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The practice of glycaemic control in intensive care units: a multicentre survey of nursing and medical professionals

Title: The practice of glycaemic control in intensive care units: a multicentre survey of nursing and medical professionals

Running head: Glycaemic control practice in ICU

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Conflicts of interests

The authors declare that they have no competing interests.

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Availability of data
The datasets generated and/or analysed during the current study are available from the University of Cambridge repository for research data: https://doi.org/10.17863/CAM.13951.

Abstract

Aims and objectives

To determine the views of nurses and physicians working in intensive care units (ICU) about the aims of glycaemic control and use of their protocols.

Background

Evidence about the optimal aims and methods for glycaemic control in ICU is controversial, and current local protocols guiding practice differ between ICUs, both nationally and internationally. The views of professionals on glycaemic control can influence their practice.

Design

Cross-sectional, multi-centre, survey based study.

Methods

An online, short survey was sent to all physicians and nurses of seven ICUs, including questions on effective glycaemic control, treatment of hypoglycaemia, and deviations from protocols' instructions. STROBE reporting guidelines were followed.

Results

Over half of the 40 respondents opined that a patient spending <75% admission time within the target glycaemic levels constituted poor glycaemic control. Professionals with more than five years' experience were more likely to rate a patient spending 50-74% admission time within target glycaemic levels as poor than less experienced colleagues. Physicians were more likely to rate a patient spending <50% admission time within target as poor than nurses. There was general agreement on how professionals would rate most deviations from their protocols. Nurses were more likely to rate insulin infusions restarted late and incorrect dosage of rescue glucose as major deviations than physicians. Most professionals agreed on when they would treat hypoglycaemia.

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Conclusions

When surveyed on various aspects of glycaemic control, ICU nurses and physicians often agreed, although there were certain areas of disagreement, in which their profession and level of experience seemed to play a role.

Relevance to clinical practice

Differing views on glycaemic control among professionals may affect their practice and, thus, could lead to health inequalities. Clinical leads and the multidisciplinary ICU team should assess and, if necessary, address these differing opinions.

Key words
Health care survey; hyperglycaemia; hypoglycaemia; critical care

Introduction

Stress-induced hyperglycaemia is a common consequence of the stress response in critically ill patients admitted to intensive care units (ICU). It can be broadly defined as the increase of blood glucose levels above those considered as normal levels (above 7 or 11.1mmol/L fasting or postprandial blood glucose), reverting to normal when the critical condition is resolved (Dungan, Braithwaite, & Preiser, 2009). Untreated stress-induced hyperglycaemia can mean patients spend a sub-optimal percentage of their time in the ICU in a target blood glucose range. This percentage of time, referred to as TIR, has been proposed as a useful unifying metric to evaluate the quality of glycaemic control in the ICU (Preiser & Straaten, 2016). There is evidence that low values of TIR, at different ranges, are associated with poor clinical outcomes, including mortality (Krinsley & Preiser, 2015; Penning et al., 2015), and it is generally accepted that stress-induced hyperglycaemia should be treated (Finfer et al., 2013; Van den Berghe et al., 2001). Nevertheless, despite recent attempts to standardise recommendations on glycaemic control in the ICU (Finfer et al., 2013; Krinsley et al., 2017), views about ideal glycaemic targets and practice surrounding stress-induced hyperglycaemia are discrepant amongst the clinical and scientific communities.

ICUs develop their own local protocols for glycaemic control. These differ from one another in their instructions, as well as their impact (Cook et al., 2009; Niven, Rubenfeld, Kramer, & Stelfox, 2015; Orban et al., 2013; Paddle, Eve, & Sharpe, 2011), although it has been suggested that they are often not adhered to (Kanji, Jones, Goddard, Meggison, & Neilipovitz, 2010; Rood, Bosman, van der Spoel, Taylor, & Zandstra, 2005). It is crucial to understand the views of ICU professionals on the use, quality and impact of such protocols, as this will highlight potential areas for quality improvement (Brouwers et al., 2010; Draper, Felland, Liebhaber, & Melichar, 2008).

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Background

Previous surveys of professionals (Aragon, 2006; Bland et al., 2005; Cheekati, Osburne, Jameson, & Cook, 2009; Cook et al., 2008; McMullin et al., 2004) have shown that, while clinicians generally agree on the need for treating dysglycaemias (Aragon, 2006; Cheekati et al., 2009), many of them have important concerns, and differing views, about how to achieve good glycaemic control (Cheekati et al., 2009; Cook et al., 2008; McMullin et al., 2004), particularly tight control (Aragon, 2006; Bland et al., 2005). However, the views of professionals on certain important aspects of glycaemic control have not been explored as yet. These include views on the aims of glycaemic control in terms of TIR, and on the need to adhere to the instructions of glycaemic control local protocols.

The [Blinded] study was a multi-methods study, which aimed to determine the characteristics and the impact of the current clinical practice of glycaemic control in ICU, and involved a document review of the ICUs' clinical protocols, a retrospective review of their medical records, and a survey to ICU professionals. The aim of the survey was to determine the views of ICU nurses and physicians about the following aspects of glycaemic control: what constitutes good or poor glycaemic control as measured by TIR, when should hypoglycaemic events be treated, and which deviations from protocol instructions are considered as major or minor deviations.

Methodology

Study design and setting

This was a cross-sectional, multi-centre, survey based study, conducted as part of the larger [Blinded] study. The research was carried out in the seven ICUs of the [Blinded] Network ([Blinded]) that admit medical and surgical (except cardiac surgery) patients with the highest level of care needs (classified as level 3 patients in the UK). The network serves a population of more than three million, and the number of level-3 patients admitted annually in the participating units can range from 200 to 1000 patients per ICU ([Blinded]). The seven participating ICUs develop and implement their own glycaemic control protocols, and they differ in their glycaemic targets and methods for glycaemic control ([Blinded])

The survey was launched on 1st December 2014 and closed on 31st March 2015.

