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# **Blood glucose management in the critically ill: perception and clinical practice in the ICU**

Graduate thesis in Medicine

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## **Abstract**

### ***Background***

Contradictory findings from multiple studies on blood glucose management in the ICU and the absence of clear international guidelines leads to varying perceptions and clinical practice among clinicians.

### ***Objectives***

To assess clinical practice and perceptions regarding blood glucose management in a Norwegian ICU.

### ***Methods***

We performed a self-performed survey for doctors working in the main and thoracic ICU at St. Olavs University Hospital regarding their blood glucose management perceptions. We also collected blood glucose management data from ICU patients from the last year from our electronic health record system. Data were analysed with descriptive statistics.

### ***Results***

The response rate for the survey was 72.5%. Blood glucose threshold for what the clinicians regarded as “hypoglycaemia” and “hyperglycaemia” were, respectively,  $4.19 \pm 0.62$  mmol/L and  $9.60 \pm 1.68$  mmol/L. The mean blood glucose value for patients was  $7.66 \pm 2.23$  mmol/L. 62.07% of surveyed clinicians believed that 11-40% of patients had blood glucose values above 10.0 mmol/L compared to 51.54% patients in patient data, 68.97% believed 1-30% of patients had blood glucose values below 5.0 mmol/L compared to 53.92% in patient data, and 68.97% believed that 1-10% of patients had blood glucose values below 2.2 mmol/L compared to 1.39% in patient data. 76% of clinicians believed that patients were in range (5.0-10.0 mmol/L) 61-90% of their stay in the ICU, while time in range for the median patient was 91% of monitoring time.

### ***Conclusions***

Clinician perception regarding definition of hyperglycaemia concedes well with blood glucose target protocol of the unit, whilst clinician definition of hypoglycaemia is lower than blood glucose target protocol. Clinicians in our survey underestimates the number of patients with blood glucose values above 10.0 mmol/L and below 5.0 mmol/L, but give good estimates for patients with values below 2.2 mmol/L. The findings from our study coincide with the findings of previous similar studies of clinician's perceptions, which might contradict the use of clinician's perceptions as the basis for further research and quality improvement

measures. Further studies on this subject, including nurse's perceptions and multiple centres is needed.

## Introduction

The publication of the Leuven-1 study in 2001<sup>1</sup> provided a change in the understanding of blood glucose management in critically ill patients, with the suggested causal association between hyperglycaemia and mortality. This led to many following RCTs with mixed findings regarding tight glycaemic control and mortality in ICUs<sup>2-5</sup> and in acute myocardial infarction<sup>6-8</sup>. The differences in results from these studies has led to a general uncertainty and controversy regarding blood glucose management in the ICU, although a systematic review by Mesotten et al states a general consensus that excessive hyperglycaemia (>10.0 mmol/L) and severe hypoglycaemia (<2.2 mmol/L) should be avoided in critically ill adults<sup>9</sup>. The discrepancies between the RCTs combined with the absence of a clear international guideline on blood glucose target leads to varying practice patterns and perceptions regarding blood glucose management among clinicians. There have been several studies regarding clinician practice habits and attitudes towards glycaemic control<sup>10-17</sup>. Most of these studies looked only at stated practice habits and attitudes in their studies, although Hirshberg et al compared their survey results to patient data from literature. The results from these studies are contradictory, as McMullin et al found no significant difference between different centres whereas Preissig et al, both studies by Hirshberg et al and Schultz et al found great variance in blood glucose management<sup>10,12,14-17</sup>. These studies also have limitations as they only surveyed the stated practice and did not determine if this truly represented the actual practice habits of the clinicians. Both studies by Hirshberg et al found that clinicians underestimated the frequency of hypoglycaemia and hyperglycaemia when compared to frequencies found in other literature<sup>12,17</sup>. An interesting finding from comparison of the two Hirshberg et al studies showed that variance in blood glucose management increased from the first to the second study<sup>17</sup>, possibly a sign of increased uncertainty after the mixed findings from RCTs following the Leuven-1 study.

A combined practice survey and inception cohort study was done by Mitchell et al in Australian and New Zealand ICUs<sup>11</sup>. The practice survey showed differences in the stated adoption of tight glycaemic control between centres, where 10% stated that they had adopted tight glycaemic control, but the cohort study showed that there was little difference in actual glucose management between centres with different stated practices. Another study by Brunkhorst et al determined both perceived and actual adherence to recommended interventions in sepsis treatment, which included glycaemic control<sup>13</sup>. This study showed that perceived adherence was higher than actual patient data showed adherence to be, with a

perceived adherence of 65.9% and only 6.2% of patients euglycaemic. All these studies that combined perceived practice with actual adherence show a mismatch between actual delivered care and the clinician's perception of care, which raises concern about results obtained from observational and perception studies that lack the ability to verify that stated adherence correlates with actual adherence. Limitations to many of these studies, including both the study of Mitchell et al and Brunkhorst et al, is that they were published before the important NICE-SUGAR study of 2009 and other RCTs, which it would be reasonable to assume changed both local guidelines for glycaemic control and the perceptions of clinicians on this subject.

As the studies above indicate the routines for glycaemic control vary from one hospital to another and the actual adherence to blood glucose management guidelines is lower than stated adherence. The purpose of this study is to uncover if the intensive care unit's glycaemic control protocol is executed as planned and how trustworthy clinician's perceptions and opinions regarding glycaemic control is when there is no regular audit. Without regular audit of the unit's glycaemic control there is no way to be sure if actual clinical practice is in line with the unit's protocol on glycaemic control, and will therefore also have no baseline for quality improvement. This study aims to establish a data baseline for possible quality improvement on glycaemic control in intensive care units.

To our knowledge there is not published any studies regarding the perceptions and clinical practices related to glycaemic control in Norwegian intensive care units in later years.

Geographical differences in the clinical practice of glycaemic control cannot be excluded since Norwegian intensive care units in general is significantly more manned than foreign intensive care units<sup>18</sup>. This means that the application of foreign studies might have a limited value. As the NICE-SUGAR-study was published as late as 2009, and is thought to have influenced how clinicians relate to glycaemic control, giving older studies limited application today. This means that there is need for a new study on Norwegian practice to assess clinical practice and perceptions regarding glycaemic control in intensive care units.

## **Methods**

### ***Study population***

We conducted a survey to ascertain the perceptions and practice habits concerning glycaemic control in the main and thoracic intensive care unit at St. Olav University Hospital, Norway. Protocol for blood glucose management at these ICUs states a target blood glucose range between 5-10 mmol/L.

### ***Administration of survey***

The link for the electronic survey was sent by e-mail to 40 doctors working daily hours and/or on-call in the main and thoracic intensive care unit. The survey was active from 29.09-28.11.2016. Participation was voluntary, data were anonymous and all responses were kept confidential.

