

## Do Nurses Really need Physics? (Analysis of the Results of a Written Test)

Zuzana Balázsová\*

Faculty of Medicine, Comenius University, Bratislava, Slovak Republic.

### \*Corresponding author

Zuzana Balázsová, university lecturer, Institute of Medical Physics, Biophysics, Informatics and Telemedicine, Faculty of Medicine, Comenius University, Sasinkova 2, 813 72 Bratislava, Slovakia, e-mail: zuzana.balazsova@fmed.uniba.sk

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### Abstract

The aim of the work was to assess the physics literacy of 266 practising registered nurses-studying for a master's degree in nursing; a written test was used to determine whether they were able to apply the knowledge of physics that they had acquired in their studies to solve model problems in nursing practice. The results indicated that: 1. The nurses' physics and technical literacy was insufficient and, in our view, does not meet the needs of the present time, in which health care establishments are making increasing use of instruments and equipment. 2. Errors were identified in the solutions to practical nursing problems that could have had a negative effect on patients' condition in real practice.

Student nurses' knowledge of physics could be improved by changing the way in which biophysics is taught in the nursing curriculum.

**Keywords:** Biophysics in nursing. Retention of biophysics knowledge. Nurses' physics and technology literacy.

### Introduction

The current education system in Slovakia is based on the Bologna Declaration, which recommended that nurses study in higher education to at least bachelor's level [1]. In EEC documents, biophysics is defined as one of the basic scientific subjects for the theoretical and technical higher education of nurses responsible for general care [2]. Based on the profile for a graduate of the nursing study programme and cited EEC directive, biophysics is an obligatory pre-clinical subject that is a pre-requisite for nearly all clinical subjects [2, 3]. Even so, it is a common belief amongst nursing students that biophysics courses are too difficult and unnecessary. Students are often unaware of the subject's importance and they are not always able and willing to accept the reasons for its inclusion in the curriculum. This work uses an analysis of a written test to assess nurses' physics and technical literacy.

### Method

#### Respondents' characteristics

The research sample was 266 nurses in part time study for a master's degree in nursing at three Slovak universities. The average age of the respondents was (33.62±8.68) years. The youngest respondent was 23 and the oldest was 57. The majority worked in various hospital departments. The average length of nursing experience was (13.47±9.53) years.

The students took the test at the end of the first or the start of second year of the master's stage of their studies.

### Characteristics of the test

The test was intended to determine how much knowledge of biophysics the nurses retained and their ability to apply this knowledge in healthcare practice. It included material on biophysics that is taught in the first year of a bachelor's degree in nursing. In eleven tasks it covered three thematic areas where physics is relevant for nursing practice:

1. Medication delivery-questions focussed on: 1. reading from a calibrated scale to determine the correct delivery of medication; 2. how the physical properties of medications (tonicity, surface tension of a solution) may affect their dosage and delivery.
2. Detection of vital signs-questions focussed on: 1. the effect of physical factors and methods of measurement on the accuracy of the result, 2. the ability of nurses to assess the accuracy of measured values.
3. Knowledge of the location of a person's centre of gravity, which is of vital importance for the correct and safe manipulation of patients by nurses.

### How the test was marked

The test was marked using a binary score (correct answer-1 point, incorrect answer-0 points). The pass mark for the test was set at 60% of answers correct. The results were processed using descriptive statistics (average points scored per respondent, standard deviation, median, mode). Differences in level of knowledge between respondents within the group were evaluated using the coefficient of variation (CV). A qualitative analysis was also conducted of the numbers of individual responses and the respondents' most common errors.

## Results

Respondents gave correct answers to an average of (6.7±1.6) of questions where a correct answer could depend on knowledge of physics; in percentage terms, it was (61.00±14.45)% There were 2 respondents who scored 100% correct, and 1 respondent who scored 0%. The median number of points was 7. The largest number of respondents scored 6 points, which means 6 correct answers out of 11.

The value of the coefficient of variation showed that there were no statistically significant differences within the population of respondents (CV = 0.237).

### Qualitative analysis of the test

#### 1. Medication delivery

**Question 1.** Two bottles of equal size contain 95 ml of solvent and 5 ml of the medicament-active substance. Bottle I has water as a solvent and bottle II has alcohol. Both bottles have a standard dropping closure. What rules apply to dosage?

- The same number drops are needed from bottle I and bottle II for a dose of the medicament
- A different number of drops may be needed from bottle I and bottle II for a dose of the medicament
- The dosage depends on the type of dropping closure

It was found that 44.74% of nurses claimed that if two types of medication contained the same quantity of the medicament and differed only in the type of solvent, the dose required the same number of drops. The correct answer - that the dosage may be different, was given by just 39.10% of nurses. 11.65% of the nurses said that dosage depended only on the type of dropping closure and 4.51% did not answer.