Sample

Nurses and physicians working as permanent staff at the seven ICUs were invited to participate in the survey via e-mail. Since the purpose of the survey was descriptive and the interest was on proportions, the minimum expected sample size was calculated using Equation 1 (Eng, 2003), where P is the proportion of the variable of interest in the population, D is the maximum marginal error of the estimates that the researcher is ready to accept (i.e., the width of the confidence interval, CI),

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and $Z_{\alpha/2}$ is the value of the standard normal deviate corresponding to the chosen significance level (approximately 1.96 for a 95% CI) (Eng, 2003).

$$n \geq \frac{4\left(Z_{\frac{\alpha}{2}}\right)^2 * P(1-P)}{D^2} \quad \text{(Equation 1)}$$

For most of the questions it was expected that there would be high variability of opinions. For questions with the lowest possible proportion of professionals agreeing to the same answer (P=0.5), and with 0.3 width of the 95% CI, a minimum sample size of 43 would be required. Therefore, a minimum sample size of 43 professionals was expected.

Survey

An online survey was specifically designed for [Blinded] study using the Bristol Online Surveys service. The survey mainly included closed questions, organised in four domains, one with two questions about the professional's role and number of years of experience (Q.1, Table 1), and three with questions about professionals' views on three aspects of glycaemic control (Q.2-4, Table 1). The first aspect of glycaemic control focused on professionals' views on the degree of glycaemic control achieved, in terms of TIR. The second aspect addressed the management moderate (4mmol/L), severe (2.2mmol/L) and very severe (1.5mmol/L) hypoglycaemia (Finfer et al., 2013; Krinsley et al., 2011; Krinsley & Grover, 2007; Van den Berghe et al., 2001; Frier, 2014). In the last section, professionals were asked to rate possible deviations from protocol instructions as major or minor (or "other"). The deviations were based on those proposed by Taylor et al. (Taylor et al., 2006).

Face validity checks of the survey were carried out by three investigators, of whom two were clinicians, through cycles of pretesting and reviewing the content and structure of the survey. Questions were formulated so that they could be used to check for the consistency of the answers. This means that the answer to a question could be used to check whether the answer to other questions followed a logical trend. The survey was designed so that it could be self-administered and would require approximately five minutes to complete. Participants were required to answer the questions in a set order (Evans & Mathur, 2005; F. J. Fowler, 2009).

The local collaborators of [Blinded] study at each of the ICUs invited ICU nurses and physicians of their respective ICUs to complete the survey by means of an email, which included the electronic link to the online survey ([blinded]).

Ethics

The Research Governance Team of the [Blinded], as [Blinded] study Research Sponsor, reviewed and approved the survey before it was distributed. Ethical approval from a Research Ethics Committee of the [Blinded] (Approval reference number: 14/EM/0177) and permissions from the Research and Development department of each of the hospitals, were obtained before commencement of the study.

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Participants were told that they did not need to participate, but that by completing the survey they were consenting to participation. The introductory page to the survey reminded participants that their answers would be held anonymously and securely, and that no personal data would be asked for.

Analyses

Quantifiable variables were summarised using counts and percentages, and presented graphically as bar charts. Values of the percentages were rounded to the nearest integer as the final sample size was lower than 100.

Chi squared tests were used for the comparison of proportions. Alternatively, Fisher's exact tests were used for cases when Chi squared tests are not recommended. All statistical tests were two-tailed, and the level of statistical significance was set at $\alpha=0.05$.

Multiple logistic regression analysis was used to explore how the professionals' role and experience affected their answers to the survey's categorical questions. The interest was on their likelihood to rate pre-specified TIR ranges as poor glycaemic control and to rate pre-specified deviations as major. "Other" answers were recoded as missing values in the regression analyses except for one "other" answer to the question on rating a TIR of 95% or more as good or poor. This answer included the comment "excellent", hence it was recoded as good glycaemic control. Odds Ratios (OR), adjusted ORs and their 95% CI were given to one decimal place, since, given their wide CI, estimates to more decimal places would have given a false sense of precision (Cole, 2015).

Qualitative information, including the open question and the comments to closed questions, were used mainly as anecdotal material for illustrative purposes (F. J. Fowler, 2009). In one case, it was possible to use the comment to recode one of the answers for the regression analyses, as described above.

STROBE guidelines have been followed for the reporting of this research (Supplementary table 1).

Results

Sample

Forty professionals completed the survey. Amongst these, 11 (28%) were nurses and 29 (72%) were physicians, 13 (33%) had five or less years of experience in intensive care, and 26 (65%) had more than five years of experience (one nurse answered "other" to this question about experience) (Table 2). The proportion of nurses who had more than five years' experience (73%) was higher than the proportion of physicians who had more than five years' experience (62%), but this difference was not statistically significant at the 95% confidence level.

Degree of glycaemic control

Over 83% of respondents considered a TIR≥75% as good glycaemic control, while over 75% of them considered a TIR<50% as poor glycaemic control (Figure 1 and Figure 2). Opinions were more divided regarding a TIR of 50-74%. In the optional free text spaces for questions, one professional pointed

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out the need to consider the patient's reason for admission and the different patient groups, to be able to rate a TIR of 50-74% as poor or good.

Physicians and professionals with more than five years' experience in intensive care were more likely to rate TIR values below 75% as poor glycaemic control than nurses and less experienced staff (Figure 1, Figure 2, Table 3). Nonetheless, while results from the logistic regression analyses were statistically significant at the 95% confidence level, the estimates of the coefficients also had very large CIs, and therefore there was some uncertainty about the actual size of the effects.

There were four nurses, with different levels of experience, who rated a TIR<25% as good glycaemic control while they rated a TIR≥95% as poor glycaemic control, and two of them also rated a 75-94% TIR as poor glycaemic control. These answers did not follow a logical trend and hence may not reflect consistent opinions of these four nurses. Possible reasons and potential solutions for this are described in the discussion section.

Treatment of hypoglycaemic events

While most professionals (78%) stated that they would treat moderate hypoglycaemias with rescue glucose only depending on the patient's underlying condition, seven (18%) respondents indicated that they would always give this treatment, and one nurse and one physician, both with 6 to 15 years' experience, said that they would never treat these hypoglycaemias with glucose (Figure 3). On the other hand, all professionals except one agreed with the need to administer glucose to patients with severe hypoglycaemias. No statistically significant differences in the respondents' opinions were found between the groups of profession, and of level of experience, in all of the questions regarding the management of hypoglycaemia.