### ***Development of survey***

The survey comprised a 14-point questionnaire and can be found in Appendix. The questionnaire surveyed four different aspects of blood glucose management: hyperglycaemia, hypoglycaemia, therapeutic interventions and time-in-range in addition to demographic participant information. The questions were developed based on the questions from the Hirshberg et al survey of 2013<sup>17</sup>. The questions were altered, and some deleted, to reflect and better capture the clinical environment of the ICUs involved in the study. To increase validity of self-reported information, increase the number of respondents included in the study and to save time we used a self-administered survey rather than interviewer-administered.

### ***Patient data***

Patient data was collected in retrospect from the electronic health record system used at the ICUs, PICIS, for one year in the period September 1<sup>st</sup> 2015 to August 31<sup>st</sup> 2016 from all patients and glucose values in the main ICU. This data included 30.550 unique glucose values from 650 patients.

### ***Ethics***

The study was presented for Regional-Etisk Komité (REK), Norway (ID 2016/400). However, the committee regarded the project not to need an ethical approval according to Norwegian regulations, as they considered it to be a quality insurance project.

### ***Analysis***

The glucose values were manually inspected for input-errors (manually typing in the PICIS journal) and outliers, and obvious mistakes were corrected. After corrections, eight values above 50 mmol/L were removed from the data-set, as they were expected to be a result of

typing mistakes and affected the overall statistics. We report means and standard deviation (SD), and median and interquartile ranges (IQR) where appropriate. Normality was determined for each variable by Q-Q-plots and Shapiro-Wilk Test. We performed t-tests to compare parametric continuous variables and Wilcoxon Test for non-parametric. One-way ANOVA was used to test for differences in responses between groups in parametric variables and Kruskal Wallis test for non-parametric variables. A p-value of  $<0.05$  was considered significant. Analysis was performed using SPSS version 24.0 and Microsoft Excel Spreadsheet.

## Results

### *Clinical survey*

29 of 40 doctors responded (72,5%), of the respondents 6 (20,7%) worked daily hours in the main ICU, 6 (20,7%) worked daily hours in the thoracic ICU and 17 (58,6%) were doctors regularly on-call at the main ICU, but no daily hours. In general, the doctors working daily hours at the main ICU had worked longer in intensive care, followed by daily hours at the thoracic ICU and lastly the doctors only on-call at the main ICU. Full list of characteristics can be found in table 1.

**Respondent characteristics**

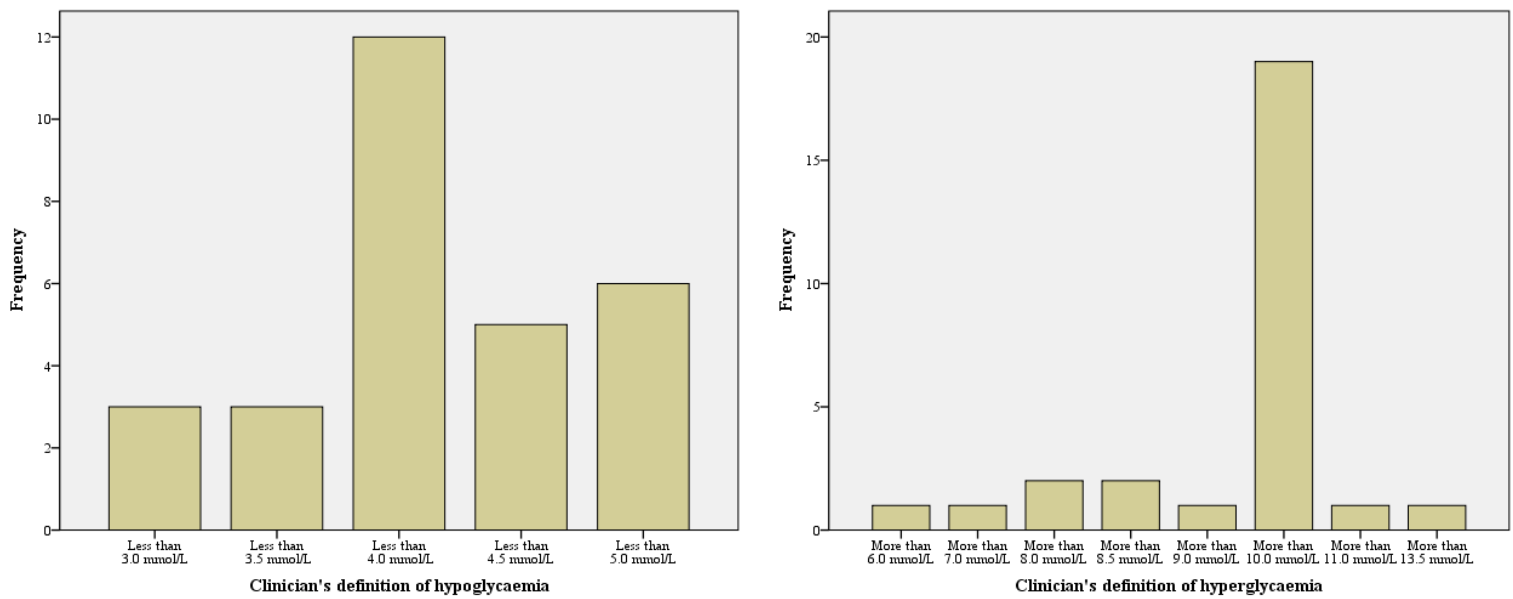
TITLE		Time in intensive care		Time in surveyed ICU	
		Frequency	Percent	Frequency	Percent
Full-time employment at main ICU	4-6 years	1	16,7	0	0
	7-10 years	1	16,7	2	33,3
	More than 15 years	4	66,7	4	66,7
	Total	6	100,0	6	100,0
Full-time employment at thoracic ICU	1-3 years	1	16,7	1	16,7
	7-10 years	2	33,3	2	33,3
	11-15 years	2	33,3	2	33,3
	More than 15 years	1	16,7	1	16,7
	Total	6	100,0	6	100,0
Doctors with regular shift-work at main ICU	Less than 1 year	0	0	1	5,9
	1-3 years	2	11,8	7	41,2
	4-6 years	9	52,9	7	41,2
	7-10 years	6	35,3	2	11,8
	Total	17	100,0	17	100,0

**Table 1**

Respondent characteristics for the questionnaire on clinician's perception on blood glucose management in the ICU