**Question 2.** Medication can be delivered intravenously without endangering the patient's health in a

- hypertonic solution
- hypotonic solution
- isotonic solution

The correct answer was given by 89.95% of nurses - to avoid risk to a patient a medication is delivered intravenously in an isotonic solution. A hypertonic solution was chosen by 4.51% of respondents and a hypotonic solution by 3.01%. No response was given by 2.63% of nurses.

**Question 3.** Which claim is true?

- The lower an infusion bottle is hung, the slower an infusion solution flows
- The higher an infusion bottle is hung, the slower an infusion solution flows
- The flow speed of an infusion solution depends only on its physical characteristics

The correct answer - that the flow speed of an infusion solution is directly proportionate to the height of the infusion bottle above the ground - was given by 77.44% of nurses. The claim that the speed of an infusion flow decreases as the infusion bottle is raised higher was chosen by 4.14% of nurses while 17.29% said that flow speed depended only on the physical characteristics of the infusion solution. No answer was given by 1.13% of nurses.

**Question 4.** What volume is the volume of the liquid (in dm<sup>3</sup>) in the measuring cylinder? (the test included a picture of a measuring cylinder)

The percentage of all respondents who were able to read the correct value and then convert it to the required physical units (from ml to dm<sup>3</sup>) was just 20.68%. Just over two fifths (41.35%) of the nurses read the calibrated scale correctly but made a mistake in converting millilitres to cubic decimetres. Another 31.5% of nurses read the volume of liquid incorrectly from the calibrated measuring cylinder. The task was omitted by 6.02% of nurses.

#### 2. Detection of vital signs

**Question 1.** When measuring blood pressure, a general principle is:

- The larger the circumference of a patient's shoulder, the wider a cuff should be
- The larger the circumference of a patient's shoulder, the narrower a cuff should be
- The result of measurement is not affected by the width of the cuff

The question was answered correctly by 72.18% of nurses. The answer that as the circumference of the shoulder increased, the width of the cuff should be reduced was chosen by 0.38% of respondents (1 nurse) and 27.07% of respondents claimed that the result of measurement did not depend on the width of the sphygmomanometric cuff. No response was given by 0.38% of nurses.

**Question 2. Statement I:** A nurse takes a pulse by lightly pressing three fingers on the inside of the patient's left wrist

**Statement II:** A nurse takes a pulse by lightly pressing the thumb on the inside of the patient's left wrist

- The results of measurement as described in I and II must be the same
- The results of measurement as described in I and II may be different
- The results of measuring the pulse do not depend on how the pulse is taken.

The correct answer was chosen by 70.68% of nurses - measuring the pulse using the thumb or fingers can give different results. The answer that the measurements must be the same was chosen by 9.77% of the nurses and 17.67% thought that the result did not depend on the method of measurement. No answer was given by 1.88% of nurses.

**Question 3.** A nurse counts 11 pulses on a patient's cervical artery in 10 seconds. What is the patient's pulse rate, assuming that they have a regular pulse?

The correct pulse rate was given in the correct form, with the right number and the right physical unit, by 42.48% of the nurses. The right number but the wrong physical unit or no physical unit was given by 44.74% of respondents. The wrong number and the wrong physical unit were given by 4.51% of the nurses and 5.64% of nurses did not complete the task.

**Question 4.** Use the patient's temperature chart (shown in an illustration in the test) to determine the difference between their highest and lowest daily body temperatures on the second day of hospitalisation.

The correct answer was given by 31.20% of the nurses. The wrong number but the right physical unit were given by 30.83%. Both the wrong number and the wrong unit were given by 13.53% of nurses. No answer was given in 16.92% of cases.

**Question 5.** At first sight a stethoscope appears to be in good

*condition (bell, diaphragm, transfer system) but you do not hear anything on auscultation. Give a reason.*

No answer was given by 24.81% of nurses. Regardless of the proposed phenomenon, 60.15% of nurses gave 1 reason, 12.41% gave 2 reasons and just 2.63% of nurses gave 3 reasons. In their explanations of the phenomenon, 34.21% of nurses mentioned a “blocked” stethoscope, 13.5% of nurses mentioned an error in the method of examination and 30.08% of nurses mentioned the patient’s health condition.