Deviations from instructions of protocols for glycaemic control

Most of the pre-specified deviations from protocol instructions (eight out of ten) were rated as major by 50% or more of respondents (Figure 4 and Figure 5). Amongst these, deviations from instructions related to the administration of insulin were rated as major by higher proportions of professionals than the other types of instructions (Figure 4 and Figure 5). In the free text spaces provided for these questions on deviations from insulin related instructions (Supplementary table 2), professionals also mentioned a number of contextual factors that may justify these deviations, including the status of the patient, a lack of a central venous catheter, a medical history of insulin dependent diabetes, or the lack of feed or glucose-containing fluids. Some professionals also mentioned that the glycaemic levels of the patient, and how large the incorrect insulin dosage was, were also aspects that would affect how they would rate the deviation.

Opinions on deviations regarding blood glucose monitoring and regarding rescue glucose administration for the management of hypoglycaemias were more divided. Most professionals (90%) considered missing a blood glucose measurement twice or more as a major deviation, but most of them (85%) regarded missing a blood glucose measurement only once as a minor deviation (Figure 4 and Figure 5). In the free text space provided for these questions, respondents stated that the level

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of stability of patients' glycaemic levels, whether the patient was receiving insulin, and any situation that would make blood glucose monitoring difficult at a specific moment, were contextual factors that could justify the need to deviate from protocol instructions (Supplementary table 2). Opinions on deviations regarding the administration of rescue glucose were also divided (Figure 4 and Figure 5). In the free-text comments, contextual factors that were described as possible justifications for these deviations included whether the patient was receiving insulin, whether there were other priorities, and whether the hypoglycaemia was severe (Supplementary table 2).

Nurses and professionals with five or less years' experience were more likely to rate a number of deviations related to the administration of insulin and rescue glucose as major deviations than physicians and more experienced colleagues (Figure 4, Figure 5, Table 4). Nonetheless, the estimates of the ORs had very large CI so, while they were statistically significant, there was some uncertainty about the actual size of the effect.

All the "other events" that professionals described as potential deviations from their ICU protocol for glycaemic control, in the final optional open question of the survey, can be found in Supplementary table 3. Many of the professionals commented on the need to maintain a safe balance between the administration of insulin and the input of nutrition and/or fluids with glucose. Other deviations which were mentioned are related to the treatment with insulin, including incorrect interpretations of the sliding scale, incorrect concentration of the insulin preparation, or "too intensive" insulin therapies. Deviations related to monitoring include the contamination of the blood sample with a glucose solution, and a failure to double-check unexpectedly abnormal glycaemic levels with a different monitoring method.

Discussion

Professionals' attitudes towards, and perceptions about, the aims and methods for glycaemic control of protocols, are rarely reported in studies on the effectiveness of these protocols. Previous surveys to professionals have focused on tight glycaemic control approaches (Aragon, 2006; Bland et al., 2005), on professionals' beliefs and attitudes towards the practicalities and strategies of glycaemic control (Cheekati et al., 2009; Cook et al., 2008; McMullin et al., 2004), or on the blood glucose goals that should be targeted (Cheekati et al., 2009; Cook et al., 2008). None of these surveys looked at professionals' views on the aims of glycaemic control as measured by the TIR, the treatment of hypoglycaemic events, or about not adhering to protocol instructions. The [Blinded] survey thus contributed to the current knowledge, by exploring the opinions of nurses and physicians from several ICUs, on these important aspects of glycaemic control. The study showed that over half of the respondents described a TIR of less than 75% as poor glycaemic control; most professionals rated the majority of the proposed protocol deviations as major; and most professionals would treat hypoglycaemias only depending on patients' underlying condition and the severity of the hypoglycaemia. Nurses and physicians often agreed, but there were particular disagreements, which seemed related to both the profession and level of experience of the survey participants.

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Degree of glycaemic control

Several studies have proposed different TIR thresholds to define good glycaemic control, based on the impact on clinical outcomes, which have often ranged within 70-80% TIR. For example, TIR>80% (Krinsley & Preiser, 2015; Penning et al., 2015), and TIR>70% (Signal, Le Compte, Shaw, & Chase, 2012), depending on the blood glucose levels targeted and the particular study, have all been associated with higher survival. The findings of the [Blinded] survey, in which over half of the respondents stated that a patient spending less than 75% of the admission time within a targeted glycaemic range constituted poor glycaemic control, indicates that professionals seemed to be aware of the evidence associating lower TIR with poor outcomes. However, TIR≥75% has proven to be difficult to achieve amongst critically ill patients, at various glycaemic target ranges, with numerous studies from different institutions and countries often reporting median or mean TIR values lower than 75% (Boord et al., 2007; Kanji et al., 2010; Krinsley & Preiser, 2015; Preiser et al., 2009; Rood et al., 2005; Zimmerman, Mlynarek, Jordan, Rajda, & Horst, 2004). It could be that either TIR≥75% was actually being achieved in the [Blinded] units, or that such level of TIR was not being achieved but professionals still had the evidence based aspiration of achieving it.

Nonetheless, there were still 7 (18%) to 15 (38%) professionals who rated different ranges of TIR, which were lower than 75%, as good glycaemic control. These were mostly nurses or professionals with less than five years' experience. The level of experience and other factors that may have affected such opinions are explored further on within this discussion section.

Treatment of hypoglycaemic events

Severe hypoglycaemia has been largely associated with higher risk of neurological damage and mortality (Krinsley & Grover, 2007; Van den Berghe et al., 2001). Professionals who responded to this survey seemed to be aware of these associations as all of them except one stated that they would always treat hypoglycaemias below 2.2mmol/L with rescue glucose. On the other hand, most professionals stated that they would only administer rescue glucose to patients with hypoglycaemia below 4mmol/L (but higher than 2.2mmol/L) depending on the underlying condition of the patients, which also shows existing concerns about the development of hyperglycaemic events.

