. All students received CPR training during the first year of their nursing programme and 22.2% ($n = 4$) reported completing other CPR training prior to their nursing course.

A quasi-experimental time series design was used as it facilitated pre-testing and post-testing within a single group of subjects (Dempsey and Dempsey, 1992). On three occasions nurses' CPR cognitive knowledge and psychomotor skills were assessed.

Ethical approval was secured from the Local Research Ethics Committee. Permission to access the study sample was obtained from the hospital Nursing Director. A full explanation was given to each student prior to them being invited to participate in the study and sign a consent form. All data collection sheets were coded with an index number and at the end of the study all raw data were destroyed. I acknowledge the ethical issue of my relationship as a nurse lecturer with the students, as they may have felt indirectly 'coerced' into participating in the study. This was addressed by meeting with each of the students individually, to discuss their involvement before they were invited to participate in the study. I made clear that they could withdraw from the study at any time without explanation. All subjects were assured that there would be no consequences for ineffective CPR skills and confidentiality was assured with regard to individual subjects' levels of CPR knowledge and skills.

Instruments

Nurses' CPR cognitive knowledge was assessed by a 21 item structured multiple-choice assessment that is evidence-based and validated by expert consensus from the AHA (IHF/AHA, 2000a). The pass standard for this study was accepted as 85.7% (18 points).

Nurses' psychomotor skills were assessed by structured observation of CPR performance on a Resusci-Anne manikin and data from the Laerdal skill-meter. An established observation checklist, designed by the IHF/AHA (2000b) was used. Content and construct validity of the observational tool has been established (AHA/ILCOR, 2000).

Many authors have challenged the consistency of using CPR checklists alone and argued that they do not achieve adequate reliability levels for research purposes (Mancini and Kaye, 1990; Brennan et al., 1996). In an attempt to overcome the limitations of the CPR checklist, the Laerdal skill-meter was also used, which is regarded as the gold standard for objectively measuring discrete CPR skill components (Brennan et al., 1996). The range of scores achievable for the CPR skills test was between 0 and 18 points, where 1 point was assigned if the CPR skill component was performed correctly.

A pilot study was conducted with five students from the population. Inter-rater reliability of observations was established by having another CPR instructor simultaneously score the students CPR skills. Close agreement was achieved on all performance criteria, yielding an average agreement of 94% (Polit and Hungler, 1999).

Data collection

On day one of the main study, a pre-test, CPR training programme, and a post-test were conducted. A re-test was conducted on day-seventy (10 weeks later). This time frame was considered as an appropriate delay between intervention and re-testing as it was previously used in a similar study (Broomfield, 1996). The venue for data collection was the CPR training room in the study hospital.

During the pre-test, students individually underwent a 3-min assessment of their CPR psychomotor skills in isolation of peer students. I read standardised instructions to the student, who was asked to begin a simulated rescue on a collapsed person. I then assumed an observer role and completed the CPR checklist. A print-out of the effectiveness of the students' CPR performance was produced by the skill-meter. After the skills test, students completed the knowledge MCQ test.

The CPR training programme consisted of a 4 h course, which incorporated module one and module two of the Healthcare Providers Course (IHF/AHA, 2000c). This included theory on heart disease, risk factors and epidemiology of heart disease. The skills taught included adult one-rescuer CPR and management of foreign-body airway obstruction.

As a certified CPR instructor, I was the course instructor and the ratio of students to instructor was 6:1 (AHA, 2001).

Students' CPR knowledge and skills acquisition were assessed immediately after the training course in a post-test. Ten weeks following the CPR programme, a re-test was conducted to assess students' CPR knowledge and skills retention. In both of these tests, the same manikin simulation, data collection instruments and procedures were used as on pre-testing. After the tests were completed the researcher corrected any errors in individual students' CPR knowledge and skills.