### 3. Patient positioning

**Question 1.** Where is a person’s centre of gravity?

- a) outside their body
- b) in the vicinity of the chest
- c) in the vicinity of the pelvis and the abdomen

The correct location of the centre of gravity in a patient’s body was given by 87.97% of nurses. A location in the vicinity of the chest was chosen by 9.02% of nurses and a location outside the body by 1.13%. No answer was given by 1.88% of nurses.

**Question 2.** *After an operation on their appendix, it is easier for a patient to get out of bed if they start on their*

- a) stomach
- b) back
- c) side

A total of 87.97% of the nurses knew that it is easier for a patient who has had an operation in their abdominal cavity to get up from a position on their side. Starting from a position on the belly was chosen by 1.13% of nurses and 9.02% suggested starting from on their back. The task was not completed by 1.88% of nurses.

### Discussion

On completion of the analysis of the results achieved by practising nurses also participating in a part-time master’s degree programme in nursing who were tested on nursing problems whose solution could involve the application of knowledge of (bio) physics, it was found that the average score was 61%, which was just above the set pass mark. There were no significant differences between nurses in the level of knowledge ( $CV = 0.237$ ). This may be related to the fact that all the tasks focussed on activities that nurses perform in most healthcare establishments. In our view, the nurses achieved their results mainly by applying knowledge from nursing. The weak results in the test may be the result of a negative relationship to (bio) physics and inadequate education on physics at secondary school [4-6]. Our teaching experience suggests that if the students applied elementary knowledge of physics in solving problems they could get better results not just in theoretical questions but also in their nursing practice.

A lack of skill in physics was identified in the questions related to reading from a calibrated scale and using the correct physical units. With reference to the current mobility options for nurses, a good habit of recording the results of an examination in the correct form with the correct physical unit is particularly important when working as a nurse in countries that use different physical units from SI units (in Great Britain, for example) [4].

Current medicines policy in Slovakia prefers the use of cheaper, generic medications [7]. We were therefore disturbed by the finding that only a third of respondents knew that medications with the same active substance in different solvents could have different

dosages. It is likely that the cause of this finding was the fact that nursing studies emphasise nursing procedures and the correct performance of actions. Applications of principles from physics such as the properties of liquid medications are not mentioned in higher years, and if so then only on the margins.

The measurement of blood pressure and the acquisition of information from a patient’s temperature chart are basic nursing activities in all hospital departments. Even so, it was found that nurses have deficits in their knowledge of the correct way to measure blood pressure and their ability to make active use of a patient’s body temperature records. The literature also includes example of clinical nurses having a low level of knowledge of the use of a pulse oximeter, the reliability of the use of alarms and identification of factors that could affect the results of examination [8].

Stethoscopes are used routinely in nearly all healthcare establishments. Even so, the task focussing on their function and physical principles was completed in the required quality (specification of the physical basis) by less than half the respondents. Nearly a quarter of respondents gave no answer to this question. This shows that nurses have a deficit in their knowledge of physics and the instruments that are commonly used in nursing practice. There is work from the last century that warned that nurses often first encountered the instruments needed for their work when went into working departments at the end of their studies and that they had to learn to use them by themselves using “trial and error” methods [9]. Pfeil, Zuzelo and Paclová have also described gaps in nurses’ technical literacy [10-12]. When new nurses begin working with instruments and medical devices, they are not adequately familiar with their instructions and they often have problems with technical skills [13].

The low number of possible solutions that the respondents in the present research - on average each nurse gave only 1.2 reasons - may indicate deficiencies in nurses’ ability to make a flexible and comprehensive response to problems in practice. There was only one case in which a respondent proposed solutions related to the measurement technique, an error in the stethoscope and the patient’s health condition. Although the problem of nurse’s low ability to solve nursing problems on graduation has been described previously [9,14], our findings show that it remains an issue of high importance in the present.

The problems that the present work has identified could be mitigated by changing the method used to teach biophysics in the nursing curriculum. It should not involve just the passive transmission of information. It should be based on solving nursing problems that could serve as a basis for explaining (bio) physical principles. The physics concepts needed in nursing practice should be explained using elementary ideas and a minimum of mathematics [4,15]. Healthcare practice should incorporate training on technology and technical skills into nurses’ continuing education [13].

### Conclusion

The concept of nursing now includes the use of instruments, which nurses need to be able to control without errors in order to prevent harm to patients’ health. This requires a certain level of knowledge in physics and technical skills. The present research has found that nurses do not have adequate knowledge of physics, the theory of measurement and the instruments that they use in

their work. In solving model problems in nursing they are able to make only limited use of biophysics learned in the first year of the bachelor's course. There is reason to fear that if nurses do not have a comprehensive command of physics and the skills required in the present time, there is a risk of more frequent errors in nursing practice.

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