Deviations from instructions of protocols for glycaemic control

Most of the pre-specified deviations from protocol instructions included in this survey were rated as major by the majority of professionals, especially those deviations related to the administration of intravenous insulin. The latter indicates an awareness of professionals about the significant risks associated with the treatment of critically ill patients with insulin (Chase et al., 2008; D. Fowler & Rayman, 2010). Insulin resistance in critically ill patients often requires that insulin is administered in very high concentrations for its effect to saturate, which in turn increases the risk for iatrogenic hypoglycaemia (Preiser et al., 2009). In addition, insulin treatment in ICUs is often used reactively rather than to prevent hyperglycaemia, and this increases the probability of making errors (Chase et al., 2008)

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Nonetheless, there were two of the insulin related deviations that were rated as minor by 30-48% of respondents. Given the previously described risks associated with the treatment of ICU patients with insulin, considering late or incorrect titrations of insulin infusions as minor deviations may be of some concern, as these could exacerbate the risks. On the other hand, insulin needs are affected by a multitude of factors, including patient related and treatment related ones. This makes the determination of insulin needs even more complex, and may result in fixed insulin sliding scales of protocols not being followed by clinicians (Geoffrey Chase et al., 2007).

A blood glucose measurement missed once and the administration of rescue glucose 15 or less minutes late, were also rated as minor by most professionals (85% and 65%, respectively). During the hours that a patient is not monitored, dysglycaemic events could be missed. Also, a late rescue glucose in a patient with severe hypoglycaemia could have detrimental effects, including increasing the risk of mortality (Bagshaw et al., 2009; Krinsley et al., 2011). However, in the free text comments to these questions, professionals pointed out the need to consider the context of the deviation, such as when an insulin infusion is not in place, or when the blood glucose has been stable for a long time.

Participants' rating of the deviations as major or minor generally agreed with the ratings proposed by Taylor et al. (2006). However, there were three deviations categorised as minor by Taylor et al. (2006), which the majority of the professionals of the [Blinded] survey considered as major. These included an insulin infusion not turned off, an insulin titration missed or done incorrectly once, and an insulin infusion restarted two or less hours late. Given that Taylor et al. (2006) had done the classification based on their clinical judgement (C. Coopersmith, personal communication via email, May 2016), and that [Blinded] found that lower level of experience was associated with a higher likelihood of rating deviations as major, a lower level of experience among [Blinded] survey respondent than that of Taylor and colleagues could be behind these divergent opinions. Contextual differences, including institutional and geographical factors (single ICU in the USA vs several ICUs in the UK), as well as the availability of large new evidence at the time of [Blinded] study (2015) as compared with when Taylor's study was carried out (2005), could also be part of the reason for these differences in opinion.

Factors that may have affected the survey respondents' opinions, including their profession and level of experience, are discussed below.

Factors associated with professionals' views

The survey responses indicate that physicians and more experienced staff seemed more concerned about maintaining patients within the glycaemic target so as to achieve high TIR values, while nurses and less experienced professionals seemed more concerned about adhering to what they are supposed to do according to their protocol instructions. Similar observations have been reported in other studies. A survey to physicians reported that almost all of them (96-97%) considered glycaemic control in critically ill patients as a complication which is very important to treat (Cheekati et al., 2009; Cook et al., 2008). In their large survey on glycaemic control, Mc Mullin et al. (McMullin et al., 2004) found that more physicians were concerned about hyperglycaemia, while more nurses were concerned about aspects that can affect their practice, which would in turn affect their adherence to instructions, such as the glucometer availability, duration of laboratory turnaround, and taking blood

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glucose measurements too often. The same study also found that significantly higher proportions of physicians than of nurses endorsed the need to put different strategies in place to achieve optimal glycaemic control. Also, previous studies have shown that professionals' experience can affect how medication is prescribed (Fehrenbach, Budnitz, Gazmararian, & Krumholz, 2001; Peters-Klimm et al., 2012). The different opinions found in [Blinded] survey depending on professionals' role and experience could lead to different practice, and therefore different patient outcomes. It seems necessary that a higher awareness about the impact of poor glycaemic control, defined by a low TIR, is promoted especially amongst nurses and less experienced staff.

Other than the professionals' role and level of experience, a number of factors have been found to affect professionals' views, including lack of knowledge or unawareness about the latest evidence, resistance to change established ways of practice, and a tendency to overemphasise successful personal clinical decisions over successful decisions based on rules, among others (Blakey, Brown, Pinchin, Barley, & Sharples, 2015). Since exploring these factors was not the aim of the [Blinded] survey, they were not included in the questionnaire. Future studies investigating a more comprehensive group of variables affecting professionals' opinions may be able to determine other factors, as well as to confirm the effects of the profession and level of experience found in [Blinded]. While these factors will not be easy to investigate in future studies, whether any of these or other reasons are behind the differences found in the [Blinded] survey should be investigated, and qualitative research approaches may be the best way forward for this.

Another important factor that could be related to why some professionals were less concerned about straying from protocols, could be the implementation of "one size fits all" protocols, where the same set of instructions are given for all patients, without considering sub populations that may benefit from different management approaches, or without leaving some degree of flexibility (Niven et al., 2015; Orban et al., 2013; Paddle et al., 2011). For example, patients with diabetes may require a different glucose target and/or higher dosages of insulin, to achieve the same glucose levels (Krinsley et al., 2013; Rady, Johnson, Patel, Larson, & Helmers, 2005). Also, patients with acute cardiac syndrome (Deedwania et al., 2008) or with cardiac surgery and ICU length of stay above three days (Lazar et al., 2009) may benefit from lower glycaemic target ranges. On these grounds, a more personalised approach in the management of glycaemic control in the ICU has been proposed in the past few years by experts in the field (Krinsley et al., 2017; Krinsley, 2014; Le et al., 2013; Preiser & Straaten, 2016).

Finally, some methodological aspects should be considered in the interpretation of this study. The number of staff the survey was distributed to was not collected, and therefore it was not possible to calculate the recruitment rate. The final sample size had three participants less than the minimum expected sample size, which may have affected the large confidence intervals. In addition, nurses may be under-represented, as there were approximately three physicians for every nurse in the group of respondents. This, in fact, is notably different from the usual distribution of professionals in UK ICUs, where there should be approximately one physician for every 8 to 15 nurses (Core Standards Working Party of the Joint Professional Standards Committee of the Faculty of Intensive Care Medicine (FICM) and the Intensive Care Society (ICS), 2013). Therefore, it is recommended that the present study is replicated with a larger sample, putting in place techniques that help increasing the participation of nurses. Also, some of the answers to the survey questions had a distribution that did not show a logical trend, and some of the comments included in the free text spaces indicated

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that some questions may need further clarifications. As a consequence of being an online self-administered questionnaire, it could be that some of the questions were not sufficiently self-explanatory for some respondents, and occasional misunderstandings may have occurred. As an anonymous self-administered online survey, inter-rater reliability and test retest reliability did not apply to this survey. Future studies could build on the [Blinded] survey, to improve its reliability and internal validity, and to reduce the possibility of misunderstandings in the survey questions. On the other hand, a number of measures were put in place to increase the study quality, including to increase response rate (short and online completion) (Evans & Mathur, 2005); to reduce the interviewer bias and increase the internal validity (self-administration) (F. J. Fowler, 2009); and to reduce the survey bias (set order to answer questions) (Evans & Mathur, 2005).

