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Workload in the Care of a Patient with Congenital Diaphragmatic Hernia and the Patient's Need for Nursing Care

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Abstract:

Introduction. The main task of the study was to measure the workload of nurses in the care of a patient with a developmental defect–congenital diaphragmatic hernia (*CDH)*–in the neonatal intensive care unit, which was evaluated on the basis of standardized tools *Therapeutic Intervention Scoring System (TISS–28)*, *Nine Equivalents of Nursing Manpower use Score (NEMS)* and *Nursing activities Score (NAS)*. Methods. Retrospective study. The workload was measured using *TISS–28, NEMS* and *NAS* tools. Descriptive statistics were used to analyze the data, and a single-sample test was used to verify the research hypotheses. Results. The sample consisted of medical records of 33 patients; 592 observations were analyzed. Studies prove the need for research on the workload of nurses in neonatal intensive care units. A patient with CDH should receive nursing care as required. Conclusion. It is necessary to implement a model for measuring the workload of nurses in neonatal intensive care units, taking into account the evaluation of work and its optimization.

Keywords: nurse; workload; staff workload; nursing intensive care; nursing activities score

1. Introduction

1.1. Workload of Nurses

The number of nurses is not only a cost, but a concrete benefit to GDP (Gross Domestic Product) [1] and an opportunity to achieve the United Union Sustainable Development Goals (SDGs). It also affects patient safety as well as the quality of nursing care and costs, or missed care–as an effect of nursing workload [2,3]. The research results indicate that the high workload of nurses has a negative impact on the results of patient treatment. Therefore, it is proposed to increase the nursing staff or reduce the number of patients assigned to care for one nurse. The weak point of the available studies is the omission of the influence of contextual factors on the work of nurses and the degree of workload [4,5] and ignoring the impact of contextual factors and workload. Measurement of workload based on the characteristics of the profession is useful in human resources planning, prevention of staff turnover, resignation from work and shortage of personnel, or retirement in general [4,5].

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The specificity of ICU (Intensive care unit) is the impact of new technologies on care. They change the health status of critically ill patients, increase the number of co-existing diseases and increase the number of procedures performed. This increases the need for care and workload, as well as the need for specific competencies [6,7]. It is considered that the workload of the nurse consists of the time of performing activities directly and indirectly related to the care of the patient. The proportions between these actions may change due to the variability of the patient's clinical condition [8]. The workload of nurses is the sum of all the needs that must be met in relation to the needs of the patient and their family, but also organizational, administrative, as well as educational work [9].

Many concepts of systems for measuring the workload of nurses have been developed [5,10]. These criteria can be determined by measuring workload basing on: (1) the type of hospital unit (unit level), (2) the professional role (work Level), (3) the number and health status of patients (patient level) and (4) the specific situation (situation level) [4,5].

The measurement of workload at the ward level (unit level) is based on a comparison of the number of patients to the number of nurses (nurse-to-patient ratio), used to compare wards in the context of patient outcomes in wards with similar specifics (benchmarking). Direct patient care is under analysis, excluding administrative actions [4,5].

The second category of workload measurement (work level), based on the characteristics of the profession, makes it possible to compare the consequences of workload depending on the scope of the professional role or specialization performed. This type of measurement determines the impact of workload on occupational burnout and the functioning of intensive care nurses. Load measures, referring to the characteristics of the profession, combine the consequences of performing various nursing roles, such as stress and job dissatisfaction.

Another category of measurement of nurses' workload (patient level) assumes that the main determinant of workload is the patient's clinical condition and therapeutic variables (e.g. Therapeutic Intervention Scoring System) [4,5,11].

The last, previously indicated category of workload measurement is the situational concept of measuring the workload of a nurse. This measurement takes into account the time of day and night, the number of hours, the number of patients assigned to the nurse's care, as well as the health status of patients, and the broadly understood working environment. The situational measurement concept is based on a subjective assessment of the load experienced by the nurse and their individual projection of the microsystem of work, focusing on the analysis of the impact of contextual factors that increase the load *versus* facilitating the work of the nurse [4,5,11].

The world's first nurses workload analysis in ICU was based on objective assessments of patients' clinical condition, level of demand for nursing care, nursing workload, and the optimal level of Human Resource Management, and was conducted in 1970 [12].

In the following years, research tools were developed, such as: Therapeutic Intervention Scoring System 57 (TISS–57) followed by TISS–28, OMEGA, Time Oriented Score System (TOSS), Nine Equivalents of Nursing Manpower Use Score (NEMS), Nursing

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Activities Score (NAS), which were validated in subsequent studies [12,13]. They have many limitations and focus mainly on measuring the intensity of work or actions performed in a certain period of time [14]. Without exhausting the problem of the workload in the intensive care unit [12,15,16]. Relatively few studies have been conducted in pediatric intensive care units [17,18].

