Subjective workload measurements among critical care nurses in a Greek intensive care unit of a small urban hospital: Prelimanary Results

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ABSTRACT

Subjective workload measurements among critical care nurses in a Greek intensive care unit of a small urban hospital: Prelimanary Results.

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Patient care in Intensive Care Units is characterized be high demanding tasks, which lead in daily high workload. In the present study, a questionnaire-based evaluation of ICU nurse's workload was conducted at the adult general 7 - beds ICU of a small urban hospital. NASA Task Load Index (TLX) along with other two tools, used for the first time in healthcare environment: Instantaneous Self-Assessment (ISA) and Crew Status Survey (CSS) were used for that purpose. Information about every nurse's professional background and basic demographics were also collected. Responses from 70% of total nurse staff were collected. A total of 93 questionnaires (response rate=total shift coverage 40.25%) were included for further analysis while 2 questionnaires were excluded due to >50% of missing answers. The overall average workload for the period in interest is little to moderate, yet interesting variations do exist. Physical workloads seem to be highly related with both mental workload and time pressure; yet the last two are not related. Increased workload is perceived during morning shifts, and though there is variety in individually recordings, no relation was found between measurements and other characteristics, such as work experience (total or ICU), age of nursing staff, family status or time to work arrival. Subjective workload assessment via NASA TLX index, CSS and ISA workload surveillance tool provide a useful method of early detection of group or individual increased workload that allows proper management measures to be applied.

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INTRODUCTION

Intensive Care Unit (ICU) is very complex environment, where the continuous integration of both technological and medical progress on one hand, and the dynamic character of the clinical condition presented in each ICU case on the other, poses great challenges to its staff. Patient care is characterized by high demanding tasks, which leads in daily high workload[1-2]. The latter has been identified as a major occupational stressor and has been related to several adverse effects, for ICU staff as well as for their patients[3-5].

Mental workload monitoring is identified early as the key point in order to assure higher levels of comfort, satisfaction, efficiency, and safety in this workplace[6].

Several tools have been developed for this purpose and there is a trend of creation of more oriented indices[7-8]. Most of these methods fall into the three following categories (a) performance-based measures, (b) subjective measures, and (c) physiological measures. The practical advantages of subjective procedures include their ease of implementation, non-intrusiveness and their capability to provide sensitive measures of operator load[7, 9-10]. Therefore, they are the more often used in the literature.

NASA Task Load Index (TLX) is a subjective workload assessment tool to allow users to perform subjective workload assessments on operator(s) working with various human-machine interface systems. It derives an overall workload (OW) score based on a weighted average of ratings on six subscales:

a) Mental Demand (Ment), i.e. how much mental and perceptual activity was required? Was the task easy or demanding, simple or complex?

b) Physical Demand (Phys), i.e. how much physical activity was required? Was the task easy or demanding, slack or strenuous?

c) Temporal Demand (Temp), i.e. how much time pressure did you feel due to the pace at which the tasks or task elements occurred? Was the pace slow or rapid?

d) Performance (Per), i.e. How successful were you in performing the task? How satisfied were you with your performance?

e) Effort (Ef), i.e. How hard did you have to work (mentally and physically) to accomplish your level of performance? and

f) Frustration (Fr).How irritated, stressed, and annoyed versus content, relaxed, and complacent did you feel during the task?

Coincidentally, these dimensions also correspond to various theories that equate workload with the magnitude of the demands imposed on the operator or the operator's ability to meet those demands[11].Originally developed as a paper and pencil questionnaire, it is currently used as computerized version. In each subscale the score varies between 0-100 (no workload to extreme workload), with 5-point steps. Results can be analyzed both as raw data or weighted scores. The observer evaluates the contribution of each

factor (its weight) to the workload of a specific task, thus providing diagnostic information about the nature of the workload imposed by the task.