Conclusion

During the survey conducted in seven ICUs, nurses and physicians often agreed on the aims of, and methods for, glycaemic control. However, there were particular disagreements, which seemed related to the survey participants' profession and level of experience. There is a risk of health inequalities as differing opinions may lead to variability in clinical practice. This is likely the case in other ICUs, at the national and international level.

Relevance to clinical practice

It is paramount to assess and, if necessary, address differing views on glycaemic control among ICU professionals, in order to achieve optimal care. This applies not only to ICU clinical leads and the broader team, but also to researchers designing future studies on the impact of new methods for glycaemic control.

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What does this paper contribute to the wider global clinical community?

The study presented in this paper had several findings which contribute to the knowledge of global clinical community. These can be summarised as follows:

- While ICU professionals often agree on the aims of glycaemic control in intensive care, and the relevance of deviations from their protocols, there are specific areas of disagreement in which their profession and level of experience seem to play a role.
- Given that professionals' views can affect their clinical practice, the results of this study indicate that there may be inconsistencies in the implemented methods for glycaemic control, even within the same ICU. This is likely the case for most ICUs.
- The results of this study can serve as an example to help ICU clinical leads and the broader team to assess and, if necessary, address differing views on glycaemic control. These results are also useful for researchers, who should consider such differences as a potential confounder in research studies on the impact of glycaemic control.

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Table 1 – Summary of the sections of GlyCon online survey to intensive care professionals

(Q.1) Socio-demographic information
(Q.1.1) Role (Q.1.2) Years working in intensive care: ≤5; 6–15 ; 16–30; >30
(Q.2) Degree of glycaemic control
Rate the following percentages of time spent within the target glycaemic range as "poor" or "good" glycaemic control, or "other (specify)"
(Q.2.1) (0-24%) (Q.2.2) 25-49% (Q.2.3) 50-74% (Q.2.4) 75-94% (Q.2.5) ≥95%
(Q.3) Treatment of hypoglycaemia
Specify when these hypoglycaemic ranges should be treated with glucose: "always" vs. "depending on underlying condition" vs. "never", or "other (specify)" (plus optional comments for each item)
(Q.3.1) <4mmol/L (Q.3.2) <2.2mmol/L (Q.3.3) <1.5mmol/L
(Q.4) Deviations from protocol instructions
Rate the following deviations from instructions of an ICU protocol for glycaemic control as: "minor" vs. "major" (plus optional comments for each item)
(Q.4.1) Blood glucose measurement missed x1
(Q.4.2) Insulin titration missed or done incorrectly x1
(Q.4.3) Insulin infusion restarted 2 or less hours late
(Q.4.4) Blood glucose measurement missed 2 or more consecutive times
(Q.4.5) Insulin titration missed/done incorrectly 2 or more consecutive times
(Q.4.6) Insulin infusion restarted more than 2 hours late
(Q.4.7) Insulin infusion not turned off
(Q.4.8) Rescue glucose infusion dose done incorrectly x1
(Q.4.9) Rescue glucose infusion administered 15 or less minutes late
(Q.4.10) Rescue glucose infusion administered more than 15 minutes late
(Q.4.11) Open question (optional): other events considered as minor and/or major deviations

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Table 2 – Sample distribution (number and percentage) by professionals' role and number of years of experience in intensive care

0-5 years' experience	
Physicians	11 (28%)
Nurses	2 (5%)
6-15 years' experience	
Physicians	12 (30%)
Nurses	6 (15%)
16-30 years' experience	
Physicians	4 (10%)
Nurses	2 (5%)
>30 years' experience	
Physicians	2 (5%)
Nurses	0

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Table 3 – Effect of professionals' role and number of years of experience in intensive care, on their likelihood for rating pre-specified ranges of TIR as poor glycaemic control. TIR: Percentage of admission time spent within the glycaemic target range.

		OR (95% CI)	Adj OR (95% CI)
Rating these TIR (%) ranges as poor glycaemic control			
0-24 TIR			
	Physicians †	11.3 (1.7, 72.5) *	17.2 (1.5, 191.2) *
	>5 years' experience ‡	2.3 (0.4, 13.4)	6.0 (0.5, 67.4)
25-49 TIR			
	Physicians †	10 (1.9, 54) **	17.8 (1.8, 178.9) **
	>5 years' experience ‡	2.8 (0.6, 13.7)	7.6 (0.7, 77.2)
50-74 TIR			
	Physicians †	1.7 (0.4, 7.4)	3.2 (0.6, 17.7)
	>5 years' experience ‡	4.9 (1.1, 21.5)	6.2 (1.3, 30.2) *
75-94 TIR			
	Physicians †	0.5 (0.1, 3.8)	1.2 (0.1, 13.3)
	>5 years' experience ‡	1.6 (0.2, 17.5)	1.7 (0.2, 18.5)
≥95 TIR			
	Physicians †	1	1
	>5 years' experience ‡	1	1

**p<0.05; **p<0.01; ***p<0.001*

OR: odds ratio; Adj OR: adjusted odds ratio, adjusting for professionals' role and level of experience

† Physicians as compared with nurses

‡ Professionals with more than five years' experience as compared with professionals with five or less years' experience

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Table 4 – Effect of professionals' role and number of years' experience in intensive care on their likelihood for rating pre-specified deviations from the protocol as major deviations