1.2. Nursing Care for a Patient with Congenital Diaphragmatic Hernia

Congenital hernia of the diaphragm (*CDH, Congenital Diaphragmatic Hernia*) occurs between 3 and 8 weeks of embryonic life and is a birth defect, the essence of which is a loss in the diaphragm with a displacement of the viscera to the chest and pulmonary hypoplasia. Pulmonary hypoplasia occurs on both sides, with a greater severity on the side of the defect. The morphologically and functionally determined propensity to pulmonary hypertension is the consequence of underdevelopment of pulmonary tissue and defects of pulmonary vessels. Pulmonary hypertension is characterized by increased vascular resistance in the pulmonary circulation and right-left blood leakage, leading to impaired oxidation of the body [19]. Defects of hernias are divided into two types, *Bochdalek hernia*, i.e. posterior-lateral and *Morgagni hernia* aka parasternal hernia. *Bochdalek hernia* is a defect in which the opening in the diaphragm is located on the left side (which occurs more often, accounting for about 84% of all diaphragmatic hernias). *Morgagni hernia* is located on the right side of the diaphragm and accounts for about 13% of all diaphragmatic hernias. Bilateral hernia also occurs and accounts for 3% of all diaphragmatic hernias [20].

In Poland, the percentage of deaths of newborns with congenital malformations is 37,1% live births (Q00–Q99) [21]. Overall survival of neonates with *CDH* is estimated at about 60% [22]. The survival rate of newborns with *CDH in* centers providing optimal diagnostics and pre-and postnatal care increases to 90% [23–25].

ECMO (Extra Corporeal Membrane Oxygenation) is the extra corporal oxidation of blood by a membrane oxygen exchanger, and is an invasive [26] method of respiratory and/or cardiovascular support. Initiation of *ECMO therapy* improved survival of newborns with *CDH* [27] postponing surgery, which should be performed after, and not during *ECMO therapy*, especially in newborns from the high risk group [28].

Cooperation of (1) the doctor responsible for the diagnostic and therapeutic process, (2) the nurse who exclusively cares for the patient, and (3) the perfusionist during *ECMO* therapy is mandatory.

2. Materials and Methods

2.1. Study Design

The main task of the study was to measure the workload of nurses in the care of a patient with a developmental defect–congenital diaphragmatic hernia (CDH)–in the neonatal intensive care unit, which was evaluated on the basis of standardized tools *Therapeutic Intervention Scoring System (TISS–28)*, *Nine Equivalents of Nursing Manpower use Score (NEMS)* and *Nursing activities Score (NAS)*. The retrospective study was conducted

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from January 1, 2017 to December 31, 2017 in the Clinic of Intensive Care and Congenital Malformations of Newborns and Infants.

2.2. Participants

The sample consisted of medical records of 33 patients, basing on which 592 observations were analyzed. The indication for childbirth in the III° reference center was a prenatal congenital defect, i.e. hernia of the diaphragm *(Q79. 0 according to ICD–10*). 30 patients were diagnosed with left–sided malformation and three with right–sided malformation. Median relative to the clinical status of patients, based on *Apgar* scale, was 6/6/6/6.

Among the newborns studied, 19 were male and 14 were female. Surgical procedure was performed on 25 patients. Of these, 20 surgeries were performed on day duty and 5 on night duty. Of the 25 patients who underwent surgery, implementation of the extracorporeal circulation procedure was decided in 15. Ten patients were disqualified from the procedure. 8 patients were not qualified for surgery and implementation of the *ECMO* procedure. Among the group of 33 newborns, 27 patients died, 5 patients were discharged home (for whom the *ECMO* procedure was not implemented), and one patient was discharged to an external medical facility (*ECMO* procedure implemented).

2.3. Instruments

Standardized tools *TISS–28*, *NEMS and NAS* were used to measure workload. Further analysis took into account the accepted model of nurse work, which is expressed as nurse-to-patient ratio of 1:2 or 1:1. A Nurse-to-patient ratio of 1:2 ** means that one nurse takes care of two patients. These patients undergo the following procedures, which for the purpose of research are marked with numbers from (1) to (14). These are: (1) invasive mechanical ventilation or non-invasive mechanical ventilation (1.1), central intravenous access (2), arterial access (3), continuous heparin infusion (3.1), parenteral nutrition (4), continuous infusion pharmacotherapy (5), antibiotic and fractionated pharmacotherapy (6), additional fluid therapy (7), monitoring of bladder catheter diuresis (8) or monitoring diuresis with a scale (8.1), intragastric tube feeding (9), monitoring and control of pain (10), monitoring and control of vital signs (11), patient care management (12), patient comfort (13), specialist procedures (14). Nurse-to-patient ratio 1:1* means that one nurse takes care of one patient who is undergoing procedures as above. (1)–(14).