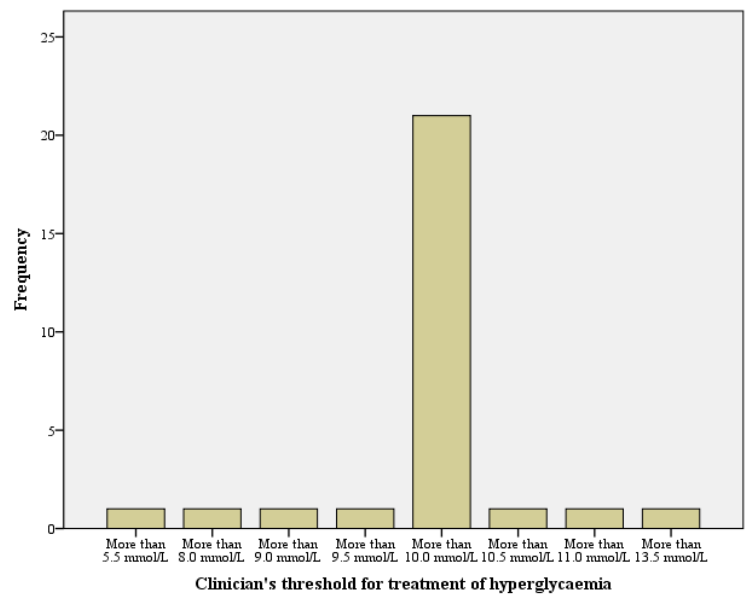
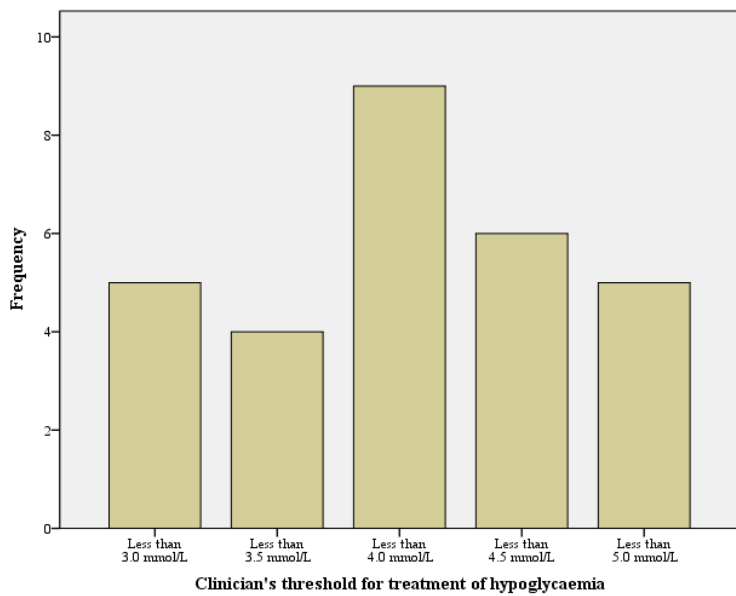
The clinicians were asked to define the threshold value for hypo- and hyperglycaemia. Among clinicians the mean value for definition of hypoglycaemia was  $4.19 \pm 0.62$  mmol/L (median 4.00 mmol/L and IQR 0.63), and the mean value for definition of hyperglycaemia was  $9.60 \pm 1.38$  mmol/L (median 10.00 mmol/L and IQR 1.13). The definition values for hypo- and hyperglycaemia can be seen in figure 1.





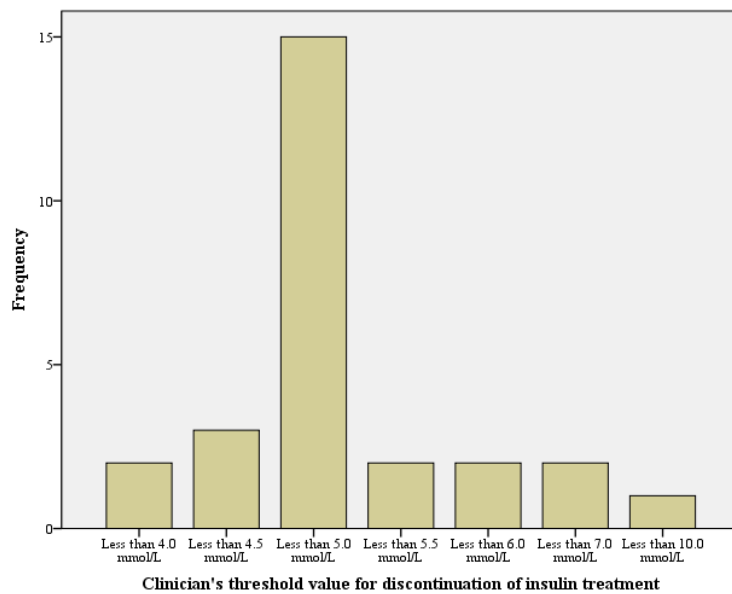
**Figure 1**  
Answers from questionnaire regarding clinician's defining value for hypoglycaemia and hyperglycaemia

The clinicians were also asked at which value they would initiate treatment to prevent hypoglycaemia and hyperglycaemia. The mean value that prompted treatment for hypoglycaemia was  $4.06 \pm 0.70$  mmol/L (median 4.00 mmol/L and IQR 1.00), while the mean value for treatment of hyperglycaemia  $9.90 \pm 1.22$  mmol/L (median 10.0 mmol/L and IQR 0.00). All values can be seen in figure 2. There was no significant difference between clinician's threshold value for hyperglycaemia and the threshold value for initiation of therapy to treat hyperglycaemia ( $p=0.33$ ), likewise regarding hypoglycaemia ( $p=0.30$ ). The clinicians were also asked at which value they would stop treatment of hyperglycaemia with insulin to avoid hypoglycaemia. The mean threshold value for discontinuation of insulin was  $5.33 \pm 1.19$  mmol/L (median 5.00 and IQR 0.50). All values shown in figure 3.



**Figure 2**

Answers from questionnaire regarding clinician's threshold value for initiating treatment for hypoglycaemia and hyperglycaemia