	OR (95% CI)	Adj OR (95% CI)
Rating these deviations are major:		
Blood glucose measurement missed x1		
Nurses †	3.3 (0.5, 19.4)	3.9 (0.6, 25.0)
≤5 years' experience ‡	1.0 (0.2, 6.3)	1.3 (0.2. 9.1)
Insulin titration missed/incorrect x1		
Nurses †	4.9 (0.5, 44.6)	4.4 (0.5, 41.5)
≤5 years' experience ‡	1.1 (0.3, 4.8)	1.3 (0.3, 5.7)
Insulin infusion restarted ≤2 hours late		
Nurses †	6.7 (1.3, 38.4) *	14.8 (2.0, 108.4) **
≤5 years' experience ‡	5.9 (1.3, 27.3) *	13.0 (2.2, 78.2) **
Blood glucose measurement missed x2 or more		
Nurses †	1	1
≤5 years' experience ‡	0.5 (0.1, 3.7)	0.6 (0.1, 4.7)
Insulin titration missed/incorrect x2 or more		
Nurses †	1	1
≤5 years' experience ‡	1.6 (0.1, 16.7)	2.0 (0.2, 22.1)
Insulin infusion restarted >2 hours late		
Nurses †	3.2 (0.3, 29.4)	3.2 (0.3, 30.9)
≤5 years' experience ‡	1.7 (0.3, 9.6)	1.9 (0.3, 11.6)
Insulin infusion not turned off		
Nurses †	1	1
≤5 years' experience ‡	1	1
Incorrect amount of rescue glucose x1		
Nurses †	8.1 (0.9, 72.0)	9.7 (1.0, 91.8) *
≤5 years' experience ‡	2.4 (0.5, 11.0)	3.5 (0.7, 17.2)
Rescue glucose administered ≤15 minutes late		
Nurses †	1.5 (0.3, 7.0)	1.7 (0.4, 8.1)
≤5 years' experience ‡	0.7 (0.1, 3.2)	0.7 (0.1, 3.6)
Rescue glucose administered >15 minutes late		
Nurses †	0.8 (0.2, 4.2)	0.7 (0.1, 3.9)
≤5 years' experience ‡	0.73 (0.2, 3.6)	1.0 (0.2, 5.1)

**p<0.05; **p<0.01; ***p<0.001*

OR: odds ratio; Adj OR: adjusted odds ratio, adjusting for professionals' role and level of experience

† Nurses as compared with physicians

‡ Professionals with five or less years' experience as compared with professionals with more than five years' experience

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Figure 1 Distribution of opinions on whether pre-specified percentages of admission time spent within the target glycaemic range (TIR) constitute poor or good glycaemic control, by profession

Figure 2 Distribution of opinions on whether pre-specified percentages of admission time spent within the target glycaemic range (TIR) constitute poor or good glycaemic control, by level of experience

Figure 3 Distribution of opinions on when pre-specified levels of hypoglycaemia should be treated with glucose

Figure 4 Distribution of opinions on whether pre-specified deviations from protocols for glycaemic control are major or minor deviations, by profession

Figure 5 Distribution of opinions on whether pre-specified deviations from protocols for glycaemic control are major or minor deviations, by level of experience

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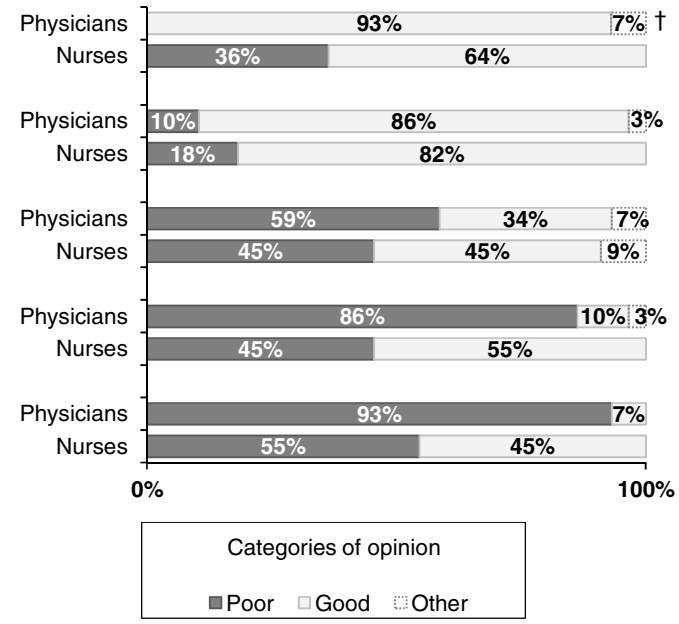
Professionals' opinions on possible TIR values, by profession

Pre-specified ranges of TIR (%)	Profession	% respondents per opinion category	p-value ‡
≥95 TIR	Physicians	93% 7% †	0.004
	Nurses	36% 64%	
75-94 TIR	Physicians	10% 86% 3%	0.609
	Nurses	18% 82%	
50-74 TIR	Physicians	59% 34% 7%	0.476
	Nurses	45% 45% 9%	
25-49 TIR	Physicians	86% 10% 3%	0.008
	Nurses	45% 55%	
0-24 TIR	Physicians	93% 7%	0.011
	Nurses	55% 45%	



† Among the "other" answers to the question on TIR≥95%, one (7%) physician, with 6-15 years' experience, used the free text comments to rate this as "excellent".

‡ P-value for the difference in proportions of opinions between nurses and physicians