The Instantaneous Self- Assessment (ISA) is a measurement method using five-point rating scale that was originally developed at the ATMDC (Air Traffic Management Development Centre, National Air Traffic Services) to assess mental workload in real time. ISA was developed as a tool that an operator could use to estimate their perceived workload during real-time simulations (from 1 = underutilized, to 5 means excessively busy)[14-15]. Even though the method is low cost, requires little training, has small data analysis requirements, and is sensitive to specific task demands, there is no literature about its application in healthcare domain.

Another useful tool is Crew Status Survey (CSS) that was initially designed by USA Airforce School of Aerospace medicine for assessing workload (CSSw) and previous fatigue (CSSf) in pilots throughout shifts. Again, despite its simplicity and well concordance with other tools it has never been used in healthcare domain[16].

Several other methods exist for operator-based subjective workload: The Cooper-Harper Scale, the perceived workload scale, the Subjective Workload Assessment Technique (SWAT), the Workload Profile (WP), the Rating Scale Mental Effort (RSME) and the NASA-Task Load Index (NASA-TLX). Yet, literature shows that the latter is a reliable and valid instrument and is more reliable and valid than other subjective workload instruments[7, 17].

The aim of the study is to evaluate ICU nurse's workload with the 3 aforementioned tools as part of larger project of workload assessment in critical care.

METHODS

This prospective observational study was conducted at the adult general 7- beds ICU, at Saint Paul ("Agios Pavlos") General Hospital, Thessaloniki (total of 225 beds) in Greece for a period of 22 days (from 08 to 31 October). The study took place while before COVID19 pandemic and it consisted of measurements of ICU nurses' 8-hour shifts workload (total of 66 shifts). Shift distribution was defined as: 07.00-15.00 morning, 15.00-23.00 afternoon and 23.00-07.00-night shift. A previously validated translation of NASA TLX index was used[18], while the other 2 tools were translated in Greek for the purpose of the study by a professional medical writer and tested beforehand by 2 ICU nurses. Information about every nurse's professional background and basic demographics were also collected. During study period there were 11 patients hospitalized in the ICU (out of 123 for the same year) with mean severity APACHE II Score of 24.5.

A paper format survey was used with the questionnaires handed over by an observer/ consultant with previous experience in the first application of the tools in Greece[18].

Explorative data analysis (EDA) was performed with MS Excel 2020 (Microsoft Co, USA) and Rstudio® IDE v.4.0.0 (Rstudio Inc, Boston, MA, USA). Results are presented as descriptive statistics are presented as mean ($\bar{x}$), standard deviation (s).

RESULTS

Responses from 70% of total nurse staff were collected. A total of 93 questionnaires (response rate= total shift coverage 40.25%) were included for further analysis while 2 questionnaires were excluded due to >50% of missing answers.

All responders were women. The mean age was 43 years (range 37-48) old. Mean total nursing working experience was 18.25 years, while mean nursing working experience in ICU was 13 years (range 5.5-22). All had technical institute education background and one with master's degree; while 3 were holding student status during the study (2 for obtaining master's degree, one for obtaining University degree). All but one, was married with mean average of children 1.9/nurse. Mean arrival time to work is 18 min (range 10-35). Medical history reveals that 30% of the responder report chronical medical problem (50% regarding musculocutaneous problems).

Overall descriptive statistics in for the NASA TLX index measurements conducted are displayed in Table 1, while boxplots of each subscale for both categories is shown in Graph 1.

Table 1. Subscales raw and weighted scores as mean (standard deviation) rounded in the 2nd decimal.

Raw scores	**Ment**	**Phys**	**Temp**	**Per**	**Ef**	**Fr**	**OW**
$\bar{x}$	43.48	47.85	41.45	37.71	51.56	28.89	11853.08
s	22.58	25.29	24.47	27.75	25.47	26.19	63628.28
Weighted scores	**Ment**	**Phys**	**Temp**	**Per**	**Ef**	**Fr**	
$\bar{x}$	0.17	0.23	0.13	0.21	0.17	0.09	
s	0.09	0.08	0.07	0.09	0.08	0.01	

Overall descriptive statistics for ISA and CSS scales (fatigue and work) are displaying in table 2 and graph 2. Exploring workloads per shift is revealing several interesting relations in Graph 3.

