

1 Intensive care admission criteria for traumatic brain injury patients across Europe

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34 **Conflict of interest**

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**Abstract**

Within a prospective, observational, multi-center cohort study 68 hospitals (of which 66 responded), mostly academic (n=60, 91%) level I trauma centers (n=44, 67%) in 20 countries were asked to complete questionnaires regarding the “standard of care” for severe neurotrauma patients in their hospitals. From the questionnaire pertaining to ICU management, 12 questions related to admission criteria were selected for this analysis.

The questionnaires were completed by 66 centers. The median number of TBI patients admitted to the ICU was 92 [interquartile range (IQR): 52-160] annually. Admission policy varied; in 45 (68%) centers, patients with a Glasgow Come Score (GCS) between 13-15 without CT abnormalities but with other risk factors would be admitted to the ICU while the rest indicated that they would not admit these patients routinely to the ICU.

We found no association between ICU admission policy and the presence of a dedicated neuro ICU, the discipline in charge of rounds, the presence of step down beds or geographic location (North- Western Europe vs. South – Eastern Europe and Israel).

Variation in admission policy, primarily of mild TBI patients to ICU exists, even among high-volume academic centers and seems to be largely independent of other center characteristics. The observed variation suggests a role for comparative effectiveness research to investigate the potential benefit and cost-effectiveness of a liberal versus more restrictive admission policies.

**Introduction**

Intensive care unit (ICU) beds are a costly and limited resource. Admission is clearly justified for more severely injured patients needing acute life-sustaining physiological support. For the

1 less severely injured, ICU admission could be justified by the notion that a proportion of these  
2 patients subsequently deteriorate or because of care needs that are still too intense to be  
3 adequately provided at the ward. However, accurate and broadly applicable admission criteria  
4 for such less severely ill patients are lacking and may be subject to service-configuration,  
5 other institutional, or clinician-specific determinants. Admission of patients to the ICU who  
6 have a low risk of subsequently requiring physiological support or emergent surgical  
7 intervention, as a result of the severity of their traumatic brain injury (TBI) or extra-cranial  
8 injuries, is undesirable and may have adverse financial consequences.

9 In the United States, 20% of patients with mild TBI, defined as those with a Glasgow Coma  
10 Scale (GCS) of 13-15, presenting to the Emergency Department are admitted to the ICU <sup>1</sup>.  
11 Even though admitting a patient with a 'mild' traumatic brain injury (TBI) to the ICU might  
12 be the appropriate decision to ensure proper interventions in the case of secondary  
13 neurological worsening, existing data do not support this <sup>2,3</sup>. In Europe, a recent survey  
14 demonstrated large variation in the number of critical care beds across countries. Moreover,  
15 no clear central policies to facilitate planning to meet the demand and optimal utilization in  
16 the future exist<sup>4</sup>.

17 In this study we aim to describe the variation in policy of European neurotrauma centers  
18 regarding admission of TBI patients to the ICU.

19

## 20 **Materials and methods**

### 21 *Data*

22 Between 2014 and 2015, 68 centers from 20 European countries, participating in the  
23 CENTER-TBI prospective longitudinal observational study <sup>5</sup>, were approached to complete a  
24 set of questionnaires about structure and process of care: The Provider Profiling (PP)  
25 questionnaires. These were developed according to best practice. In the item generation phase  
26 we have gathered experts together within the CENTER-TBI team and proceeded with item  
27 generation and item reduction in a second phase. The questionnaires were then pre-tested with  
28 a group of participating centers and face validity was discussed with the participants and the  
29 experts involved in item generation. The pilot testing evaluated flow and time required to  
30 complete.<sup>6</sup>

31 We have measured reliability and concordance rates of the questionnaire.

32 - To estimate reliability of the questionnaires, we included 17 (5%) duplicate questions,  
33 including all question formats. We equally included structure and process questions in  
34 the duplicate questions.

35 Concordance rates were estimated by calculating the percentage of overlap between duplicate  
36 questions, and presented as mean, median and range. For open questions (e.g. what is the  
37 number of intensivists in your center), a maximum difference of 10% was considered  
38 concordant. Questionnaires were disseminated during presentations, workshops and email  
39 conversations. More information is available at length in one of our groups' previous  
40 publications<sup>6,7</sup>.

