PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Does adherence to a quality indicator regarding early weaning from invasive ventilation improve economic outcome? A single-center retrospective study.
AUTHORS	Zuber, Alexander; Kumpf, Oliver; Spies, Claudia; Höft, Moritz; Deffland, Marc; Ahlborn, Robert; Kruppa, Jochen; Jochem, Roland; Balzer, Felix

VERSION 1 – REVIEW

REVIEWER	Aslanidis, Theodoros St.Paul General Hospital of Thessaloniki, Intensive Care Unit
REVIEW RETURNED	03-Nov-2020

GENERAL COMMENTS	Good written , detailed presentation of the study conducted by the authors in the specific center. Well written discussion. Of special note is the good limitation section ; since factors like ICU SOPs, protocols' policy making and updating,staff education and experience, staffing and equipement (including any EHR/EMR, Reports producing software, etc) availability stogngly affects any results and limits repeatibility of the study. Yet, it provides a good " research path" for similar future studies in different ICU settings. Thus, I feel that the manuscript could be published in its present form.

REVIEWER	Valentin, Andreas Kardinal Schwarzenberg Hospital, Internal Medicine
REVIEW RETURNED	14-Mar-2021

GENERAL COMMENTS	This paper deals with an important question – is quality in intensive care medicine associated with a better economic outcome? At least for the process of weaning from mechanical ventilation the authors provide some evidence to answer this question with “Yes”. The paper is well structured, in most parts the descriptions and statements are clear and reasonable, the paper reads very well. From a general perspective I think the paper could further benefit from the following aspects: a) A more specific description and discussion of the balance between costs and reimbursement system. The economic results in this study depend heavily on the related DRG-system (fixed prices for a given case). If another reimbursement system would be used, the results could be quite different. In other words, profits depend on the actual system for reimbursement. b) Maybe a point for the discussion section: the results support an approach to combine patient-centered outcomes with economic outcomes. In such an approach economic profits will only occur if

	the principle “quality has it’s prize” will be accepted. In addition positive patient-centered outcomes should not be impeded by wrong incentives from the reimbursement system (e.g. disproportionate treatments in association with higher incomes). c) A basic requirement for Quality Initiatives consists in appropriate resources. It is very likely that available resources in a tertiary University Reference Center are quite different from other hospitals. Maybe this aspect should be more stressed in the discussion and conclusion section. Questions and Comments in detail: 1) Page 4, line 81: the authors state “In modern medicine, a major part of hospital costs arises from intensive care”. Considering the costs of e.g. modern oncologic treatments, this description as a “major part” is questionable. Maybe “considerable part” would be a better expression. In addition the next sentence should be changed to “The cost structure of a tertiary German hospital…… 2) Page 5, line 140: please provide a description of the criteria for “ready to wean” (electronic supplementary material?) 3) Page 6, line 163-178: This section should provide more detailed information about the indicators used in quality assessment. A definition or at least a description of the quality indicator “early weaning from invasive ventilation” is missing. Please provide also a description of the key performance indicators (KPIs), maybe in the format of an additional table. Electronic supplementary material? 4) Page 6, line 164: the recommendation for weaning protocols in reference 8 (S3-Leitlinie) contains some exceptions (e.g. neurologic and neurosurgical patients). Did you consider this exceptions in your exclusion criteria (study design)? 5) Page 7, line 237-241: Please describe which kind of mortality assessment is meant. Ideally it should not be ICU mortality but hospital mortality or mortality at 30 days. 6) Page 9, line 249-251 and table 2: p-values in the text are not consistent with referring values in table 2. 7) Page 9, line 252: do you have an explanation why a higher daily averaged SOFA score increased profits per case? Could be explained in the discussion section 8) Table 1: “Death”. See comment above (3) 9) Table 2: there are two explanations of abbreviations that do not exist in the table (PACU, OT) 10) Table 3: Do you had an explanation why profits per case were positive in the years 2015 and 2016? Thank you very much for having the opportunity to review this interesting manuscript.