Correlations EDA is revealing that higher Temp, Ef and Frare related with significantly increased ISA Score, while CSSf is highly related to high Fr, Temp and Ef workload, (Table 3). Exploring among NASA TLX indices measurement also highly reveals relations between Ment/Phys and Temp/Phys measurement raw recordings (linear, correlation coefficient r^2 0.71 and r^2 0.75 respectively) (Graph 4.)

Graph 1. Side by side boxplots for each subscale of NASA TLX index.

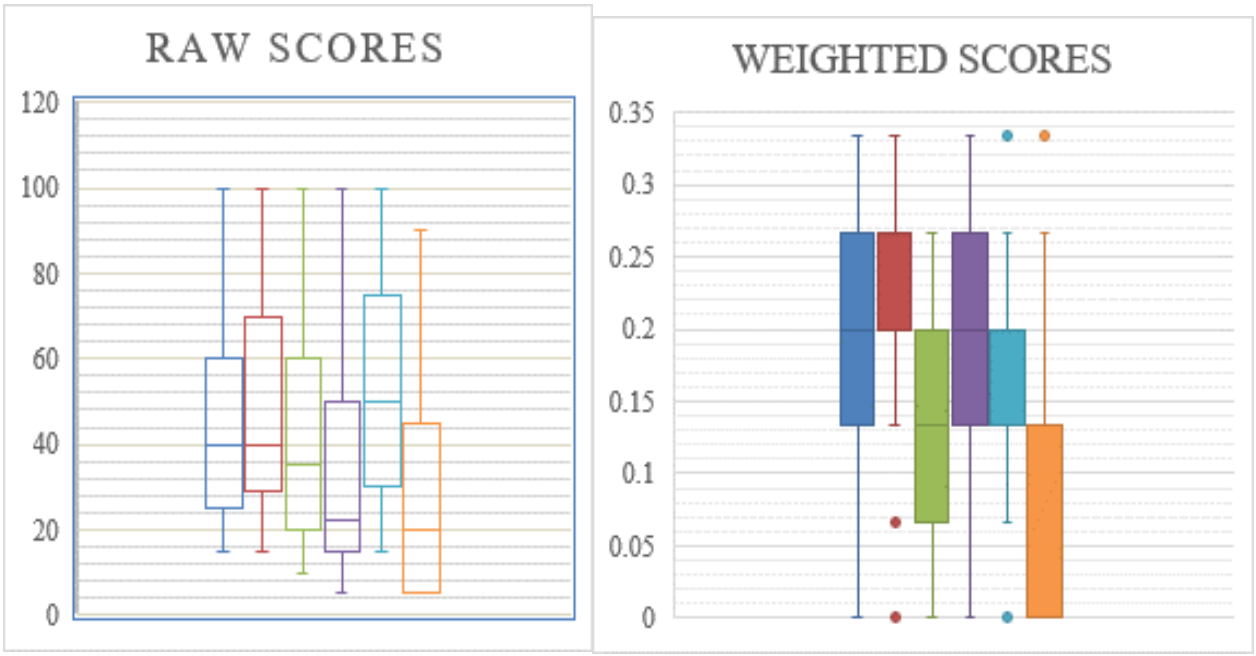
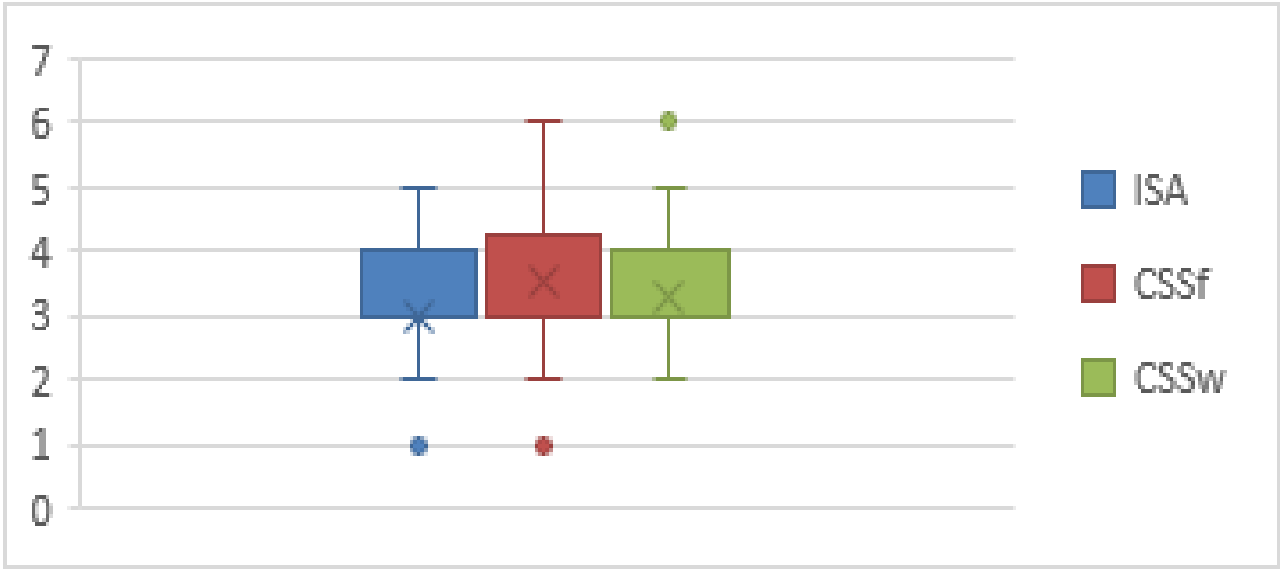