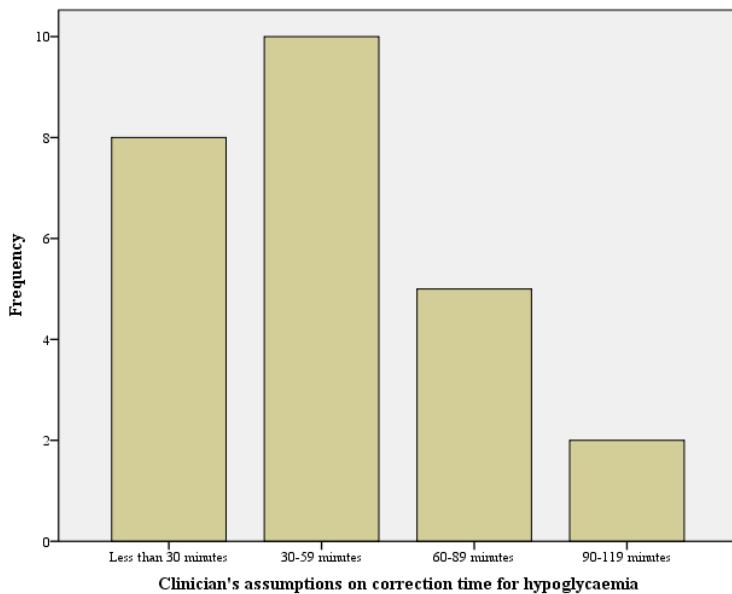


**Figure 3**

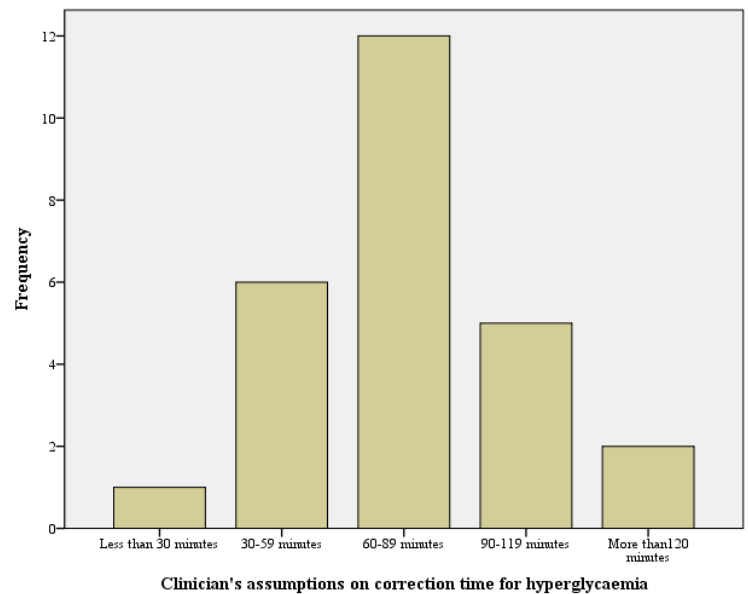
Answers from questionnaire regarding clinician's threshold value for discontinuation of insulin treatment to avoid hypoglycaemia

Compared to the target range of blood glucose values in the blood glucose management protocol (5.0-10.0 mmol/L), there was no statistical difference between clinician's definition of hyperglycaemia and definition for therapy initiation for hyperglycaemia, and the upper defining value in the protocol (p=123 and 611). There was however a statistical significant difference between clinician definition regarding hypoglycaemia and therapy initiation for hypoglycaemia, and the lower defining value in the protocol (p<0.0005).

The clinicians were also asked to give an assumption of the amount of time from the first hyperglycaemic value (>10.0 mmol/L) to the first non-hyperglycaemic value (<10.0 mmol/L) and also the amount of time from a hypoglycaemic value (<5.0 mmol/L) to the first non-hypoglycaemic value (>5.0 mmol/L), defined in this study as correction time. Most, 12 (41.38%), of the clinicians assumed that it would take between 60-89 minutes from a hyperglycaemic value (>10.0 mmol/L) to the first non-hyperglycaemic value (<10.0 mmol/L). 18 (62.07%) clinicians assumed that it would take less than 60 minutes from a hypoglycaemic value (<5.0 mmol/L) to the first non-hypoglycaemic value (>5.0 mmol/L). A full overview of answers can be found in figures 4-5.



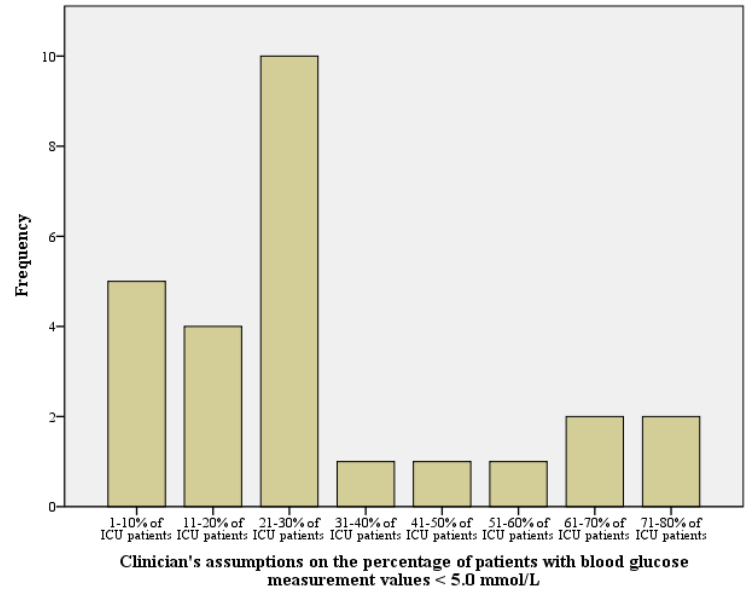
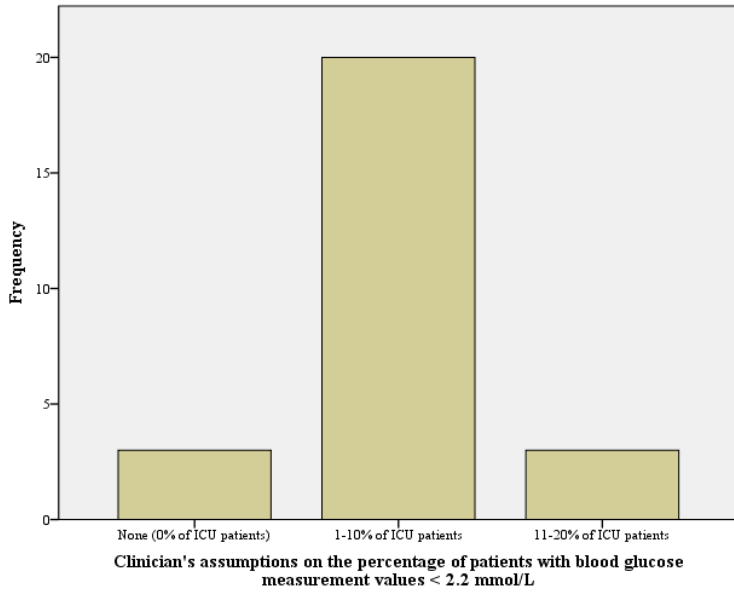
**Figure 5**  
Answers from questionnaire regarding clinician's assumption on time from first hypoglycaemic measurement to first non-hypoglycaemic measurement, correction time



**Figure 5**  
Answers from questionnaire regarding clinician's assumption on time from first hyperglycaemic measurement to first non-hyperglycaemic measurement, correction time