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1 The questionnaire on ICU care contained 3 items and 7 sub-questions on admission criteria  
2 which were selected for this analysis (Appendix A) . In most questions the ‘general policy’ at  
3 each center was requested, which was defined as ‘routine policy’, i.e. what the standard  
4 treatment or policy would be in a particular case. In others, we asked for quantitative  
5 estimations, whereby the frequency of a treatment strategy could be indicated (never 0-10%,  
6 rarely 10-30%, sometimes 30-70%, frequently 70-90%, always 90-100%). The options  
7 ‘frequently’ and ‘always’ were interpreted as representing the general policy, in line with  
8 previous provider profiling studies.<sup>7</sup>

### 9 *Statistical analyses*

10 To identify possible factors that are associated with admission policy to the ICU, we  
11 compared admission policy between different ICU organizations: dedicated neuro- ICU  
12 present (yes/no); high or low volume (according to number of beds and according to number  
13 of patients admitted, ‘high’ designating all centers with a number of beds above the median  
14 and ‘low’ centers the centers with number of beds lower than the median); presence of step-  
15 down beds (yes/no); healthcare expenditure as % of Gross Domestic Product (GDP;  
16 dichotomized in relatively lower and higher % of expenditure); number of ICU beds per  
17 100,000 inhabitants (dichotomized to countries with relatively high vs low numbers of beds);  
18 and health expenditure ( countries with a higher % expenditure than the median being  
19 classified as relatively high and the others classified as relatively low). For analysis of the  
20 geographic location, countries were divided into Northern and Western Europe and Southern  
21 and Eastern Europe. Differences were tested with chi-square tests, and if appropriate Fisher’s  
22 exact test. This approach dichotomized hospitals based on admission of mild TBI patients to  
23 the ICU into those with a liberal admission policy, versus those with a more conservative  
24 policy. A liberal admission policy was defined as the admission of mild TBI patients to the  
25 ICU as ‘general policy’.

26 Analyses were performed using the Statistical Package for Social Sciences (SPSS) version  
27 21.

## 28 **Results**

### 29 *General characteristics*

30 Among the 68 eligible centers, 66 (97%) completed the questions regarding ICU admission  
31 policy. Sixty (91%) of these centers had an academic affiliation and 44 (67%) were  
32 designated as level I trauma centers. Experts that completed these questionnaires were  
33 primarily intensivists ( $n = 35$ , 53%) and neurosurgeons ( $n = 23$ , 35%) but also included  
34 administrative staff.

35 The median number of ICU beds was 33 ([interquartile range (IQR): 22-44], more than half of  
36 the centers had a dedicated neuro ICU ( $n=39$ , 59%) with a median admission rate of 92 (IQR  
37 52-160) TBI patients annually. The median number of all annual ICU admissions (across all  
38 diagnoses) in 2013 was 1214 (IQR 554-1950). TBI admissions therefore represented 7% (IQR  
39 5-8) of all admissions. The majority of these ICUs had a closed organization (the intensivist is

1 primarily responsible for the care of patients), with intensivists that are either physically  
2 present 24/7, or can reach the hospital within 30 minutes ( $n=63$ , 93%) (*Table 1*).

### 3 *Admission criteria*

4 Patients with severe TBI (GCS  $\leq 8$ ) would be admitted to the ICU as a general policy in 65  
5 (98%) of the 66 centers. One center would not admit a patient to the ICU based on GCS score  
6 alone, but a only after looking at the patient ‘as a whole’.

7 Moderate TBI patients with GCS of 9-12 and CT abnormalities would be admitted to the ICU  
8 as a general policy in 42 (63%) of the centers. The remainder stated that they would admit  
9 such patients to the ICU only in the presence of other risk factors. The risk factors were not  
10 explicitly indicated in the provider profiling questionnaire.

11 However, patients with initial GCS of 9-12 and no CT abnormalities would be admitted to the  
12 ICU as a general policy only in 17 centers (25%), and in another 43 centers (64%) only if  
13 other risk factors were present (*Figure 1*).

14 Fourteen centers (21%) would admit a mild TBI patient with initial GCS of 13 to 15 to the  
15 ICU with prior anticoagulant therapy. Another 53 centers (80%) would admit such a patient to  
16 the ICU routinely if there were additional risk factors present. Patients with mild TBI who  
17 also had either a small epidural hematoma (EDH) or acute subdural hematoma (ASDH) would  
18 be admitted to the ICU as a general policy in 15 (22%) centers. Fourteen (21%) centers would  
19 always admit a mild TBI patient to the ICU if he or she had contusional lesions present on the  
20 CT Scan. (figure 1)

21 Most centers ( $n=50$ , or 76%) indicated that they admit TBI patients postoperatively to the  
22 ICU as a general policy regardless of their GCS. 64 centers (97%) would admit such patients  
23 in the presence of other risk factors. Only 6 centers (9%) would admit a patient with mild TBI  
24 and concomitant extracranial injuries to the ICU if these, taken in isolation, would not  
25 necessitate ICU observation. This number increases to 60 (91%) if other risk factors were  
26 present.