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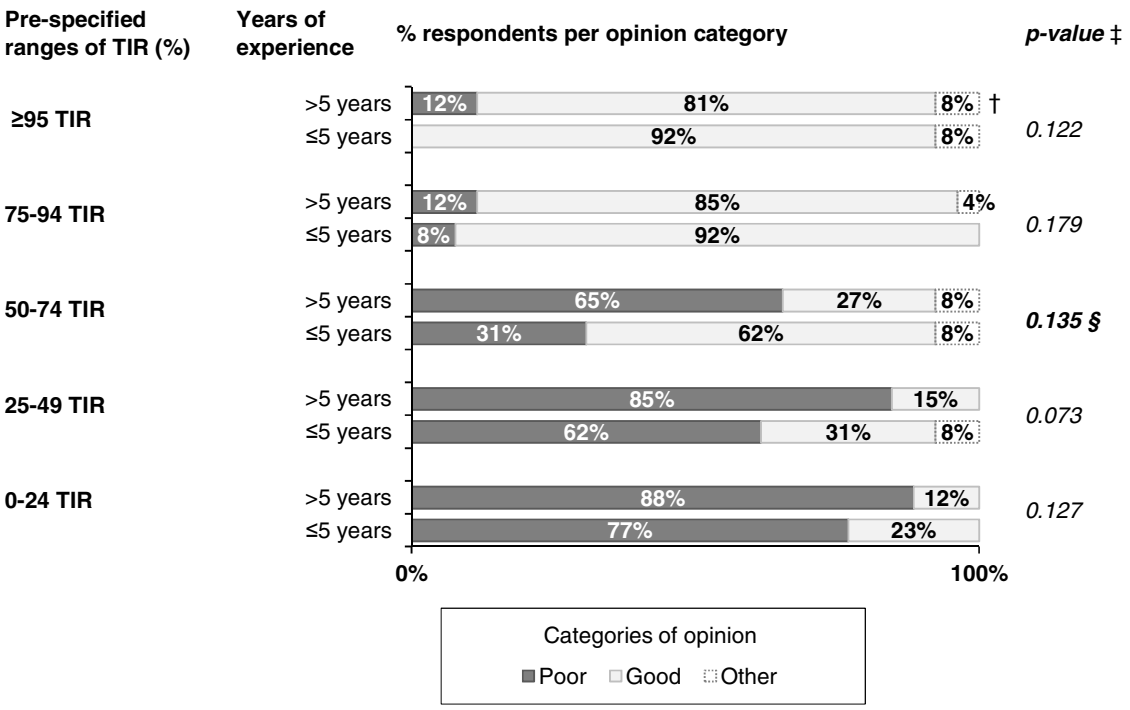
Professionals' opinions on possible TIR values, by profession



† Among the "other" answers to the question on TIR≥95%, physician with 6-15 years' experience used the free text comments to rate this as "excellent".

‡ P-value for the difference in proportions of opinions between groups of level of experience.

§ Excluding "other" answers: Of the 24 more experienced professionals, 17 (71%) considered TIRs within 50-74% as poor GC; among the 12 less experienced professionals, 4 (33%) rated TIRs within 50-74% as poor GC (p=0.037).

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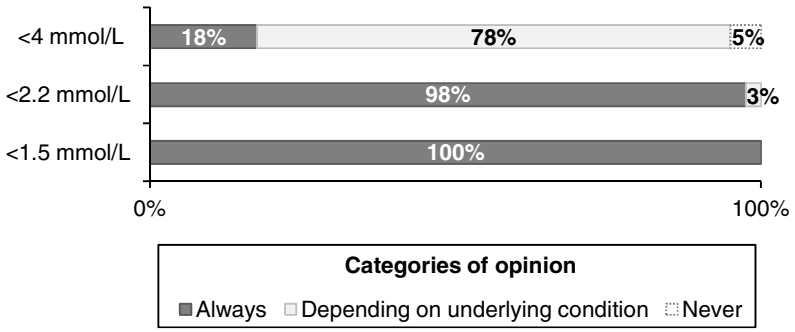
Professionals' opinions on when hypoglycaemia should be treated with glucose



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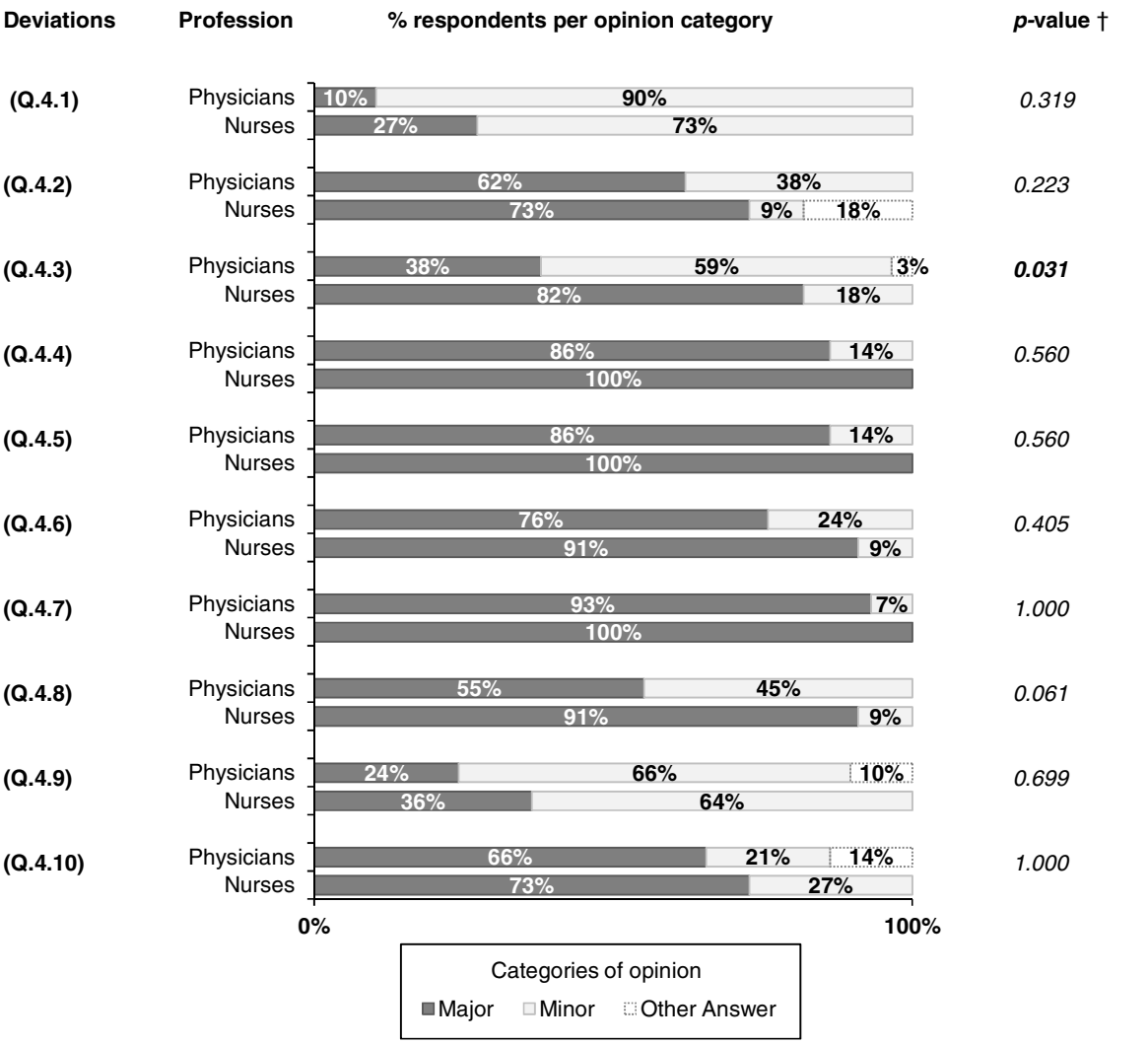
Professionals' opinions on possible deviations from protocols for glycaemic control