2.4. *Data Collection*

TISS–28 and *NEMS* were used to measure the workload. They were applied in accordance with the methodology indicated by the authors. Implemented nurses interventions were analyzed (separately for day and night duty). Work pattern in the hospital word consists of two shifts, which last from 7:00 to 19:00 and from 19:00 to 7: 00 (12 h). The *TISS–28* and *NEMS* were standardized into an 8–hour work pattern. For the purpose of this work, the measurement was performed once every 12 hours of the nurse's

 doi:10.20944/preprints202302.0187.v1

work. Documented medical procedures were referred to the tools, gaining a sum of points. Then the points from two shifts (24 h) were added up and divided into 3 shifts (3 shifts x 8h) to obtain an average of 8 hours of nurse work.

The second stage of the study was extended to the measurement and analysis of medical records, which were listed in the first part of the study. Paper documents were analyzed: (1) medical history, (2) daily observation card of the patient, (3) study card, (4) patient pain observation card, (5) central tract observation card, (6) arterial tract observation card, (7) peripheral tract observation card, (8) operating site observation card, (9) observation card of catheter in the bladder, (10) doctor's order card, (11) book of nurse reports. Nursing intervention analysis was summed up with 24 hours of nurse work according to the *NAS* methodology for direct patient care within 24 hours using Microsoft Excel and analyzed using the *Statistica 13.3.721.1. 64-bit (pl) program.*

The obtained results (*TISS–28*, *NEMS and NAS*) were then converted to the same–hourly–unit of comparison. The test results were then converted into hours (according to the guidelines for each tool). For *TISS–28* the average nurse workload for the analyzed hospitalization days (expressed in minutes) was multiplied by 3, and the result was divided by 60'according to the methodology of the tool [29,30]. Calculations using *TISS–28* omit the conversion of the average result into minutes (multiplied by 10.6') because the collected data was expressed and analyzed in a minute record. For the *NEMS* tool, the average (expressed in points) of day and night duty was multiplied by 10.6'. The result in minutes was multiplied by 3, followed by the result being divided by 60'[14,29–30].

Rating in *NAS* is expressed in points. Each point means 14.4 minutes of nursing care, and 100 points means that the patient needed 100% of the nurse's time in the last 24 hours [31]. Therefore, the average results obtained from the *NAS* tool were multiplied by 14.4 minutes. Then the result was divided into 60'[30,32]. The results obtained determined a nurse's average workload over 24 hours of work.

2.5. *Data Analysis*

The data was collected using Microsoft Excel and analyzed using *Statistica 13.3.721.1. 64-bit (pl) program.*

The obtained results determined the average workload of a nurse during 24 hours of work, which made it possible to compare the results obtained from three research tools (*TISS–28*, *NEMS*, *NAS*). Descriptive statistics were used to analyze the data, and a single-sample test was used to verify the research hypotheses.

2.6. *Purpose and Research Hypotheses*

In order to assess the need for nursing care of a patient with CDH, six research hypotheses were put forward:

1. H_0 The workload of a nurse in the care of a patient with congenital diaphragmatic hernia, determined on the basis of *TISS–28*, is higher than 46 points.
2. H_0 The workload of a nurse in the care of a patient with congenital diaphragmatic hernia, determined on the basis of *NEMS*, is higher than 46 points.

 doi:10.20944/preprints202302.0187.v1

3. H_0 The workload of a nurse in the care of a patient with congenital diaphragmatic hernia, determined on the basis of *NAS*, is higher than 100 points.
4. H_0 The ratio of nursing care for a patient with congenital diaphragmatic hernia of 1:2 is sufficient.
5. H_0 There is a correlation of results for *TISS–28 & NEMS* and *TISS–28 & NAS*.
6. H_0 There is a correlation of results for *NEMS* and *NAS*.

3. Results

3.1. The Workload of a Nurse in the Care of a Patient with CDH in the Neonatal Intensive Care Unit on the Basis of TISS–28

To assess the workload of a nurse in the care of a patient with congenital diaphragmatic hernia, *TISS–28* was used. The maximum workload must not exceed 46 points[1] [27,33]. The average workload of a nurse for the analyzed hospitalization days was multiplied by 3, and the result was divided into 60 [29]. When calculating for *TISS–28* the step of converting the average result into minutes by multiplying by 10.6 minutes was omitted, since the collected results were expressed and analyzed in a minute record. Descriptive statistics were used to analyze the data and the results of the analysis are shown in Table 1. The analysis of the results was carried out for the patient's hospitalization rates expressed in Table 2 (No.) from (1) to (9), i.e.: (1) day of patient admission to the ward, (2) day of surgery, (3) day of start of extracorporeal circulation, (4) first day of extracorporeal circulation, (5) last day of extracorporeal circulation, (6) day of end of therapy *ECMO*, (7) date of death of the patient.