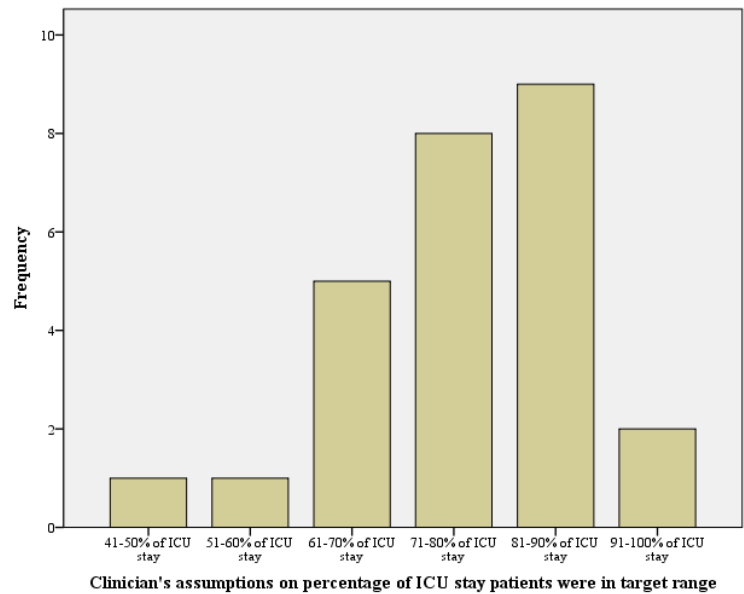
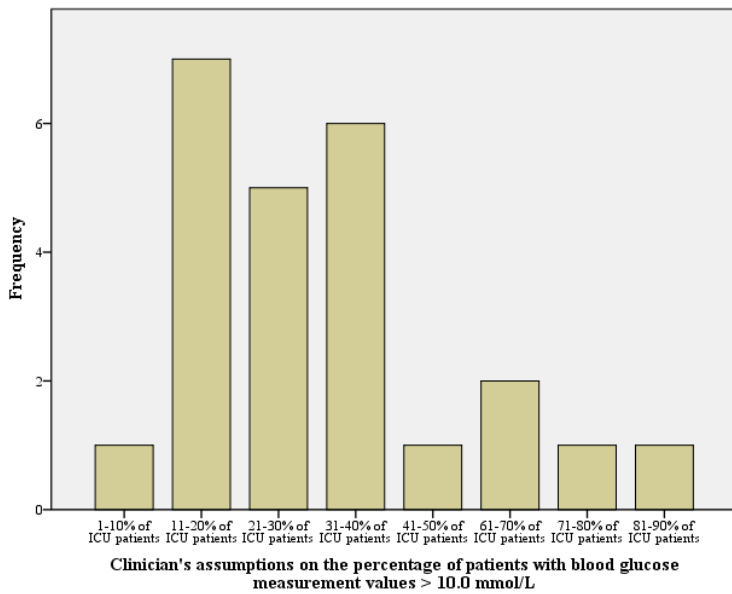
Clinicians were asked to give an assumption on the percentage of patients with at least one blood glucose value value above 10.0 mmol/L (hyperglycaemia) and below 5.0 mmol/L (mild/moderate hypoglycaemia) and 2.2 mmol/L (severe hypoglycaemia) during their ICU stay. 18 (62.07%) clinicians assumed that between 11-40% of patients had at least one blood glucose value above 10.0 mmol/L during their ICU stay. 20 (68.97%) clinicians assumed that between 1-30% of patients had at least blood glucose value below 5.0 mmol/L. 20 (68.97%) clinicians assumed that between 1-10% of patients had at least one blood glucose value below 2.2 mmol/L. The clinicians were also asked to give an estimate on the percentage of time during their ICU stay a patient had blood glucose values in the target range (5.0-10.0 mmol/L), where 22 (75.86%) of the respondents believed patients were euglycaemic 61-90% of their ICU stay. Overview is presented in figures 6-7.

Doctors working daily hours at the main ICU assumed that a higher percentage of patients had values below 2.2 mmol/L than doctors working daily hours at the thoracic ICU ( $p=0.017$ ). Doctors with more than 15 years of experience in intensive care medicine had a generally higher threshold value for discontinuation of insulin than doctors with 1-10 years of experience in intensive care medicine ( $p=0.050$ ), in the groups 1-3 years (mean dif.=2.76 mmol/L), 4-6 years (mean dif.=2.55 mmol/L) and 7-10 years (mean dif.=2.50 mmol/L) of experience in intensive care medicine.



**Figure 7**

Answers from questionnaire regarding clinician's assumptions on the percentage of patients with one or more blood glucose measurements <2.2 mmol/L and <5.0 mmol/L during their ICU stay

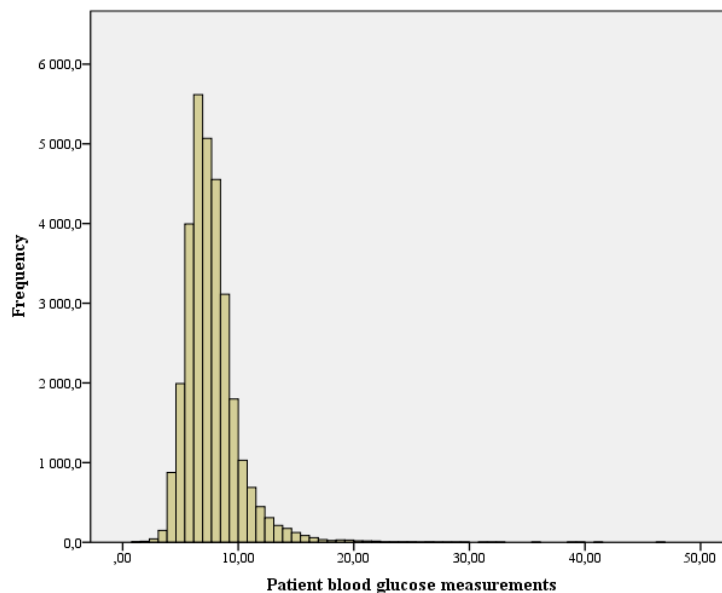


**Figure 7**

Answers from questionnaire regarding clinician's assumptions on percentage of patients with one or more blood glucose measurements >10.0 mmol/L and the assumptions on the percentage of time spent in blood glucose target range (5.0-10.0 mmol/L) during their ICU stay

### ***Patient data***

The median value for all recorded blood glucose values was 7.30 mmol/L (IQR 4.9-9.7 mmol/L), see figure 8 for full overview. 136 (20.92%) patients only had blood glucose values in the target range, 5.0-10.0 mmol/L, during their stay in the ICU. Time in range was calculated as AUC in the range of 5.0-10.0 mmol/L, giving a time in range of 91% for the median patient. Percentage of total time spent <5.0 mmol/L was 4.4% and time spent >10.0 mmol/L was 8.1%. The mean monitoring time, defined as time from first blood glucose measurement to last blood glucose measurement per patient, for all patients was 3 days, while the mean monitoring time for patients with >1 blood glucose measurement <5.0 mmol/L was 4.2 days and 5.8 days for patients with >1 blood glucose measurement >10.0 mmol/L.