Deviations:

(Q.4.1) BG measurement missed x1

(Q.4.2) Insulin titration missed or incorrect x1

(Q.4.3) Insulin infusion restarted ≤2 hours late

(Q.4.4) BG measurement missed x2 or more

(Q.4.5) Insulin titration missed or incorrect x2 or more

(Q.4.6) Insulin infusion restarted >2 hours late

(Q.4.7) Insulin infusion not turned off

(Q.4.8) Giving incorrect amount of rescue glucose x1

(Q.4.9) Rescue glucose administered ≤15minutes late

(Q.4.10) Rescue glucose administered >15 minutes late

† P-value for the difference in proportions of opinions between nurses and physicians.

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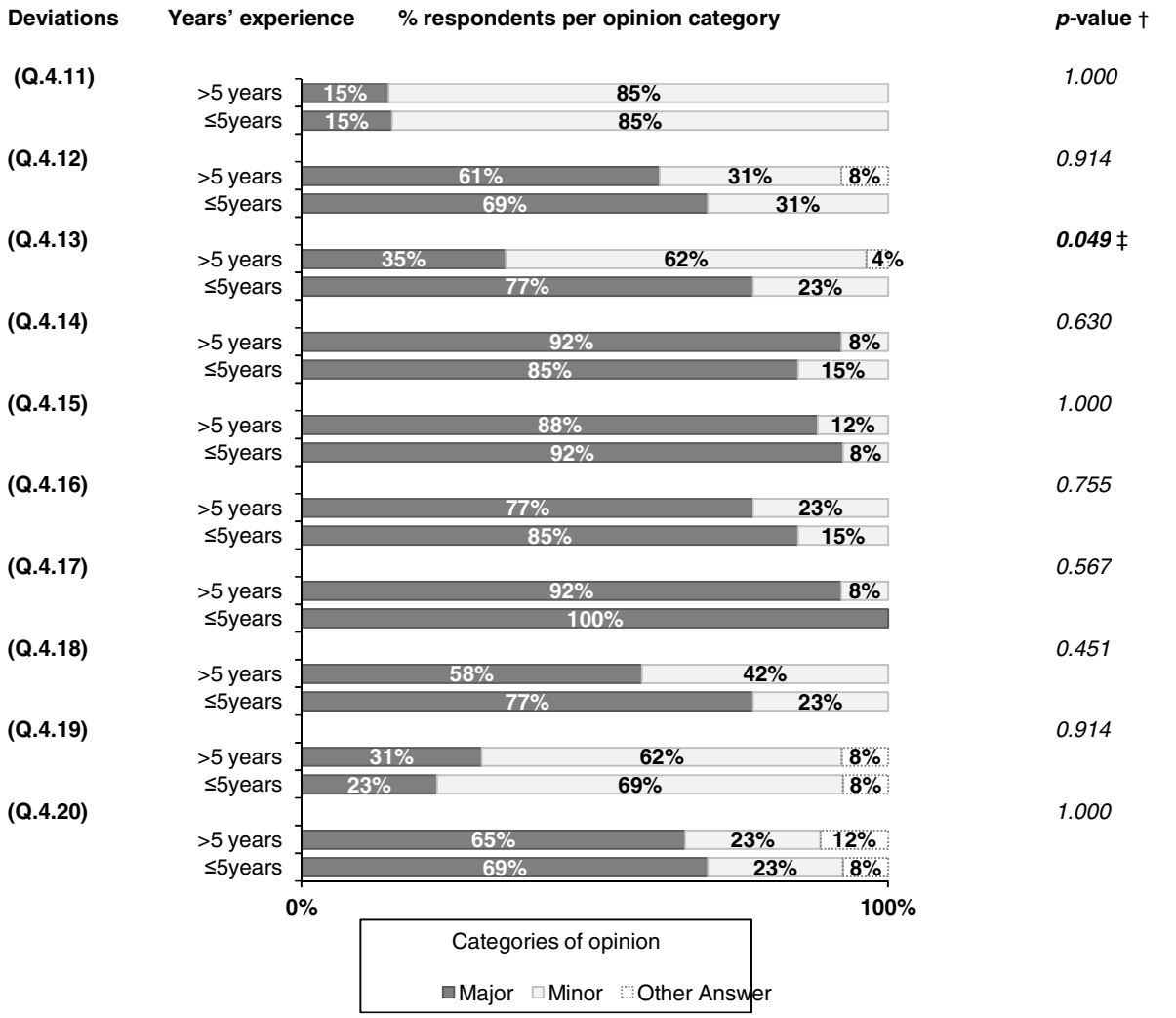
Professionals' opinions on possible deviations from protocols for glycaemic control



Deviations:

(Q.4.11) BG measurement missed x1

(Q.4.12) Insulin titration missed or incorrect x1

(Q.4.13) Insulin infusion restarted ≤2 hours late

(Q.4.14) BG measurement missed x2 or more

(Q.4.15) Insulin titration missed or incorrect x2 or more

(Q.4.16) Insulin infusion restarted >2 hours late

(Q.4.17) Insulin infusion not turned off

(Q.4.18) Giving incorrect amount of rescue glucose x1

(Q.4.19) Rescue glucose administered ≤15minutes late

(Q.4.20) Rescue glucose administered >15 minutes late

† P-value for the difference in proportions of opinions between groups of level of experience.

‡ Excluding "other" answers: Of the 25 more experienced professionals, 9(36%) rated Q.4.3 as major; among the 13 less experienced professionals, 10 (77%) rated Q.4.3 as major (p=0.019).

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