Table 1. *TISS–28* analysis of the daily workload of a nurse expressed in hours

No.	Variable	Nurse-to-patient ratio	Average number of working hours in 24 hours	SD	*N*	Min	Max	Me
(1)	Patient admission to the ward	1:2**	24.5	3.69	33	15.3	29.1	25.2
(2)	Surgical procedure	1:2**	27.1	3.22	25	19.6	32.3	27.5
(3)	Entry to ECMO	1:1*	29.4	2.00	15	25.9	33.4	29.7
(4)	1 day ECMO	1:1*	26.1	1.75	12	24.1	29.4	25.9
(5)	Last day ECMO	1:1*	20.4	7.45	17	5.8	30.2	22.0
(6)	exit ECMO	1:1*	27.8	1.86	12	23.8	30.7	27.8
(7)	Patient's death	1:1* or 1: 2**	26.7	1.92	27	22.8	30.2	26.5

Legend:
1:1* = nurse-to-patient ratio one-to-one (1:1), means that the patient is cared for by one nurse;
1:2** = nurse-to-patient ratio one-to-two (1:2). It is understood as nursing care performed by one nurse on two patients requiring intensive care (mechanically ventilated patient)
SD = standard deviation ; ECMO – Extra Corporeal Membrane Oxygenation.

A single-sample test was used to verify the first research hypothesis (Table 2).

Table 2. Test of averages against a fixed reference value for TISS–28

No.	Variable	Test of averages against a fixed reference value

[1] By calculating 46 points per daily workload (46 points x 10.6 minutes x 3 / 60 = the result is the number of hours worked during 24 hours of work), a result of 24.38 h/24h hours during 24 hours of work of a nurse was obtained.

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		Me	SD	N	S. E.	t	df	Cohen's d	P
(1)	Patient admission to the ward	19.0	2.82	33	0.49	6.41	32	1.12	0.000000
(2)	Surgical procedure	22.6	2.71	25	0.54	12.44	24	2.49	0.000000
(3)	Entry to ECMO	23.6	1.76	15	0.45	16.99	14	4.39	0.000000
(4)	1 day ECMO	20.7	1.22	12	0.35	13.76	11	3.97	0.000000
(5)	Last day ECMO	15.7	7.08	16	1.77	-0.14	15	-0.04	0.890314
(6)	exit ECMO	23.1	2.05	12	0.59	12.15	11	3.51	0.000000
(7)	Patient's death	21.6	1.60	27	0.31	18.57	26	3.57	0.000000

Legend:
1:1* = nurse-to-patient ratio one-to-one (1:1), means that the patient is cared for by one nurse;
1:2** = nurse-to-patient ratio one-to-two (1:2). It is understood as nursing care performed by one nurse on two patients requiring intensive care (mechanically ventilated patient)
SD = standard deviation; ECMO – Extra Corporeal Membrane Oxygenation

3.2. *The Workload of a Nurse in the Care of a Patient with Congenital Diaphragmatic Hernia on the Basis of NEMS*

To evaluate the work of a nurse in the care of a patient with *CDH* the neonatal intensive care unit *NEMS* was used, the results are shown in Table 3. Average *NEMS* results (expressed in hours) in the analyzed periods of hospitalization, described below, denoting according to the scheme used from (1)–(7), column 1 (No.(1)-(7)). Day of hospitalization: (1) admission of the patient to the ward, (2) surgery, (3) entry into *ECMO*, (4) 1 (first) day *ECMO*, (5) last day *ECMO*, (6) exit *ECMO*, (7) death of the patient. The point range of this scale ranges from 0 to 63 points. However, the maximum workload of a nurse may not exceed 46 points during nursing duty (8 h) [34].

For *NEMS*, the average (expressed in points) from day and night duty was multiplied by 10.6 minutes (thus obtaining a result in minutes), the result expressed in minutes was multiplied by 3, then the result was divided into 60 [29]. The results are shown in Table 3.

Table 3. Average NEMS results per day (results expressed in hours)

No.	**Clinical pathway**	**Nurse-to-patient ratio**	**Avg no of working hours in 24 hours**	**SD**	Me	Min	**Max**	N
(1)	Patient admission to the ward	1:2**	19.0	2.82	20.7	14.3	23.3	33
(2)	Surgical procedure	1:2**	22.6	2.71	23.3	17.0	29.7	25
(3)	Entry to *ECMO*	1:1*	23.6	1.76	23.3	20.7	26.5	15
(4)	1 day *ECMO*	1:1*	20.7	1.22	20.7	18.0	22.3	12
(5)	Last day in *ECMO*	1:1*	15.7	7.08	18.4	1.59	23.9	12
(6)	exit *ECMO*	1:1*	23.1	2.05	23.6	20.1	26.5	12
(7)	Patient's death	1:2* * or 1:1*	21.6	1.60	20.7	20.1	26.5	27

Legend:
1:1* = nurse-to-patient ratio one-to-one (1:1), means that the patient is cared for by one nurse;
1:2** = nurse-to-patient ratio one-to-two (1:2). It is understood as nursing care performed by one nurse on two patients requiring intensive care (mechanically ventilated patient); SD = standard deviation; ECMO – Extra Corporeal Membrane Oxygenation.