### 27 *Characteristics of centers with a liberal admission policy*

28 The centers were dichotomized into two categories; those who had responded ‘general policy’  
29 to any of the questions regarding the admission of GCS 13-15 patients to the ICU ( $n=23$ ,  
30 34.9%) and those who did not ( $n=43$ , 65.1%). Number of ICU beds per 100 000 inhabitants  
31 and healthcare expenditure as % of GDP were not associated with a higher tendency to admit  
32 mild TBI patients to the ICU. These data, however, were not available for all 66 centers. The  
33 specialist deciding to transfer a TBI patient to the hospital did not influence a liberal or more  
34 conservative approach to patient admission either: when looking at intensivists versus other  
35 specialties or neurosurgeons, the majority ( $n=41$ ; 62%), versus other specialties (*Table 1*).

36 The only statistically significant difference between these two categories was the fact that  
37 ICUs that reported a more liberal admission policy for mild TBI were less likely to follow  
38 formal guidelines for severe TBI management ( $p = 0.05$ ). In absolute numbers, 22 centers of

1 the 55 (less than half, 40%) that follow severe TBI guidelines also have a liberal admission  
2 policy. Several other center characteristics were compared between these groups but we did  
3 not find any clear differences in internal organization of ICUs and hospital, the specialty that  
4 oversees patient care, or the geographical region where the center is located. (Table 1).

## 5 Discussion

6 Among the 66 centers that responded to our provider profiling questionnaire, mostly  
7 academic, level I trauma centers, about a third (n=23, 35%) reported that they always  
8 admitted mild TBI patients to the ICU in the presence of risk factors. Severe and moderate  
9 TBI patients are mostly admitted to the ICU as a general policy, especially in the presence of  
10 risk factors. Having a liberal admission policy regarding mild TBI patients did not correlate  
11 with other center characteristics except following TBI guidelines, suggesting that the  
12 variability is mainly caused by (random) variability of admission policies.

13 Higher-volume or specialized neuro-ICUs did not appear to be more likely to admit mild TBI  
14 patients. Unexpectedly, presence of a step-down unit from ICU did not have an impact in this  
15 regard either. This suggests that regardless of the resources available or of the organization,  
16 clinicians apply a more liberal or more conservative admission policy according to their  
17 personal preference, based on their knowledge and experience. This applies to the presence of  
18 step down beds as well, even though our questionnaire did not specifically aim to explore the  
19 exact processes of care with regards to the use of these beds and the admission policy  
20 surrounding them. Nonetheless, even in centers without step-down beds (n=18), 7 centers  
21 (39%) would still admit mild TBI patients to the ICU. Centers that follow severe TBI  
22 guidelines are less likely to have a liberal admission policy for mild TBI.

23 This apparent variation in policy has important implications for both research and processes  
24 of care, in two separate areas. ICU admission policy for TBI is ill-supported by high-quality  
25 evidence, and from a healthcare expenditure viewpoint, a day in the ICU can incur costs as  
26 high as 1597 euro<sup>8</sup>. Given that TBI costs are steeply on the rise<sup>9</sup>, avoiding ICU admissions  
27 for uncomplicated mild TBI might be a cost-efficient alternative to current policy. Further  
28 research is needed to establish whether this alternative is not associated with worse clinical  
29 outcomes.

30 The observed variation provides support for comparative effectiveness research and  
31 prognostic modelling, in order to predict neuro-worsening and pinpoint who would indeed  
32 benefit from more intensive monitoring. Scarce literature suggests that observation of isolated  
33 mild TBI patients on the ICU is seldom necessary<sup>2,3</sup>, but the evidence is of low quality.

34 Despite the ideal occupancy rate being estimated at 70-75% and higher occupancy rates being  
35 linked to more morbidity and mortality<sup>10</sup>, many ICUs, especially in academic and larger  
36 hospitals routinely operate at far higher occupancy rates<sup>11,12</sup>. As a result, high opportunity  
37 costs arise from admitting patients who may not require ICU level care.

38 Our study was underpowered to detect subtle associations. Another limitation is that 'risk  
39 factors' in the response 'when other risk factors are present' were not specified. In practice,

1 TBI is often associated with extra-cranial lesions (as major bleedings, chest injuries, spinal  
2 lesions, limb fractures etc.), other surgical or medical comorbidities, advanced age,  
3 mechanism of injury, duration of loss of consciousness, which may, in themselves, be an  
4 indication for ICU admission. Our questionnaire was not specifically designed to detect the  
5 interplay of these factors in the decision to admit a patient to the ICU. Also, given that the  
6 respondents were mostly academic centers and mild TBI is often seen in a non-academic  
7 setting, the generalizability of the data is limited. Further research is needed to establish best  
8 practice for both academic and non-academic settings.