Scoring system for CPR performance

A scoring system was developed for evaluating students' CPR psychomotor skills drawing on an approach by Berden et al. (1992), which used penalty points for CPR skill errors. A combination of the CPR skill components from the observation checklist and the Laerdal skill-meter formed the basis of the scoring system (Table 1). Value labels were assigned to each skill component, identifying whether the skill was 'performed correctly', 'performed incorrectly' or 'not performed', and these values were given penalty points. For example, if the skill component was performed correctly, 0 penalty points were given. If the student performed the skill component incorrectly, they were given 5, 10, or 20 penalty points depending on the severity of the aberration. The range of penalty points achievable was between 0 and 235 and a satisfactory CPR performance was defined as a total score not exceeding 15 penalty points (Berden et al., 1993).

The validity and reliability of the scoring system was established by conducting a modified Delphi technique, where expert consensus was invited from a panel of seven members from the Irish Heart Foundation, National Teaching Faculty for Basic Life Support. This exercise consisted of two rounds and achieved at least 70% consensus for each of the individual scoring items, which helped to formulate a revised scoring instrument.

Data analysis

The data were analysed using the SPSS, version 10.1 for Windows. Descriptive and inferential statistics were used to describe and explore relationships in the data sets. The choice of statistical test was the *t*-test, which is used to compare the mean scores of the same participants in two or more conditions or points in time (Parahoo, 1997). Statistical significance was set at $p < 0.05$.

Results

CPR cognitive knowledge

The mean score of students' CPR knowledge in the pre-test was 15.2 (Fig. 1). Fig. 2 illustrates that 6% ($n = 1$) of students achieved the pass standard in CPR cognitive knowledge before they attended CPR training.

Following CPR training, the mean score of students' CPR knowledge in the post-test was 18.1 (Fig. 1). Fig. 2 shows that 72% ($n = 13$) of students achieved the pass standard. The increase in scores between the pre-test and post-test was found to be statistically significant (Table 2).

Ten weeks after the CPR programme, the mean score of students' CPR knowledge was 16.8 in the re-test (Fig. 1). Fig. 2 illustrates that 44% ($n = 8$) of students achieved the pass standard. The decrease in scores from the post-test to the re-test was found to be statistically significant (Table 2). Additionally, when the pre-test scores were compared with the re-test scores, the increase in scores was also statistically significant (Table 2).

CPR psychomotor skills

Fig. 3 shows that the mean score for CPR performance in the pre-test was 6. Penalty points were assigned for failing to perform or incorrectly perform CPR skill components. The range of penalty points in the pre-test was between 40 and 185, out of a maximum of 235 points. The mean penalty point score and the standard deviation are highlighted in Table 3. No student achieved the pass standard of less than 15 penalty points in the pre-test.

The mean score for CPR performance in the post-test was 15 (Fig. 3). Ninty-four percent of students achieved higher scores from the pre-test to the post-test. The range of penalty points in the post-test was between 25—80, out of a maximum of 235 penalty points. The mean penalty point score and the standard deviation are highlighted in Table 3. No student achieved the pass standard of less than 15 penalty points following CPR training. When the pre-test psychomotor scores were compared to the post-test scores, the increase in scores was statistically significant (Table 4).

In the re-test, 10 weeks following CPR training, the mean score for CPR performance was 12. The range of penalty points in the re-test was between 35 and 105, out of a maximum of 235 penalty points. The mean penalty point score and the