A single-sample test was used to verify test hypothesis number two (Table 4).

Table 4. Test of averages against a fixed reference value for *NEMS*

Variable	**Test of averages against a fixed reference value**

 doi:10.20944/preprints202302.0187.v1

No.		M	SD	N	S. E.	t	df	Cohen's d	P
(1)	Patient admission to the ward	19.05	2.82	33	0.49	-10.86	32	-1.89	0.000000
(2)	Surgical procedure	22.64	2.71	25	0.54	-3.21	24	-0.64	0.003762
(3)	Entry to *ECMO*	23.60	1.76	15	0.45	-1.71	14	-0.44	0.108538
(4)	1 day *ECMO*	20.74	1.22	12	0.35	-10.36	11	-2.99	0.000001
(5)	Last day in *ECMO*	15.65	7.08	16	1.77	-4.93	15	-1.23	0.000182
(6)	exit *ECMO*	23.10	2.05	12	0.592408	-2.1621	11	-0.62	0.053510
(7)	Patient's death	21.63	1.60	27	0.31	-8.90	26	-1.71	0.000000

Legend:
1:1* = nurse-to-patient ratio one-to-one (1:1), means that the patient is cared for by one nurse;
1:2** = nurse-to-patient ratio one-to-two (1:2). It is understood as nursing care performed by one nurse on two patients requiring intensive care (mechanically ventilated patient)
SD = standard deviation.
ECMO – Extra Corporeal Membrane Oxygenation

3.3. The Workload of a Nurse in the Care of a Patient with Congenital Diaphragmatic Hernia on the Basis of NAS

To assess the workload of a nurse in the care of a patient with *CDH* the intensive care unit was used *NAS* using the model *NAS/24h* [16] at various times of hospitalization. The results are shown in Table 5. Average results (expressed in hours) obtained with *NAS* in the individual analyzed periods of hospitalization, denoted according to the scheme used in (1)–(7), column 1 (No.) are described below. Day of hospitalization: (1) admission of the patient to the ward, (2) surgical procedure, (3) entry into *ECMO*, (4) 1 (first) day *ECMO*, (5)
last day ECMO, (6) exit *ECMO*, (7) death of the patient (Table 5).

Table 5. Average *NAS* results over 24–hour work (results expressed in hours)

No.	Variable	Nurse-to-patient ratio	Avg (no. of working hours in 24 hours	SD	Me	Min	Max	*N*
(1)	Patient admission to the ward	1:2**	25.6	1.90	26.2	17.4	28.9	33
(2)	Surgical procedure	1:2**	26.2	1.94	26.8	19.7	28.9	25
(3)	Entry to *ECMO*	1:1*	27.1	0.77	27.3	25.7	28.9	15
(4)	1 day *ECMO*	1:1*	24.0	2.96	24.8	19.6	29.0	12
(5)	Last day in *ECMO*	1:1*	22.5	3.27	21.3	19.0	29.0	12
(6)	exit *ECMO*	1:1*	23.4	4.25	24.0	15.0	29.6	12
(7)	Patient's death	1:2** or 1:1*	23.2	4.82	23.7	13.1	29.6	27

Legend:
1:1* = nurse-to-patient ratio one-to-one (1:1), means that the patient is cared for by one nurse;
1:2** = nurse-to-patient ratio one-to-two (1:2). It is understood as nursing care performed by one nurse on two patients requiring intensive care (mechanically ventilated patient); SD = standard deviation; ECMO – Extra Corporeal Membrane Oxygenation.

A single-sample test was used to verify the third research hypothesis (Table 6).