VERSION 1 – AUTHOR RESPONSE

Reviewer 2				
Page/Line	**Comment**	**Reply**	**Original**	**Revised Version**
-	From a general perspective I think the paper could further benefit from	We thank the reviewer for this valuable comment.	-	Introduction: Reimbursement for inpatients is linked to

	the following aspects: A more specific description and discussion of the balance between costs and reimbursement system. The economic results in this study depend heavily on the related DRG-system (fixed prices for a given case). If another reimbursement system would be used, the results could be quite different. In other words, profits depend on the actual system for reimbursement.	We fully agree and changed one part in the introduction accordingly and added this point in the limitation section in the discussion. Also, we discussed differences in reimbursement systems within the limitations section.		DRG accounting and updated annually based on reported data from hospitals. Discussion: […], based exclusively on the DRG-system. A transfer of our observations to other ICUs or reimbursement systems is not feasible.
-	Maybe a point for the discussion section: the results support an approach to combine patient-centered outcomes with economic outcomes. In such an approach economic profits will only occur if the principle "quality has it's prize" will be accepted. In addition positive patient-centered outcomes should not be impeded by wrong incentives	We agree with the reviewer on this point. Combining patient-centered with economic outcomes is a potential research topic in the future. However, the main goal of this study was to show that hospitals can benefit economically, given the current reimbursement situation, by providing high quality (e.g. weaning).	-	Discussion: […] and combine patient-centered outcomes with economic outcomes systematically. To avoid wrong incentives, reimbursement should potentially be tied to patient-centered outcomes. For example, the prevention of ventilator-associated pneumonia, post intensive care syndrome and chronic critical illness.

	from the reimbursement system (e.g. disproportionate treatments in association with higher incomes).	We added two sentences emphasizing this point in the discussion.		
-	A basic requirement for Quality Initiatives consists in appropriate resources. It is very likely that available resources in a tertiary University Reference Center are quite different from other hospitals. Maybe this aspect should be more stressed in the discussion and conclusion section.	We agree that quality initiatives need electronically available data and according resources to evaluate the data. However, since the reimbursement system is applied to every hospital in Germany, the positive economic results might be the same, regardless of the hospital size or type. This point is also crucial for understanding the high value of the data extracted and results shown. We marked this point as a limitation of the manuscript. After extensive discussion, we emphasized this aspect in the conclusion.	-	Conclusion: Available resources differ among the various hospital sizes and types. […] in a university reference center […], we think patients and hospitals in general benefit from high adherence to quality measures.
4 / 81	Questions and Comments in detail:	We fully agree and changed the	In modern medicine, a major part of	In modern medicine, a considerable part of hospital costs arises from

	the authors state “In modern medicine, a major part of hospital costs arises from intensive care”. Considering the costs of e.g. modern oncologic treatments, this description as a “major part” is questionable. Maybe “considerable part” would be a better expression. In addition the next sentence should be changed to “The cost structure of a tertiary German hospital…	sentence accordingly.	hospital costs arises from intensive care. The cost structure of a German hospital shows that ca. 20% of costs are generated in intensive care units (ICU) [4].	intensive care. The cost structure of a tertiary German hospital shows that ca. 20% of costs are generated in intensive care units (ICU) [4].
5 / 140	please provide a description of the criteria for “ready to wean” (electronic supplementary material?)	This is a very good review point, which will help increase the understanding and readability. We added the criteria used at our institution to define this KPI to the supplemental material (1).	-	A description of the KPI is provided in the supplementary material.
6 / 163-178	This section should provide more detailed information about the indicators used in quality assessment. A definition or at least a description of the quality	This review point is very helpful. We added the official definition of the German interdisciplinary association for intensive care and emergency medicine in the	-	This process is directly linked to a specific QI for weaning derived from the DIVI-QI [19]. A definition of the indicator is presented in the supplementary material.

	indicator “early weaning from invasive ventilation” is missing. Please provide also a description of the key performance indicators (KPIs), maybe in the format of an additional table. Electronic supplementary material?	supplemental material (2).		
6 / 164	the recommendation for weaning protocols in reference 8 (S3-Leitlinie) contains some exceptions (e.g. neurologic and neurosurgical patients). Did you consider this exceptions in your exclusion criteria (study design)?	This is a very thoughtful question. In general, patients with neurological and neurosurgical diagnoses receive the same treatment in the analyzed ICU as other patients, independent of chances for clinical outcome. We did not consider these exceptions. Patient inclusion was based on administrative data. We followed the comment and identified 55 patients with neurological and neurosurgical diagnoses in our administrative data of the existing data set. However, we were not able to reconstruct whether these patients had a neurological or neurosurgical	-	Study Design: Data related to diagnoses were not retrieved from the administrative systems. Discussion: The current study is subject to its retrospective design and potential selection bias, as some of the cases with incomplete data or special diagnoses were not detected during the observation period. We could have used neurological and neurosurgical diagnoses to exclude patients with low chances for weaning outcome, but in our administrative system there is no time point matched to it accordingly as diagnoses are often added just before discharge. For example: Patients developing specific neurological conditions after their stay on the study-ICU.