Table 1 Numerical scoring system for CPR performance

Variable	Skill component	Value	Penalty points
Variable 1	Checks unresponsiveness	Correct Incorrect/not performed	0 5
Variable 2	Summon help	Correct Not performed	0 20
Variable 3	Open airway: Head tilt Chin lift	Correct Incorrect Not performed	0 10 20
Variable 4	Check for breathing look listen and feel for 10 s	Correct Incorrect Not performed	0 5 10
Variable 5	Give two slow breaths	Correct Incorrect Not performed	0 10 20
Variable 6	Ventilation volume	Correct — 76% and over adequate Incorrect — 51—75% adequate Incorrect — 50% and below	0 10 20
Variable 7	Initial pulse check	Correct Incorrect Not performed	0 5 10
Variable 8	Correct hand position	Correct — Hand position right 76% and over in compressions Incorrect — Hand position right 51—5% compressions Incorrect — Hand position right 50% and below in compressions	0 10 20
Variable 9	Performs 15 chest compressions	Correct Incorrect	0 5
Variable 10	Depth of chest compressions	Correct — 76% and over right Incorrect — 51—75% Right Incorrect — 50% and below right	0 10 20
Variable 11	Release of chest compressions	Correct — Complete release 76% and over in compressions Incorrect — Complete release 51—75% compressions Incorrect — Complete release 50% and below in compressions	0 10 20
Variable 12	Rate of chest compressions	Correct — Rates 80—120 Incorrect — Rates 120—140 or 60—80 Incorrect — Rates of 140 and over or 60 and below	0 10 20
Variable 13	Give two slow continuing breaths	Correct Incorrect	0 5
Variable 14	Compression to breathing ratio of 15:2	Correct Incorrect	0 5
Variable 15	Performs four complete cycles	Correct Incorrect	0 5
Variable 16	Pulse check	Correct Incorrect	0 5
Variable 17	Continuing CPR	Correct Incorrect	0 5
Variable 18	Correct sequence	Correct — 16—18 steps right Incorrect — 12—15 steps right Incorrect — 12 and below steps right	0 10 20

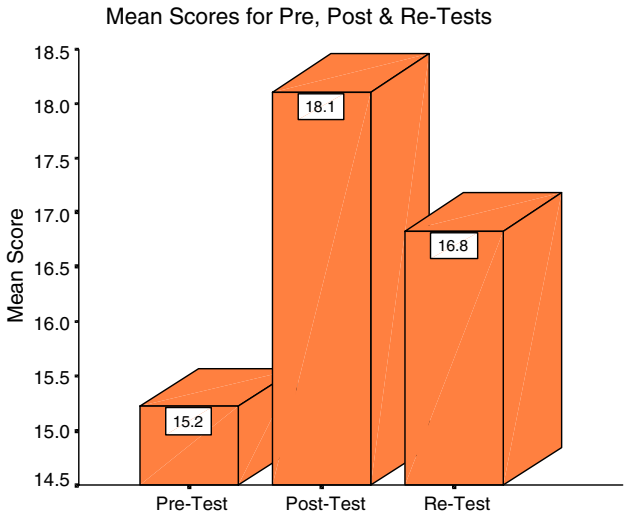

Figure 1 Mean scores for CPR cognitive knowledge.

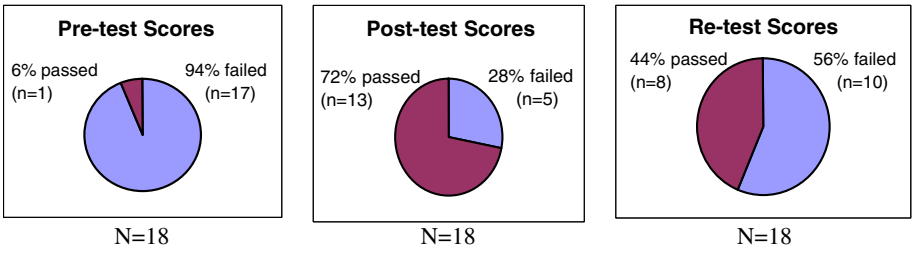

Figure 2 Pass scores in CPR cognitive knowledge.

Table 2 Statistical significance of CPR cognitive knowledge tests

	Paired differences					*t*	df	Sig. (2-tailed)
	Mean	Std. deviation	Std. error mean	95% Confidence interval of the difference				
				Lower	Upper			
Paired samples test								
Pair 1: Pre-test cognitive knowledge—Post-test cognitive knowledge	−2.89	1.78	0.42	−3.77	−2.00	−6.891	17	0.000
Pair 2: Post-test cognitive knowledge—Re-test cognitive knowledge	1.28	1.60	0.38	0.48	2.07	3.385	17	0.004
Pair 3: Pre-test cognitive knowledge—Re-test cognitive knowledge	−1.61	1.88	0.44	−2.55	−0.67	−3.630	17	0.002

standard deviation are highlighted in Table 3. No student achieved the pass standard of less than 15 penalty points. When the students' post-test scores were compared with the re-test scores, the decrease in scores was statistically significant (Table 4).