Table 6. Test of averages against a fixed reference value for NAS

	Day of hospitalization	Test of averages against a fixed reference value							
No.		Avg	SD	N	SE.	T	df	Cohen's d	P

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(1)	Patient admission to the ward	25.60	1.90	33	0.33	4.84	32	0.84	0.000032
(2)	Surgical procedure	26.16	1.94	25	0.39	5.59	24	1.12	0.000009
(3)	Entry to *ECMO*	27.10	0.77	15	0.20	15.53	14	4.01	0.000000
(4)	1 day *ECMO*	24.00	2.96	12	0.86	0.00	11	0.00	0.996353
(5)	Last day in *ECMO*	22.53	3.27	12	0.95	-1.56	11	-0.45	0.146988
(6)	exit *ECMO*	23.39	4.25	12	1.23	-0.49	11	-0.14	0.629811
(7)	Patient's death	23.24	4.82	27	0.93	-0.82	26	-0.16	0.417825

Legend:
1:1* = nurse-to-patient ratio one-to-one (1:1), means that the patient is cared for by one nurse;
1:2** = nurse-to-patient ratio one-to-two (1:2). It is understood as nursing care performed by one nurse on two patients requiring intensive care (mechanically ventilated patient)
SD = standard deviation.
ECMO – Extra Corporeal Membrane Oxygenation

3.4. Demand forNursing Care for a Patient with Congenital Diaphragmatic Hernia on the Basis of TISS–28, NEMS and NAS

In order to analyze the need of a patient with CDH for nursing care, the average working time (Tables 1, 3 and 5) was converted into points. The results were plotted and analyzed according to the NEMS recommendation (Figure 1), taking into account the accepted categorization of the patient in accordance with the recommendations of the Swiss Society of Intensive Care [2].

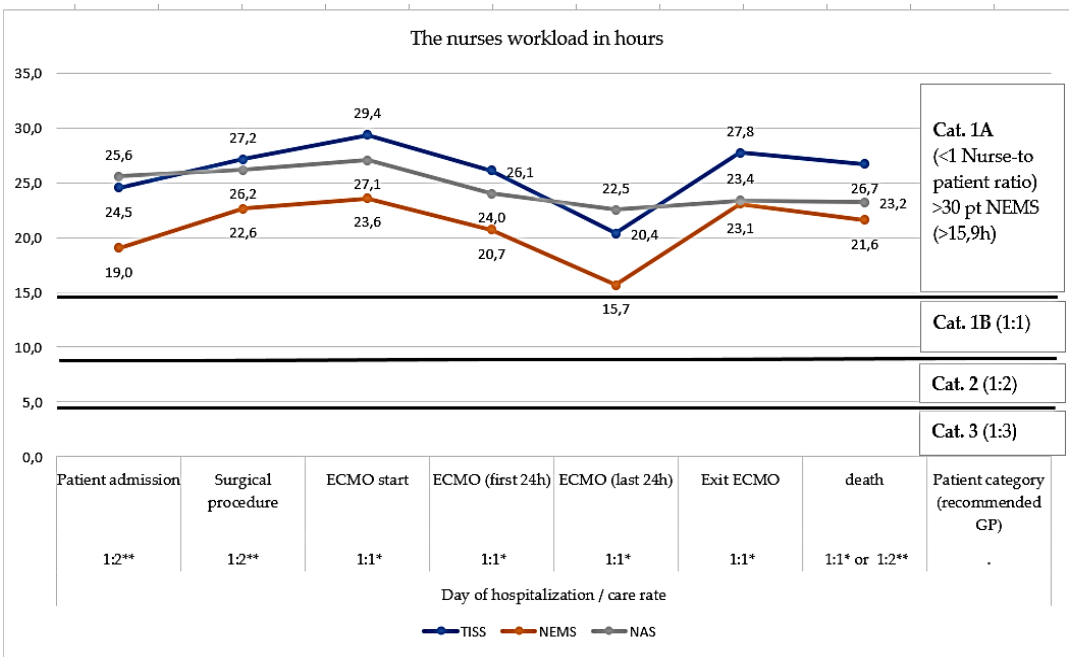

Figure 1. Average nurse working hours chart for TISS–28, NEMS and NAS
Legend: Cat. – category of patients according to NEMS [36]

4. Discussion

The main task of the research was to determine a *CDH* patient's need for nursing care. The task was accomplished by using three standardized research tools *TISS–28, NEMS* and *NAS* in intensive care units. The research hypotheses tested were confirmed.

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Converting 46 points *TISS–28* into a daily workload of a nurse, a result of 24h38 was obtained, the 24h38 work threshold was adopted as the maximum allowable, and exceeding this threshold was determined as exceeding the maximum allowable workload. It was observed that in six out of seven days of hospitalization, the average 24–hour workload of a nurse was more than half of the measures exceeding the maximum load (Table 1. No. 1: M=24h5, SD±3.69, Me=25.2; No. 2: M=27h1, SD±3.22, Me=27.5; No. 3: M=29h4, SD±2.00, Me=29.7; No. 4: M=26h1, SD±1.75, Me=25.9; No. 6: M=27h8, SD±1.86, Me=27.8; No. 7: M=26h7, SD±1.92, Me=26.5). It should be noted that during the last day of extracorporeal circulation (5), 47% of the measurements did not exceed the permissible maximum workload (Table 1. No. 5: M=20.4; SD±7.45; Me=22.0) but the result was close to the maximum. Based on a comparison of the average measures in the study group, it is concluded that the workload during six days of hospitalization of a patient exceeded 46 points. As a result of the study, no basis was found to reject the hypothesis 'The nursing workload during congenital diaphragmatic hernia patient care, determined on the basis of *TISS-28*is higher than 46 points'.