Table 2. Values for ISA and CSS tools.

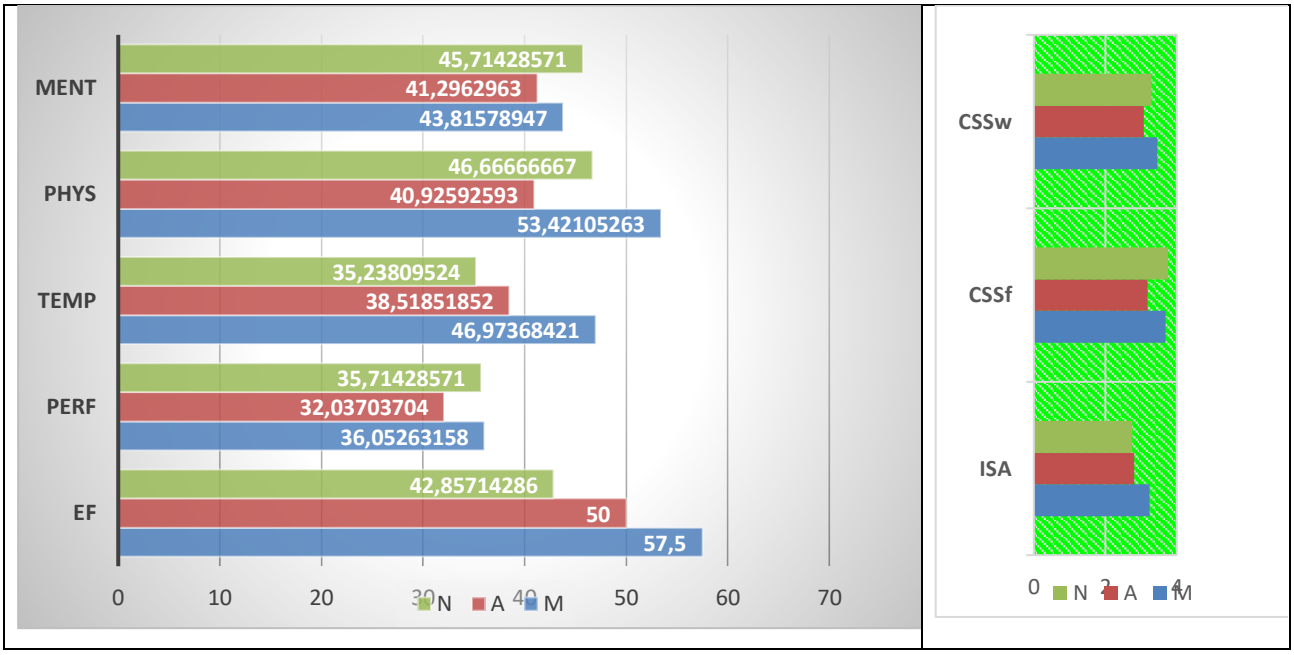
Tool	ISA	CSS f	CSS w
$\bar{x}$	2.98	3.54	3.26
s	0.88	1.38	0.73