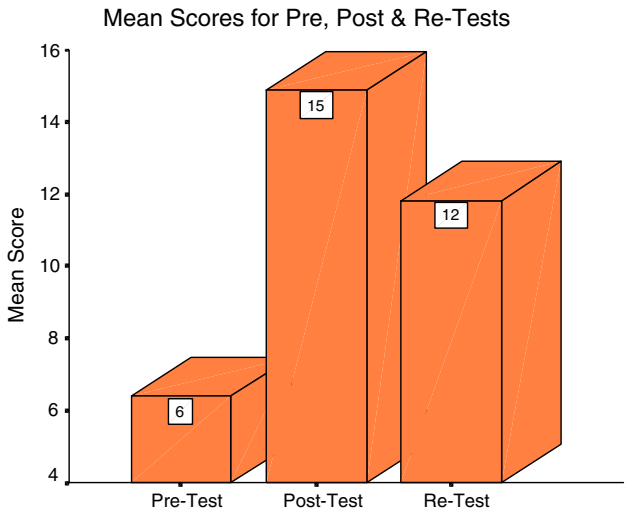

Figure 3 Mean scores for CPR psychomotor skills.

Table 3 An analysis of the penalty points scores in the study tests

	Pre-test penalty points	Post-test penalty points	Re-test penalty points
Statistics			
Valid	18	18	18
Mean	121.94	45.56	62.50
Median	125.00	40.00	52.50
Std. deviation	39.89	16.35	24.93

n = 18.

No student was able to perform all CPR skill components correctly according to the correct standards. Competency rates for individual skill components ranged from 0% to 94% in the pre-test, 0—100% in the post-test and 0—100% in the re-test. The CPR skill components that scored highest were 'release of chest compressions' and 'checks unresponsiveness'. The CPR skill components that scored lowest were 'ventilation volume' and 'depth of chest compressions'.

Discussion

Acquisition of students' CPR cognitive knowledge

The findings indicate that students lacked CPR cognitive knowledge in the pre-test, despite the fact

Table 4 Statistical significance of CPR psychomotor skill tests

	Paired difference					*t*	df	Sig. (2-tailed)
	Mean	Std. deviation	Std. error mean	95% Confidence interval of the difference				
				Lower	Upper			
Paired samples test								
Pair 1: Pre-test psychomotor skills—Post-test psychomotor skills	−8.50	3.52	0.83	−10.25	−6.75	−10.248	17	0.000
Pair 2: Post-test psychomotor skills—Re-test psychomotor skills	3.06	2.58	0.61	1.77	4.34	5.029	17	0.000
Pair 3: Pre-test psychomotor skills—Re-test psychomotor skills	−5.44	3.13	0.74	−7.00	−3.89	−7.382	17	0.000

n = 18.

that all students received CPR training one year previously. This finding is consistent with previous studies (Broomfield, 1996; Inwood, 1996).

Following the CPR training programme, there was a significant acquisition in students' CPR cognitive knowledge, which supports the findings of Broomfield (1996); and Moule and Knight (1997). While this suggested a positive training effect, it is of concern that over one quarter of students did not meet the pass standard following CPR instruction. This may be attributed to fatigue and information overload following the training programme, which may have negatively influenced students' performance.

Acquisition of students' CPR psychomotor skills

In terms of the students' CPR skills performance, the findings are more discouraging, in that at no point in this study was any student successful in achieving the pass standard in either the pre-test, post-test or re-test. While this finding is disappointing, it is consistent with other studies of nurses' CPR skills (Crunden, 1991; Devlin, 1999). However, this should not be confused with students not learning any new skills. The findings clearly demonstrate a positive training effect and a significant acquisition in psychomotor skills.