Results of analysis of measurement averages of a nursing workload during *CDH* patient care (acc. to *NEMS)* show a high workload. It was noted that during 6 hospitalization days of a *CDH* patient the average daily working time of a nurse exceeded 20 hours (Table 3. No. 2 M=22h6, SD±2.71, Me=23.3; No. 3 M=23h6, SD±1.76, Me=23.3; No. 4 M=20h7, SD±1.22, Me=20.7; No. 6 M=23h1, SD±2.05, Me=23.6; No. 7 M=21h6, SD±1.60, Me=20.7). On the first day of a patient's hospitalization, the average daily nursing workload was less than 20 hours (Table 3. No. 1 M=19.0; SD±2.82; Me=20.7). The results were interpreted against a scale of maximum scale = 46 points, which was equivalent to a 24h38 nurse's work. The data analysis showed that all the average scores were below the permissible maximum (46 points *NEMS*). On this basis, the hypothesis: 'The workload of a nurse in the care of a patient with congenital diaphragmatic hernia, basing on *NEMS* is higher than 46 points 'was rejected.

According to *NEMS* it was found that the highest workload was at the time of the onset of extracorporeal circulation *ECMO* (Table 3. No. 3 M=23.6; SD±1.76; Me=26.5). A similar result was achieved using the tool *TISS-28* (Table 1. No. 3 M=29h4, SD±2.00, Me=29.7).

According to the methodology of *NAS* , the workload of the nurse must not exceed 100 points [35]. It is proved that the average results of measuring the workload of a nurse in the care of a patient with *CDH*, ranged from 22h5 to 27h1 *NAS*. The equivalent of 100 points is 24 hours of work, which is the upper limit of the maximum allowable workload. Analyzing the average working time of the nurse, it was found that the maximum workload was exceeded in the first three days of the hospital stay (Figure 2). Table 5. No. 1 M=25.6, SD±1.90; No. 2 Me=26.2; M=26.2, SD±1.94, No. 3 Me=26.8; M=27.1, SD±0.77, Me=27.3). On the first day of ECMO, the maximum allowable workload was reached (Table 5. No. 4 M=24.0, SD±2.96, Me=24.8). In the last three days 5–7 (Table 5. No. 5–7) workload was lower, but close to 24 hours of work.

 doi:10.20944/preprints202302.0187.v1

In the first three days of hospitalization, no grounds to reject the hypothesis were found. However, this hypothesis was rejected for the patient's hospitalization days 5–7 (Table 5. No. 5–7) hospitalization of the patient.

Further considerations focus on evaluation of the 1:2 ratio of nursing care. It should be emphasized that the purpose of this work was to develop a model for determining the need for nursing care, not making recommendations. The assessment of the nursing care ratio was carried out on the basis of the results obtained from *TISS-28*, *NEMS* and *NAS* by category of care by *NEMS* [36]. As a result, it was found that a patient generated a need for care >30 points of *NEMS*. Patient qualification for nurse-to-patient ratio (1A) (nurse-to-patient ratio >1: patient), the highest on the NEMS scale, in six days of hospitalization (No. 1–4 and 6–7 figure 1) means that the patient required more comprehensive nursing care. On the fifth day of hospitalization (No. 5 Figure 1) for category 1B (30 points), nursing care demand met the required care criteria (1:1). Basing on the analyzed data, it was found that the nurse-to-patient ratio of 1:2 was insufficient for the full period of hospitalization. The 'nurse-to-patient ratio of 1:2 is sufficient' hypothesis was then rejected. It should be noted that in the six days of hospitalization of the patient in *CDH* total number of points in *NEMS* was higher than 30, but lower than 46 (Table 3 and Graph 1. No. 2, 3, 6 and 7). The total points ranged from 40 to 44 NEMS.

The workload of a nurse caring for a patient with congenital diaphragmatic hernia ranged from 38 to 54 TISS-28 points, which qualified the patient for Category III in the full period of hospitalization (Table 1. No. 1–7).

According to *NAS* (maximum of 100 nurse workload points) a nurse-to-patient ratio of 1:1 and >1:1 was distinguished. During hospitalization (Table 5. No. 1–3) the average workload of the nurse exceeded 100 points. This meant that the patient required more comprehensive nursing care, that is more than one nurse. During hospitalization (Table 5 and Figure 1 No. 4–7) the need for care did not require a second nurse, i.e. a nurse-to-patient ratio of 1:1 was sufficient. Rejection of the hypothesis 'Nurse-to-patient ratio of 1:2 is sufficient' occurred.