mean and standard deviation, right – boxplo

Graph 2. Values for ISA and CSS tools.



Graph 3. Average values for NASA TLX, CSS subcategories and ISA per shift.

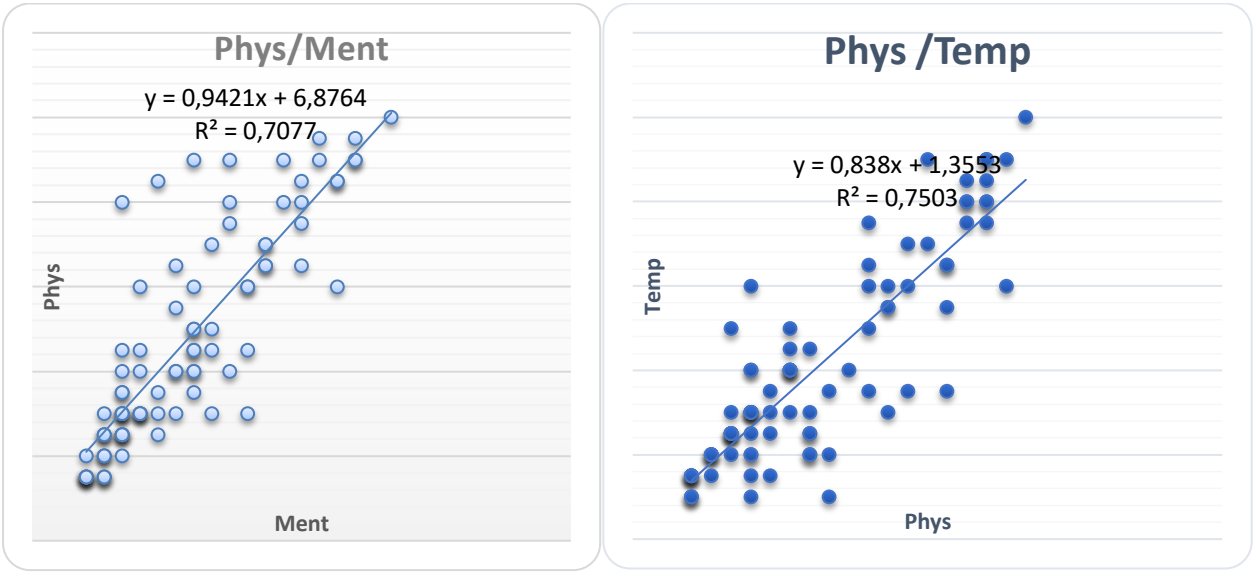


blue (morning), red (afternoon) green (night).