**Figure 8**  
Overview over all patient blood glucose measurements

Of the 650 patients included, 335 (51.54%) had a recorded blood glucose value above 10.0 mmol/L at least once during their ICU stay, recorded in a total of 3 327 (10.89%) blood glucose values above 10.0 mmol/L. 24% of patient days had 1 or more blood glucose values >10.0 mmol/L, whilst 7% of patient days had a mean blood glucose value >10.0 mmol/L. Insulin was given at least once during their stay to 183 (54.63%) patients with one or more blood glucose values above 10.0 mmol/L.

351 (53.92%) patients had a blood glucose value below 5.0 mmol/L, recorded in a total of 1 730 (5.66%) blood glucose values, and nine (1.39%) patients had a recorded blood glucose value below 2.2 mmol/L, recorded in a total of 13 (.04%) blood glucose values, at least once

during their ICU stay. 16% of patient days had 1 or more values  $<5.0$  mmol/L and 3% of patient days had a mean  $<5.0$  mmol/L. 130 (37.04%) of patients with a recorded blood glucose value below 5.0 mmol/L and seven (77.78%) of patients with a recorded blood glucose value below 2.2 mmol/L was given insulin at least once during their ICU stay. A hypoglycaemic or hyperglycaemic episode is defined as two or more blood glucose measurements  $<5.0$  mmol/L or  $>10.0$  mmol/L, and correction time is defined as time from the first hypoglycaemic or hyperglycaemic blood glucose measurement to the first euglycaemic blood glucose measurement (5.0-10.0 mmol/L). The mean time interval between two blood glucose measurements after a hypoglycaemic blood glucose measurement ( $<5.0$  mmol/L) was 142 minutes. The mean time for a hypoglycaemic episode to be corrected was  $255 \pm 458$  minutes (4 hours 15 minutes) and the mean estimated duration of a hypoglycaemic episode was  $214 \pm 393$  minutes (3 hours 34 minutes). The mean time for a hyperglycaemic episode to be corrected was  $503 \pm 646$  minutes (8 hours 23 minutes) and the mean estimated duration of a hyperglycaemic episode was  $452 \pm 632$  minutes (7 hours 32 minutes).

### ***Comparison of survey and patient data***

As presented earlier, 62.07% of surveyed clinicians believed that 11-40% of patients had at least one blood glucose value above 10.0 mmol/L during their ICU stay, giving a range of 71-260 patients when combined to the total number of patients (650), while findings from patient data showed that 335 (51.54%) of patients had at least one blood glucose value above 10.0 mmol/L during their ICU stay. 68.97% of clinicians believed that 1-30% of patients had at least one blood glucose value below 5.0 mmol/L, giving a range of 6-195 patients, while patient data showed 351 (53.92%) patients. 68.97% of clinicians believed that 1-10% of patients had at least one blood glucose value below 2.2 mmol/L, giving a range of 6-65 patients, while patient data showed that 9 (1.39%) patients. Analysis comparing the results from the questionnaire to the patient data showed that there was a significant difference between clinician's perception and actual patient data for assumptions of patients  $>10.0$  mmol/L ( $p<0.001$ ),  $<5.0$  mmol/L ( $p<0.0005$ ) and  $<2.2$  mmol/L ( $p<0.0005$ ), with clinicians underestimating the percentage of patients with blood glucose values above 10.0 mmol/L and below 5.0 mmol/L, while overestimating the percentage of patients with blood glucose values below 2.2 mmol/L.

The patient data showed that time in range was 91% of total monitoring time, whilst most clinicians (76%) believed patients were in target range 61-90% of their ICU stay, representing a significant difference ( $p<0.0005$ ) between the median of questionnaire answers and the

patient data. Comparative analysis of the results from the questionnaire and mean correction time show a significant gap in clinician's perceptions and actual patient data for both correction of hypoglycaemia ( $p < 0.0005$ ) and hyperglycaemia ( $p < 0.0005$ ), showing that clinicians underestimate the time of correction with a mean difference of 209 minutes for hypoglycaemia and 427 minutes for hyperglycaemia.



## Discussion

Clinician's definition of hyperglycaemia corresponded well with the upper value of the blood glucose target range in the blood glucose management protocol of the respective ICUs (10 mmol/L) with a mean of  $9.60 \pm 1.38$  mmol/L, indicating a consensus on threshold value for hyperglycaemia in this ICU. This is also consistent with recommendations made by Messotten et al.<sup>9</sup> that excessive hyperglycaemia ( $> 10.0$  mmol/L) should be avoided in critically ill patients. Clinician's threshold value for hypoglycaemia was lower than the lower value of the blood glucose target range in the blood glucose management protocol (5.0 mmol/L) with a mean of  $4.19 \pm 0.62$  mmol/L.

Of all patient blood glucose values, 83% (n=25 493) were in the target range for blood glucose (5.0-10.0 mmol/L) and time in range for all patients were 91% of total monitoring time, but only 21% (n=136) of patients only had values in the target range. These numbers suggest that while patients mostly were euglycaemic, 79% of patients had blood glucose values outside the target range, suggesting that values outside the target range is common in this ICU, which might indicate a lack in the blood glucose management.

Results showed that clinicians underestimated the percentage of patients with blood glucose values above 10.0 mmol/L and below 5.0 mmol/L, consistent with the findings of previous studies, showing that clinicians underestimate the number of patients with blood glucose values outside what is considered the target range in intensive care<sup>11-13</sup>. The reasons for this are better evaluated with in-depth interviews, but the explanation might be due to lack of information transfer from studies on the subject and uncertainty regarding glycaemic control, as also noted in previous studies<sup>11-13</sup>. Another finding was that clinicians overestimated the percentage of patients with blood glucose values below 2.2 mmol/L, but this finding is less meaningful as the number of patients with these values were so low that small changes in clinician assumptions gave great deviations in the results, with 69% of clinicians believing that 1-10% of patients had blood glucose values  $<2.2$  mmol/L, corresponding well with actual patient data. This indicates that clinicians have a better insight regarding severe hypoglycaemia ( $<2.2$  mmol/L) than moderate hypoglycaemia ( $<5.0$  mmol/L).

Approximately half of the patients (45.37%) with blood glucose values  $>10.0$  mmol/L did not receive any insulin during their ICU stay, suggesting that blood glucose management protocol was irregularly followed by ICU staff. This adds to the notion of uncertainty and lack of information transfer from relevant studies in regards to blood glucose management in the ICU, in addition to clinician's underestimation of hypo- and hyperglycaemia. Results also

showed that clinicians underestimate the correction time for both hypoglycaemic and hyperglycaemic episodes with 209 minutes and 427 minute's difference respectively. The big difference in clinician perception of correction time and findings from patient data might partly be caused by the delay between time of intervention and time to normalisation of blood glucose and the amount of time between blood glucose measurements, but as the difference is so great, especially for hyperglycaemia, these factors likely only contribute and not fully explain the difference.