9 The issue of cost-efficiency of liberal admission policy for patients with mild TBI to the ICU  
10 motivates further investigation to support organizational decision-making and policy making.  
11 Moreover, high-quality comparative studies and prognostic models to aid the clinicians in  
12 tailoring the admission policy to the needs of the individual patient are necessary.

### 13 **Conclusions**

14 There is considerable variation regarding the admission policy of (mild) TBI patients to the  
15 ICU in Europe. It is unclear if a liberal admission policy is beneficial for the patients and what  
16 the impact is on healthcare costs or whether there is a possible tendency to over-treat at play.  
17 Further investigation in this topic is needed, and includes, but is not limited to, on-going  
18 large-scale prospective studies, such as CENTER-TBI and TRACK-TBI.

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23 **Tables**

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25 Table 1

26

<b>Factor</b>	<b>Total (% of total respondents)</b>	<b>Centers admitting mild TBI to the ICU as a general policy (<i>n</i> = 23)</b>	<b>Centers not admitting mild TBI to the ICU as a general policy (<i>n</i></b>	<b><i>p</i>-value</b>
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				= 43)	
ICU Volume according to number of beds					.53
- High-volume	31 (47%)	12 (39%)	19 (61%)		
- Low-volume	35 (53%)	11 (31%)	24 (69%)		
ICU Volume according to number of patients admitted					.43
- High- volume	31 (47%)	13 (42%)	18 (58%)		
- Low- volume	31 (47%)	10 (32%)	21 (68%)		
Dedicated neuro ICU					.45
- Available	39 (59%)	15 (38%)	24 (62%)		
- Not available	27 (41%)	8 (30%)	19 (70%)		
Following any severe TBI treatment guidelines					.05
- Yes	55 (83%)	22 (40%)	33 (60%)		
- No	11 (16%)	1 (9%)	10 (91%)		
Having step down beds					.67
- Yes	48 (73%)	16 (33%)	32 (67%)		
- No	18 (27%)	7 (39%)	11 (61%)		

Discipline in charge of rounds				.72
- Neurosurgeons, Neurologists	16 (24%)	5 (31%)	11 (69%)	
- Intensivists, Anesthesiologists	50 (76 %)	18 (36%)	32 (64%)	
Geographic location*				.27
- North Western Europe	43 (65%)	17 (39%)	26 (61%)	
- South Eastern Europe	23 (35%)	6 (26%)	17 (74%)	
Number of ICU beds/100 000 inhabitants				1.0
- Relatively low number of beds	25 (47%)	9 (36%)	16 (64%)	
- Relatively high number of beds	28 (53%)	11 (39%)	17 (61%)	
Health expenditure as % of GDP				.59
- Relatively lower expenditure	25 (43%)	8 (32%)	17 (68%)	
- Relatively higher expenditure	33 (57%)	13 (39%)	20 (61%)	
Decision of transfer of TBI patients to the hospital made by intensivists				1.0
- Intensivists	8 (12%)	3 (37%)	5 (63%)	

- Other specialties	57 (88%)	13 (23%)	20 (77%)	
Decision of transfer of TBI patients to the hospital made by neurosurgeons				.11
- Neurosurgeons	41 (62%)	11 (27%)	30 (73%)	
- Other specialties	25 (38%)	12 (48%)	13 (52%)	
TBI patients always admitted to the same ICU				.28
- Yes	41 (62%)	12 (29%)	29 (71%)	
- No	25 (38%)	11 (44%)	14 (56%)	
TBI and polytrauma patients admitted to the same ICU				.25
- Yes	47 (71%)	14 (30%)	33 (70%)	
- No	19 (29%)	9 (47%)	10 (53%)	

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2 \* = The subdivision into geographic location was based on the classification by the United Nations.

3 Austria, Belgium, Denmark, Finland, France, Germany, Lithuania, the Netherlands, Norway, Sweden

4 and the United Kingdom (UK) were subsequently classified as countries from West and North Europe,

5 while all other countries were classified as countries from South and East Europe and Israel, in line

6 with our other publications on this matter

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**Legend to tables and figures**

Figure 1 –Indications for the admission of patients to the ICU among the interviewed centers (N=66). GCS= Glasgow Coma Scale; EDH=epidural hematoma; ASDH= acute subdural hematoma. Irrelevant in the decision to admit designates a criterion that does not influence the decision to admit someone to the ICU or not.

Table 1 –Association between factors that may influence admission policy and centers that have a liberal policy of ICU admission and those that do not.