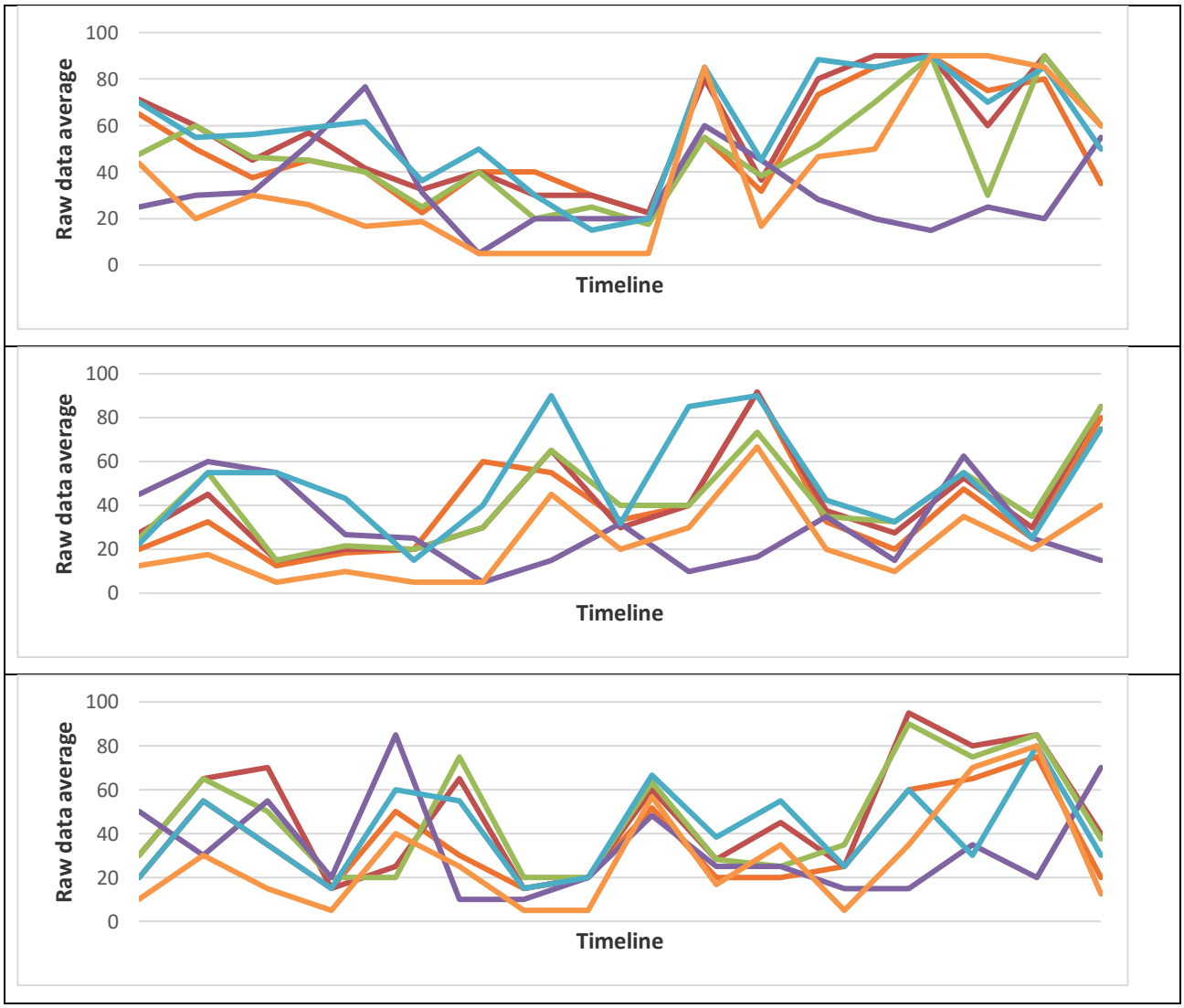
Table 3. Relations between ISA and CSS and NASA TLX subcategories average values (raw data).

ISA	CSSf	CSSw	Temp $\bar{x}$	Ment $\bar{x}$	Phys $\bar{x}$	Perf $\bar{x}$	Ef $\bar{x}$	Fr $\bar{x}$
5	6	4	75	30	60	25	70	90
4	4.26	4	65.43	60.22	72.82	21.31	74.56	50.65
3	3.44	3.14	37.21	43.25	43.95	32.63	47.59	23.72
2	2.34	2.58	22.5	24.58	26.67	45	31.25	11.67
1	3.57	3	16.42	24.28	24.28	50.71	32.85	10

Graph 4. Scatter plot between Phys/Ment and Temp/Phys subcategories (averages, raw data).



Graph 5. Time trend of average values of each of NASA TLX subactegories per shift.



blue (Ment), red (Phys), green (Temp), purple (Perf), lightblue (Ef), orange (Fr). Above- Morning shift, Middle-Afternoon shift, Bottom- Night shift.

