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Dissemination of patient blood management practices in Swiss intensive care units: a cross-sectional survey

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Summary

BACKGROUND: Patient blood management (PBM) promotes the routine detection and treatment of anaemia before surgery, optimising the management of bleeding disorders, thus minimising iatrogenic blood loss and pre-empting allogeneic blood utilisation. PBM programmes have expanded from the elective surgical setting to non-surgical patients, including those in intensive care units (ICUs), but their dissemination in a whole country is unknown.

METHODS: We performed a cross-sectional, anonymous survey (10 October 2018 to 13 March 2019) of all ordinary medical members of the Swiss Society of Intensive Care Medicine and the registered ICU nurses from the 77 certified adult Swiss ICUs. We analysed PBM-related interventions adopted in Swiss ICUs and related them to the spread of PBM in Swiss hospitals. We explored blood test ordering policies, blood-sparing strategies and red blood cell-related transfusion practices in ICUs.

RESULTS: A total of 115 medical doctors and 624 nurses (response rates 27% and 30%, respectively) completed the surveys. Hospitals had implemented a PBM programme according to 42% of physicians, more commonly in Switzerland's German-speaking regions (Odds Ratio [OR] 3.39, 95% confidence interval [CI] 1.23–9.35; p = 0.018) and in hospitals with more than 500 beds (OR 3.91, 95% CI 1.48–10.4; p = 0.006). The PBM programmes targeted the detection and correction of anaemia before surgery (79%), minimising perioperative blood loss (94%) and optimising anaemia tolerance (98%). Laboratory tests were ordered in 70.4% by the intensivist during morning rounds; the nurses performed arterial blood gas analyses autonomously in 48.4%. Blood-sparing techniques were used by only 42.1% of nurses (263 of 624, missing: 6) and 47.0% of physicians (54 of 115). Approximately 60% of respondents used an ICU-specific transfusion guideline. The reported haemoglobin threshold for the nonbleeding ICU population was 70 g/l and, therefore, was at the lower limit of current guidelines.

CONCLUSIONS: Based on this survey, the estimated proportion of the intensivists working in hospitals with a PBM initiative is 42%, with significant variability between regions and hospitals of various sizes. The risk of iatrogenic anaemia is relevant due to liberal blood sample collection practices and the underuse of blood-sparing techniques. The reported transfusion threshold suggests excellent adherence to current international ICU-specific transfusion guidelines.

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Introduction

A substantial number of patients are either anaemic at admission or become anaemic during their hospitalisation. Hospital stays lengthen, mortality rises and hospital expenses increase with anaemia severity [1, 2]. Allogeneic blood transfusion is considered an essential therapeutic measure. However, it bears the risk of increased morbidity and mortality in a dose-dependent relationship [3]. Large observational studies have shown that transfusion is specifically associated with increased infection rates [4], lung injury [5], acute kidney injury [6], cardiac overload [7] and thromboembolic events [8]. In intensive care unit (ICU) patients, allogeneic blood transfusion is associated in a dose-dependent relationship with nosocomial infections

[9], acute respiratory distress syndrome [10], ICU and hospital length of stay and death [11]. In recent decades, following the landmark Transfusion Requirements in Critical Care trial results [12], a restrictive transfusion strategy (seeking to maintain the haemoglobin level above 70 g/l) has proven to be as safe as or, in specific subpopulations, even superior to a liberal transfusion strategy (aiming at haemoglobin levels above 100 g/l) [13].

Patient blood management (PBM) is a multimodal, multidisciplinary approach based on three main pillars: improving red cell mass, for example by the early detection and treatment of preoperative anaemia, minimising blood loss, for example by optimising surgical and anaesthetic techniques, and harnessing and maximising the physiological tolerance of anaemia [14]. In a recent meta-analysis, the systematic application of a PBM programme improved essential clinical outcomes in a predominantly surgical patient population [15]. More recently, some institutions have extended patient blood management programmes to non-surgical patients, including ICU patients, who are among the leading recipients of allogeneic blood transfusions [16].