Research shows the need to change the model of care used in the clinic. Our own research shows that patients with CDH required a high level of complexity in nursing care, which generated increased workload and, in some cases, the need to involve an additional nurse. Lack of adequate number of nurses may result in missed care and reduce patient and occupational safety [28,29,37,38,41–45]. International research groups, and networks such as *The RANCARE Consortium and Missed Care Study Group*, collaborate on the concept and phenomenon of missed nursing care. They demonstrate the need to conduct research on the issue of omission and loss of nursing care in relation to medical personnel, working conditions, patient safety and the relationship between these elements [40].

The results of the studies conducted in the analyzed intensive care unit proved that work planning deviated from the recommendations of *The Minister Of Health* [46], which stems from a shortage of nurses in the labor market (6.2/100 000 population) [47]. It should be noted that the regulation of the Minister of Health [48] determines the average time of direct nursing services in a category III patient for only 300 minutes per day (5 h). However, in our own study, it was proved that the minimum average working time of a

 doi:10.20944/preprints202302.0187.v1

nurse, in the case of CDH patient was 20h4 according to TISS-28 (Table 1. Me=22.0; SD±7.45 No. 5 Table 1), NEMS = 15h7 (Me=18.4; SD±7.08 No. 5 Table 3) and NAS = 22h5 (Me=21.3; SD±3.27 No. 5 Table 5). Nursing staff are key to ensuring resilience in ICU [49]. This is one of the key elements necessary to prepare organization in response to crisis [50–52].

Correlation tests were performed on the results obtained for the applied research tools. The tools are divided into three comparative groups *TISS–28 & NEMS, NEMS & NAS* and *TISS–28 & NAS*. The highest correlation value for *TISS–28 & NEMS* was shown. A smaller correlation was found when comparing *TISS–28 & NAS*. The statistical significance of the correlation has been proven for *TISS–28 & NEMS* (of moderate strength and very weak strength). *TISS–28 & NAS* correlation was shown as average strength. The results of the analysis did not give grounds to reject the hypothesis 'there is a correlation of results for *TISS–28 & NEMS* and *TISS–28 & NAS'*. However, no correlation of results was found for *NEMS & NAS*, which led to the rejection of the research hypothesis: 'There is a correlation of results for NEMS and NAS'.

5. Conclusions

As a result of the analysis, the following conclusions were drawn for the practice:

1. A nurse-to-patient ratio >1:1 is recommended over a patient with *CDH* from the first day of hospitalization.
2. A patient with *CDH* should receive the care they need, so it is recommended to use standardized tools of *TISS–28*, *NEMS* and *NAS* to measure the workload of nurses.
3. Use of *TISS–28*, *NEMS* and *NAS* tools can help to increase the level of patient safety in *ICU.*
4. Development of a model for the use of *TISS–28*, *NEMS* and *NAS* tools to measure the workload in neonatal intensive care units is the goal of further research.
5. It is necessary to implement a model for measuring the workload of nurses in neonatal intensive care units, taking into account the evaluation of work and its optimization.

6. Limitations

Limitations in the conducted research should be mentioned. The first major limitation was the disease unit. The study was conducted in one neonatal intensive care unit, in the main reference center of the third stage of surgical treatment of congenital malformations, therefore the results of the analyzes should be interpreted with caution in relation to other groups of patients. Another limitation of the study was the fact that the tools used in the development of the field by experts were dedicated to adult patients and may not reflect practice in the pediatric intensive care unit, especially in the neonatal intensive care unit. In many studies *TISS–28 and NEMS* have been criticized for failing to take into account both direct and indirect nursing interventions, such as hygiene, as well as the psychological support of the patient's family and the nurse's managerial tasks. The answer to these aspects is *NAS* which is becoming increasingly used in intensive care units. In order to verify patient safety and occupational safety, as well as to evaluate the use of

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measurements of these tools, studies on the workload of nurses working in pediatric and neonatal intensive care units are recommended.

The conducted study provided a lot of valuable information on the workload of a nurse in the care over a patient with congenital diaphragmatic hernia, the organization of work, the number of interventions performed, the continuity of highly specialized procedures conducted. This study proves the need for research on the workload of nurses in neonatal intensive care units. The analyses from the measurements will be able to serve as an introduction to the discussion regarding the determination of optimal indicators of care.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, according to polish law the ethical statement is available only for experiment. In accordance with the law on scientific research in force in Poland, the consent of the bioethics committee can be obtained only in the case of experimental research. The Bioethics Committee of the Medical University of Lodz does not consider applications that do not have such premises, or if a doctor is not part of the research project.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. The content of the questionnaire contained information about the consent

Data Availability Statement: Non-digital data supporting this study are curated by Dorota Kilanska.

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