As to the quality of blood glucose management in this ICU, our findings suggest that while the patient's time in range is high (91%), the time from blood glucose measurements outside the target range, both high and low, to correction is quite long. Though there are mixed findings from RCTs regarding tight glycaemic control, there is consensus for moderate glycaemic control with recommended avoidance of values  $<2.2$  mmol/L and  $>10.0$  mmol/L<sup>9</sup> and Krinsley et al found that mild hypoglycaemia ( $<4.0$  mmol/L) increased length of ICU stay. Data from our study also incline increased length of stay for patients with 1 or more blood glucose measurements  $<5.0$  mmol/L and 1 or more blood glucose measurements  $>10.0$  mmol/L compared to the median monitoring time of all patients, 3 days compared to 4.2 days and 5.8 days respectively. Although our measurement of monitoring time, defined as the time from the first to the last blood glucose measurement, is not the exact same measure as length of stay it is likely that it corresponds well with length of stay. A recent study by Saliba et al showed that iatrogenic and spontaneous hypoglycaemia carried the same risk for hospital mortality, indicating that hypoglycaemia is an independent risk factor and not only an marker of illness severity<sup>19</sup>. With this in mind, and with a moderate blood glucose management protocol, as seen in this ICU, we recommend that the amount of blood glucose measurements outside the target range and the time to correction of hypoglycaemic and hyperglycaemic episodes should be reduced.

This study and its findings may serve as an environmental scan with information on the current state of practice and perceptions for future quality control on glycaemic control in the ICU. Appropriate next steps for quality improvement would be to create a data collection system to collect baseline data and a data reporting system to inform the ICU team, before introducing strategies to change behaviour towards the desired change in clinical practice<sup>20</sup>. As mentioned previously, values  $>50.0$  mmol/L were removed from the dataset as they were assessed to be data entry errors, which is a source of error in clinical practice and all studies blood glucose management due to human typing of blood glucose measurements into data systems<sup>21</sup>, and must therefore be kept in mind. We cannot exclude any data entry errors  $<50.0$

mmol/L, but this is at the current time a source of error that must be accepted. The exclusion of these eight values will affect the time dependent analyses, giving a falsely longer duration between measurements e.g., but as the number of excluded values are small and the total number of measurements are great this effect is considered to not be significant.

There were several limitations to this study. The first was that nurses were not included in the survey, although the ICU nurses were approached and welcome to answer the questionnaire, they did not join as it was believed that nurses followed the doctor's orders and the blood glucose management protocol and an audit was therefore not needed. Nurses are key in the day to day clinical execution of blood glucose management protocols and are closest to the patients, suggesting a better understanding of the clinical situation than doctors, and therefore any future study should include nurses. Second, questionnaire was not properly designed, resulting in problems when doing correlation testing to patient data. Third, only patient data from the main ICU was collected, whilst questionnaire was collected from doctors from both the main and thoracic ICU. This might affect reliability of our findings if the patient data from the thoracic ICU differ greatly from the patient data from the main ICU. Finally, we only included one ICU in our study which may limit the application of this study to other ICUs, with regards to geographical and centre-specific differences e.g. the higher number of nurses per patients in Norwegian ICUs<sup>18</sup>.

In summary, clinician perception regarding definition of hyperglycaemia concedes well with blood glucose target protocol of the unit, whilst clinician definition of hypoglycaemia is lower than blood glucose target protocol. Clinicians in our survey underestimates the number of patients with blood glucose values above 10.0 mmol/L and below 5.0 mmol/L, but give good estimates for patients with values below 2.2 mmol/L. The findings from our study coincide with the findings of previous similar studies of clinician's perceptions, which might contradict the use of clinician's perceptions as the basis for further research and quality improvement measures. Further studies on this subject, including nurse's perceptions and multiple centres is needed.

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# Spørreundersøkelse om blodsukkerkontroll ved intensivavdelingen St. Olav

Denne undersøkelsen tar 7 minutter å besvare. Du er helt anonym og svarene behandles konfidensielt.

Undersøkelsen er en del av medisinstudent ved NTNU, Hanne Bø, sin hovedoppgave. Veileder er overlege Nils Kristian Skjærvold ved St. Olavs Hospital.

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Denne spørreundersøkelsen er en del av en hovedoppgave på profesjonsstudiet i medisin. Målet er å få bedre forståelse av klinisk praksis og oppfatninger hos ansatte vedrørende blodsukkerkontroll ved intensivavdelingen på St. Olav. Oppgaven ønsker å danne et datagrunnlag som kan brukes ved behov for eventuell kvalitetsforbedring innen blodsukkerkontroll ved intensivavdelinger.

Vi ønsker at du svarer basert på din egen oppfatning. Det er ansattes oppfatninger vi ønsker å kartlegge med spørreundersøkelsen, vi vet allerede hva som er gjeldende prosedyre ved avdelingen. Dette er ikke en test på hvor godt man kjenner til avdelingens prosedyrer og vi ser etter svarmønstre i ulike grupper, ikke enkeltpersoner. Der spørsmålene ber deg om å angi prosentandelen av pasienter med en gitt hendelse ber vi deg om å gi et anslag for gjennomsnittspasienten de siste 12 mnd.

\*Må fylles ut

### 1. 1. Hvilket blodsukkernivå vil du, etter din egen mening, bruke for å definere grensen for hyperglykemi hos intensivpasienter? \*

Markér bare én oval.

- Over 4.5 mmol/L
- Over 5.0 mmol/L
- Over 5.5 mmol/L
- Over 6.0 mmol/L
- Over 6.5 mmol/L
- Over 7.0 mmol/L
- Over 7.5 mmol/L
- Over 8.0 mmol/L
- Over 8.5 mmol/L
- Over 9.0 mmol/L
- Over 9.5 mmol/L
- Over 10.0 mmol/L
- Over 10.5 mmol/L
- Over 11.0 mmol/L
- Over 13.5 mmol/L
- Over 16.5 mmol/L
- Ikke et definert nivå

**2. 2. Dersom det var opp til deg, ved hvilket blodsukkernivå er det riktig å starte insulinterapi for å behandle hyperglykemi hos intensivpasienter? \***

*Markér bare én oval.*

- Over 4.5 mmol/L
- Over 5.0 mmol/L
- Over 5.5 mmol/L
- Over 6.0 mmol/L
- Over 6.5 mmol/L
- Over 7.0 mmol/L
- Over 7.5 mmol/L
- Over 8.0 mmol/L
- Over 8.5 mmol/L
- Over 9.0 mmol/L
- Over 9.5 mmol/L
- Over 10.0 mmol/L
- Over 10.5 mmol/L
- Over 11.0 mmol/L
- Over 13.5 mmol/L
- Over 16.5 mmol/L
- Ikke et definert nivå

**3. 3.Hvor mange prosent vil du anslå har hatt en eller flere blodsukkermålinger over 10.0 mmol/L? \***

*Gjør et anslag basert på gjennomsnittspasienten på din intensivavdeling de siste 12 månedene  
Markér bare én oval.*