Although several authors have long considered patient blood management as a standard of care [17–19], there is no register of hospitals participating in the patient blood management initiative, and, consequently, we know little about the patient blood management programme in a whole country. The present survey explored the dissemination of the patient blood management initiative in Swiss adult ICUs, investigated the efforts to limit iatrogenic blood loss in ICUs with and without a patient blood management programme, and evaluated the policies adopted for transfusion practice.

Methods

Survey development

This survey was submitted to the Ethics Committee of the Canton Ticino (Bellinzona, Switzerland) and was deemed exempt from ethical review.

We used an online platform (EvaSys 6.1, Electric Paper Evaluationssysteme Gmbh, Lüneburg, Germany) to set up two questionnaires addressed to ICU doctors and ICU nurses. Three intensivists (MP, JC, AP) designed the questionnaires, which were then reviewed by an international patient blood management key opinion leader (AH) and a statistician (BC). The reference materials included a review [16], an article providing comprehensive bundles of patient blood management [20], and the recommendations for survey methodology [21, 22]. The survey aimed to characterise the participants, their hospitals and their ICUs while ensuring their anonymity; therefore, the hospitals' and ICUs' identities remained unknown. We selected the investigation's elements, aware that ICU clinicians may not be aware of all the details related to the management of preoperative anaemia. Instead, we developed more specific constructs about practices within the ICU concerning blood draws, blood-sparing techniques and transfusion strategies.

The doctors' questionnaire was created in Italian and translated into English (made available for the survey) and then back into Italian to confirm proper translation. It included 37 questions and addressed the following domains: hospital characteristics (hospital type and size, geographical region, medical specialities), in-hospital blood management programme and protocols (availability of patient blood management [yes, no, unknown] including its three pillars [preoperative anaemia detection and treatment, blood loss reduction, and optimisation of anaemia tolerance]; management of preoperative blood product requests; implementation of the "single blood unit transfusion" policy; transfusion consent form policy; involvement of blood bank physicians, blood products concerned and requested information; transfusion audits performance), ICU characteristics (number of ICU beds, postgraduate training category) including blood test ordering policies, blood-sparing strategies and red blood cell-related transfusion practice, focusing on the preferred haemoglobin transfusion threshold for patients in seven clinically relevant subpopulations with adequate O_2 delivery. The hospitals were differentiated by type (regional hospital, i.e., primary and secondary level; cantonal hospital, i.e., tertiary level; university hospital, i.e., quaternary level; private clinic) and size (fewer than 200 beds; from 200 to 500 beds; more than 500 beds). The ICUs were divided by size (small, fewer than 7 beds; medium-small, 7 to 10 beds; medium-large, 11 to 15 beds; large, more than 15 beds) and postgraduate training category (Au, almost complete spectrum of critically ill patients, part of a university centre; A, similar to Au, but without academic affiliation and the requirement of a research programme; B, wide range of critically ill patients; C, limited range of critically ill patients; none, not recognised as a training centre) according to the Swiss Institute of Medical Education (SIWF/ISFM; see appendix for static version).

The nurses' questionnaire included twenty questions. It was created in Italian and translated into French and German and then back into Italian by bilingual people to confirm proper translation. The participants could select one of the three versions according to their language preference. The questionnaire addressed demographic, hospital and ICU characteristics (hospital type and size, geographical region, medical specialities in the hospital, nurses' work experience [less than two years; two to five years; six to ten years; and more than ten years], and ICU size) and blood sampling in the ICU (blood gas analysis ordering policy, number of samplings per work shift in four different clinical situations, blood culture collection practice, availability and type of blood-sparing strategies, documentation policy regarding blood loss for laboratory testing, and use of blood-sparing analyte monitoring devices; see English version for publication in the appendix). To gather details, we asked participants to select information from predefined lists and gave them the option of providing other information or more detailed answers if needed. After pilot testing by intensivists and specialised nurses, we developed the final versions to ensure content validity and optimise the response process.