		diagnosis at the time of treatment on our study-ICU or developed it during their hospital stay. We added a limitation to the study design and the discussion section.		
7 / 237-241	Please describe which kind of mortality assessment is meant. Ideally it should not be ICU mortality but hospital mortality or mortality at 30 days.	Valid point. We used ICU mortality, which should be made clearer within the manuscript. We changed the wording accordingly. We chose ICU mortality, since patients were partly discharged to external institutions, thus potentially generating bias within the data. We added a sentence to the results section. Also, we were limited in our data of the administrative system, since 30-day mortality is not part of the standard recorded data in German hospitals.	Considering the discharge of the patients, there was a highly significant difference (P < 0.001) between both groups. Most patients were discharged to intermediate care (44.6%), other ICUs (27.6%) or rehabilitation (18.9%). Within the LAG, 50 (13.2%) patients died compared to 2 (1.0%) in the HAG. This gives room to assume a certain impact of weaning quality on mortality.	Results: Considering the discharge of the patients, there was a highly significant difference (P < 0.001) between both groups. Most patients were discharged to intermediate care (44.6%), other ICUs (27.6%) or rehabilitation (18.9%). Within the LAG, 50 (13.2%) patients died on the ICU compared to 2 (1.0%) in the HAG. This gives room to assume a certain impact of weaning quality on mortality. However, since we didn't include diagnosis data, we cannot exclude an influence from this fact.

9 / 249-251	and table 2: p-values in the text are not consistent with referring values in table 2.	We revised the values accordingly.	In the linear regression analysis, the LOS on the study-ICU (P < 0.001), the LOS in the hospital (P = 0.015), the averaged daily SOFA score (P = 0.002) and the averaged daily costs per patient (P = 0.032) were shown to have significant effects on the profitability (table 2)	In the linear regression analysis, the LOS on the study-ICU (P < 0.001), the LOS in the hospital (P < 0.001), the averaged daily SOFA score (P < 0.001) and the averaged daily costs per patient (P < 0.001) were shown to have significant effects on the profitability (table 2).
9 / 252	do you have an explanation why a higher daily averaged SOFA score increased profits per case? Could be explained in the discussion section	As part of the reimbursement scheme for ICU-patients higher SAPS 2 scores lead to higher specific values for daily ICU treatment point-values that lead to higher DRGs.	-	Higher assessment scores as SAPS II or SOFA play an important role in ICU reimbursement and might induce higher DRG reimbursement.
Table 1	"Death". See comment above (3)	„Death" is considered to express ICU mortality (s. above). We changed the wording accordingly.	Death	ICU-Mortality
Table 2	there are two explanations of abbreviations that	Your are right. We eliminated the abbreviations accordingly, i.e. below the table as	-	-

	do not exist in the table (PACU, OT)	well as in the abbreviations section.		
Table 3	Do you had an explanation why profits per case were positive in the years 2015 and 2016?	We are grateful for this valuable question. The cost weight for each DRG within the G-DRG-System is updated annually, which can lead to higher or lower reimbursements for similar cases from year to year. Apart from this effect, in 2015/2016, the number of patients receiving weaning was higher than in the other years. We assume that there is an economies of scale effect. This means that more cases within the existing infrastructure and according fixed costs, lead to higher contribution margins per case as fixed costs are covered. We added two sentences.	-	Introduction: […] as reimbursement is predefined […] Discussion: On an annual basis, cost weights are adjusted for each DRG, potentially leading to higher reimbursement per case. Hospitals can also benefit from economies of scale, considering more cases per year with fixed reimbursement values. This may explain why in 2015 and 2016 profits per case were higher.

VERSION 2 – REVIEW

REVIEWER	Valentin, Andreas Kardinal Schwarzenberg Hospital, Internal Medicine
REVIEW RETURNED	24-Aug-2021

GENERAL COMMENTS	The authors have responded to the questions and comments of the reviewer in a careful and detailed manner. As a result, the manuscript was signifcantly improved, because the conditions, limitations, and results of the study were more clearly elaborated. No further questions or comments remain. Thank you for the opportunity to review this interesting piece of work.