No differences were found between weekends and the rest of the days. Overall increase in the recordings was noticed during admissions and intrahospital patient transfers for imaging examinations; but not during discharges (either dead or alive patients).

Finally, though there is variety in individually recordings (Supplement File), no safe relation could be found regarding total or ICU work experience or age of nursing staff or other demographics factors.

DISCUSSION

Several associations with patients' condition or ICU environment and workload have been revealed in previous reports. Thus, e.g., higher workload demand was associated in the past with physiological instability (respiratory failure) and multiple severe trauma injuries in male patients[18].On the contrary, higher nursing

workload seems to have a protective role for the development of pressure ulcers[19].Other studies report that administrative problems, high ratio of patients: nurse and mismatch of the mismatch between the capacity of wards and the number of patients may increase workload[20]. The type of the ICU and the shift also affects workload: thus, lower scores are reported during night shifts, in weekends and in Medical ICU patients and higher during morning shifts in Surgical ICU patients[21-22]. In Greece, there are few studies that relate high nursing workload with high mortality[1] and fever in ICU[22].No significant relation was found between workload (as measured by NASA-TLX index) for performing a complex monitoring task in ICU environment, and the patient's sedation level[23].

This the first study that evaluates workload with NASA TLX index, ISA, and CSS tools in nursing ICU staff. The overall average workload for the period in interest is little to moderate, yet interesting variations do exist.

Increased workload is perceived during morning shifts when most of the ICU activities usually taken place, and during night shifts, which may be a result of the nature of the shift (previous fatigue as measured by CSSf rather than other factors. The last is in controversy with previous reported studies[21]. On the contrary, workload is not affected by the day of the week (weekends or not) but is related to patients' admission or transfer for imaging examination.

Physical workloads seem to be highly related with both mental workload and time pressure; yet the last two are not related. The concomitant use of the other two tools reveals additional interesting relations. Thus, ISA score is related to higher Temporal demand, effort, and frustration. Regarding Frustration we noted another interest fact that was noted via CSS tool. Previous fatigue seems to be most related to perceive Frustration than any other workload subcategory.

No relation was found between measurements and other characteristics, such as work experience (total or ICU), age of nursing staff, family status or time to work arrival. The latter may by explained by the fact that the homogeneity of the aforementioned characteristics in the responders' group. Previous studies also report that performance did not depend on experience; thus, enforcing the former hypothesis[24-26]. Nevertheless, individual timelines recordings show large variations (Supplement Files).

The present results provide a useful "workload photograph" of the given ICU during the period of interest; thus, no generalization of the results could be made for other settings (e.g. more beds, different type of patients) with different staff composition and workflow organization. Apart from that, further studies are needed with more investigators and workload scales, either

operator-based subjective ones[7,13] or scores measuring activities (e.g., TISS-28, NAS)[24], to reach a more definite conclusion about specific factors that contribute to workload.

CSS tool seem useful to distinguish work-related fatigue from previous to work fatigue also for healthcare settings; yet again larger studies could highlight more on this point. Finally, due to pure observational character of the present study, we did not apply any strategies for reducing the overall group (staff) or individual (personal) workload. Yet, since the given ICU was converted in COVID dedicated and major staff reorganization was taken place since the first measurement, further analysis is expecting to reach more safe conclusions. Furthermore, we believe that a continuous surveillance system should be applied, so that i) early detection of increasing workload trend could be feasible and ii) individual working program arrangement could be applied in case of selected cases. Thus, the above surveillance system could provide on one hand an additional "safety net" for avoiding errors, staff burnout; and along with that, boost productivity and overall outcomes of healthcare providing[27-31].

CONCLUSION

Subjective workload assessment via NASA TLX index, CSS and ISA workload surveillance tool provide a useful method of early detection of group or individual increased workload, that allows proper management measures to be applied. Future studies will provide the exact frame of these changes (how and when to be decided) and could be a valuable tool for ameliorating both workflow and outcomes in ICUs.

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Author Disclosures:

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