- Ingen (0% av intensivpasientene)
- 1-10% av intensivpasientene
- 11-20% av intensivpasientene
- 21-30% av intensivpasientene
- 31-40% av intensivpasientene
- 41-50% av intensivpasientene
- 51-60% av intensivpasientene
- 61-70% av intensivpasientene
- 71-80% av intensivpasientene
- 81-90% av intensivpasientene
- 91-100% av intensivpasientene
- Jeg vet ikke

**4. 4. Hvilket blodsukkernivå vil du, etter din egen mening, bruke for å definere grensen for hypoglykemi hos intensivpasienter? \***

*Markér bare én oval.*

- Mindre enn 1.0 mmol/L
- Mindre enn 1.5 mmol/L
- Mindre enn 2.0 mmol/L
- Mindre enn 2.5 mmol/L
- Mindre enn 3.0 mmol/L
- Mindre enn 3.5 mmol/L
- Mindre enn 4.0 mmol/L
- Mindre enn 4.5 mmol/L
- Mindre enn 5.0 mmol/L
- Ikke et definert nivå

**5. 5. Dersom det var opp til deg, ved hvilket blodsukkernivå er det riktig å starte intravenøs dextrose (glukose) for å behandle hypoglykemi hos intensivpasienter? \***

*Markér bare én oval.*

- Mindre enn 1.0 mmol/L
- Mindre enn 1.5 mmol/L
- Mindre enn 2.0 mmol/L
- Mindre enn 2.5 mmol/L
- Mindre enn 3.0 mmol/L
- Mindre enn 3.5 mmol/L
- Mindre enn 4.0 mmol/L
- Mindre enn 4.5 mmol/L
- Mindre enn 5.0 mmol/L
- Jeg gir glukose kun dersom pasienten er symptomatisk
- Ikke et definert nivå



**6. 6. Hvor mange prosent vil du anslå har hatt en eller flere blodsuktermålinger under 2.2 mmol/L? \***

Gjør et anslag basert på gjennomsnittspasienten på din intensivavdeling de siste 12 månedene  
*Markér bare én oval.*

- Ingen (0% av intensivpasientene)
- 1-10% av intensivpasientene
- 11-20% av intensivpasientene
- 21-30% av intensivpasientene
- 31-40% av intensivpasientene
- 41-50% av intensivpasientene
- 51-60% av intensivpasientene
- 61-70% av intensivpasientene
- 71-80% av intensivpasientene
- 81-90% av intensivpasientene
- 91-100% av intensivpasientene
- Jeg vet ikke

**7. 7. Hvor mange prosent vil du anslå har hatt en eller flere blodsuktermålinger under 5.0 mmol/L? \***

Gjør et anslag basert på gjennomsnittspasienten på din intensivavdeling de siste 12 månedene  
*Markér bare én oval.*

- Ingen (0% av intensivpasientene)
- 1-10% av intensivpasientene
- 11-20% av intensivpasientene
- 21-30% av intensivpasientene
- 31-40% av intensivpasientene
- 41-50% av intensivpasientene
- 51-60% av intensivpasientene
- 61-70% av intensivpasientene
- 71-80% av intensivpasientene
- 81-90% av intensivpasientene
- 91-100% av intensivpasientene
- Jeg vet ikke

**8. 8. Dersom det var opp til deg, ved hvilket blodsukternivå mener du det er riktig å stanse insulinterapi for å unngå hypoglykemi hos intensivpasienter? \***

*Markér bare én oval.*

- Mindre enn 2.0 mmol/L
- Mindre enn 2.5 mmol/L
- Mindre enn 3.0 mmol/L
- Mindre enn 3.5 mmol/L
- Mindre enn 4.0 mmol/L
- Mindre enn 4.5 mmol/L
- Mindre enn 5.0 mmol/L
- Mindre enn 5.5 mmol/L
- Mindre enn 6.0 mmol/L
- Mindre enn 6.5 mmol/L
- Mindre enn 7.0 mmol/L
- Mindre enn 7.5 mmol/L
- Mindre enn 8.0 mmol/L
- Mindre enn 8.5 mmol/L
- Mindre enn 9.0 mmol/L
- Mindre enn 9.5 mmol/L
- Mindre enn 10.0 mmol/L
- Ikke et definert nivå

**9. 9. Hvor stor andel av oppholdet på intensivten vil du anslå at pasientenes blodsukker ligger mellom 5 og 10 mmol/L? \***

*Gjør et anslag basert på gjennomsnittspasienten på din intensivavdeling de siste 12 månedene*  
*Markér bare én oval.*

- Ingen (0% av oppholdet på intensivten)
- 1-10% av oppholdet på intensivten
- 11-20% av oppholdet på intensivten
- 21-30% av oppholdet på intensivten
- 31-40% av oppholdet på intensivten
- 41-50% av oppholdet på intensivten
- 51-60% av oppholdet på intensivten
- 61-70% av oppholdet på intensivten
- 71-80% av oppholdet på intensivten
- 81-90% av oppholdet på intensivten
- 91-100% av oppholdet på intensivten
- Jeg vet ikke

10. **10. Hvor lang tid vil du anslå at det tar fra første hypoglykemiske måling (under 5.0 mmol/L) til pasienten ikke lenger måles som hypoglykemisk (over 5.0 mmol/L)? \***

Gjør et anslag basert på gjennomsnittspasienten på din intensivavdeling de siste 12 månedene  
*Markér bare én oval.*

- Mindre enn 30 minutter
- 30-59 minutter
- 60-89 minutter
- 90-119 minutter
- Mer enn 120 minutter
- Jeg vet ikke

11. **11. Hvor lang tid vil du anslå at det tar fra første hyperglykemiske måling (over 10.0 mmol/L) til pasienten ikke lenger måles som hyperglykemisk (under 10.0 mmol/L)? \***

Gjør et anslag basert på gjennomsnittspasienten på din intensivavdeling de siste 12 månedene  
*Markér bare én oval.*

- Mindre enn 30 minutter
- 30-59 minutter
- 60-89 minutter
- 90-119 minutter
- Mer enn 120 minutter
- Jeg vet ikke

12. **12. Hva er din stillingstittel/arbeidssted? \***

*Markér bare én oval.*

- Fast overlege ved hovedintensiven
- Fast overlege ved thoraxintensiven
- LIS/overlege i primærvakt hovedintensiven

13. **13. Hvor lenge har du jobbet innen anestesi og/eller intensivmedisin? \***

*Markér bare én oval.*

- Mindre enn 1 år
- 1-3 år
- 4-6 år
- 7-10 år
- 11-15 år
- Mer enn 15 år

14. **14. Hvor lenge har du jobbet med anestesi og/eller intensivmedisin ved St. Olavs Hospital? \***

*Markér bare én oval.*

- Mindre enn 1 år
- 1-3 år
- 4-6 år
- 7-10 år
- 11-15 år
- Mer enn 15 år