This study highlighted that all students performed none of the individual CPR skill components competently, which is consistent with the findings of previous studies (Greig et al., 1996; Devlin, 1999). 'Ventilation volume' was the poorest performed skill, with no student meeting the pass criteria in any of the study tests. The second lowest ranked CPR skill was 'depth of chest compressions'. These findings differ from Devlin (1999); and Nyman and Sihvonen (2000), who consistently found that chest compressions were the poorest performed skill. This discrepancy may be due to lack of a universal definition, in what constitutes a pass standard for the skill of 'ventilation volume'. Nyman and Sihvonen (2000) defined a pass standard as 50% correct ventilations, whereas the tool in this study accepted 76% correct ventilations as the pass standard.

Retention of students' CPR cognitive knowledge

Students had a significant deterioration in CPR cognitive knowledge 10 weeks following CPR training. This finding is consistent with Inwood (1996); and Moule and Knight (1997), who also reported poor retention in nurses' CPR knowledge following CPR training. Despite this, there was nevertheless, retention in nurses' CPR cognitive knowledge over their pre-training performance.

Retention of students' CPR psychomotor skills

Greig et al. (1996) contends that a lack of CPR competency is often accepted as deterioration in CPR skills, whereas it may instead represent non-acquisition of CPR skills. The findings from this study support this, in that the CPR skills that the students acquired following CPR training did not meet the established criteria for passing the CPR skills assessment. However, out of the composite skills that were successfully acquired, there was a significant deterioration in students' CPR skills performance 10 weeks following CPR training. These findings are supported by Moser and Coleman (1992); and Berden et al. (1993).

This deterioration in CPR performance should not be equated with a total loss of skills. The findings clearly show a positive retention in CPR psychomotor skills. This conflicts with the findings of Moser and Coleman (1992). These conflicting findings may be explained by the discrepancies in the variance of points at which retention is measured in different studies. While the findings from this study suggest that CPR skills have started to decline 10 weeks following CPR training, Moser and Coleman (1992) reported that CPR skills begin to decline as early as 2 weeks after initial training.

Limitations

The major limitations of this study were the small population and sample size, in addition to the study being conducted in one geographical location in the Republic of Ireland. This prevents making inferences about similar populations of nursing students in Ireland. Within the quasi-experimental design of this study, the effects of skills practice and study preparation between post-testing and re-testing were outside the control of the study (Cook and Campbell, 1990). As a result, the retention effect may be increased. In addition, the study design did not permit studying variables such as 'motivation' and 'perceived competence in CPR', which have previously been found to influence nurses' CPR competency (Nyman and Sihvonen, 2000).

Recommendations for further research

Further research is recommended with larger samples of nursing students across nursing disciplines

from different health care institutions in Ireland to validate the findings of this study. A longitudinal follow-up of students' CPR knowledge and skills would enrich the study findings and help to further determine the critical point at which CPR knowledge and skills deteriorates. This may help to determine the optimal frequency with which CPR educational opportunities need to be made available.

Conclusions

Ultimately, nurses' CPR knowledge and skills have implications for patient survival from a cardiac arrest and is a critical health care issue as Ireland faces the huge burden of CVD mortality of its growing population. The study findings are timely for many reasons. Firstly, they are significant as Ireland is taking the lead in prioritising cardiovascular health and developing a European Union strategy for the promotion of cardiovascular health (Department of Health and Children, 2004). Secondly, they highlight an important issue for key stakeholders, including the third level education providers, An Bord Altranais and the Irish Heart Foundation at a time of unprecedented change with the recent transition of nurse education into higher education institutes in the Republic of Ireland. Thirdly, it raises a number of challenges for nurse educationalists to examine current practices regarding CPR instruction to nursing students' in order to ensure that they are competent in the performance of CPR.

Berden et al. (1993) recommends that the acquisition and retention of CPR knowledge and skills is largely dependent on training and frequency of CPR instruction and the findings from this study strongly supports this. Ultimately, the goal is to prepare nurse practitioners that are competent and confident in the event of a cardiac related emergency. It is imperative that nurse education develops a model of best practice in relation to CPR instruction in order for nursing students to progress to a level of a competent practitioner in CPR knowledge and skills. It is recommended that the provision of an ongoing structured programme of basic life support is necessary. This is particularly fundamental in the critical years of an undergraduate nursing programme and critical to Irish nurses due to lack of mandatory requirements for CPR instruction.

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