Survey sample

We conducted a cross-sectional survey on patient blood management using online self-administered anonymous questionnaires. The survey was open from 10 Octo-

ber 2018, to 13 March 2019, and offered no incentives. To be eligible, participants had to be among the ordinary medical members (physicians with a Swiss speciality degree in intensive care medicine or recognised equivalent) of the Swiss Society of Intensive Care Medicine or the registered ICU nurses from the 77 certified adult Swiss ICUs. The survey was entitled Swiss VAMPIRES: Variability among modalities, practices, indications, requests of blood components and samplings in Swiss intensive care units. Completion of the survey took approximately 10 minutes. We invited doctors to participate in the survey via email and sent a reminder once. To contact the nurses, we emailed the department heads twice and asked them to distribute the invitation to participate in the inquiry and the survey platform's link to their collaborators. Additionally, the Swiss Society of Intensive Care Medicine, who endorsed the study, promoted it at its annual congress and through its periodical newsletter and invited participants to access the survey on its webpage.

Study outcomes

Our exploratory survey aimed to analyse PBM-related interventions adopted in Swiss ICUs, relating them to the spread of patient blood management in Swiss hospitals.

To this end, we established the proportion of intensivists who worked in hospitals participating in the patient blood management initiative, characterising them according to the region, the hospital size and type, the presence of specialities and the ICU size and postgraduate training category.

The main objectives of our analysis were divided into two groups: (1) to investigate the efforts to reduce iatrogenic blood loss, including (i) blood draw decision practices, (ii) availability of blood-sparing strategies during blood draw, (iii) the number of samples per work-shift in four different clinical settings, (iv) the documentation policy of blood loss for laboratory testing, and (v) the use of blood-sparing analyte monitoring devices; (2) to analyse transfusion practices, including (i) the availability of local ICU transfusion guidelines, (ii) the haemoglobin transfusion thresholds used for seven critically ill patient categories, (iii) the implementation of the "single blood unit transfusion" policy, (iv) the transfusion consent form policy, (v) the involvement of blood bank physicians (need to justify the transfusion, blood products concerned and requested information), (vi) the practice of ordering blood products before operations; and finally, (vii) the implementation of transfusion audits.

Statistical analysis

Statistical analysis was performed in compliance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist [23]. The sample size was determined by the number of ordinary medical members of the Swiss Society of Intensive Care Medicine and the full-time equivalents of registered ICU nurses during the study period. All fully and partially completed surveys were analysed. As 98.2% of the received questionnaires were complete (predefined lists), we performed a complete case analysis and used no imputation method to estimate potential missing data. We used descriptive statistics to analyse the demographic, hospital and ICU characteristics. We presented categorical data using relative frequencies (percentage) or observations and relative frequencies. We summarised the main results regarding patient blood management programmes (yes vs no and unknown PBM categories) as a function of both the linguistic region and the hospital size using a logistic regression model with both these covariates. The transfusion triggers in different situations were ordinal categorical data with the following categories: inferior to 60 g/l (±5 g/l); 60 g/l (± 5 g/l); 70 g/l (± 5 g/l); 80 g/L (± 5 g/l); 90 g/l (± 5 g/l); 100 g/l (± 5 g/l). We reported the preferred transfusion triggers by indicating the median class and the percentage of observations in the classes below and above this median class.

We investigated the association between two categorical variables with Fisher's exact or chi-square tests when they met the use conditions. The type I error rate was 0.05. All computations were performed with R version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria), using the following additional libraries: descr, knitr, and MASS.

Results

Demographics

Among the 425 ordinary medical members of the Swiss Society of Intensive Care Medicine, 115 doctors participated in the survey (response rate 27.1%). We received 624 questionnaires from nurses, which roughly corresponds to a 30% response rate calculated on the 2116 full-time equivalents employed in the 77 certified Swiss ICUs. One hundred and thirteen medical (98.2%) and 613 (98.2%) nurse inquiries were complete. The data flow is shown in figure 1. Participating doctors practised mainly in regional (33/115, 28.7%) and cantonal hospitals (41/115, 35.7%; missing: 1, 0.9%), nurses mainly in university (251/624, 40.2%) and cantonal hospitals (186/624, 29.8%); missing: 2, 0.3%). The number of professionals per category who participated in the survey per major Swiss region was uneven (chi-square test of independence between profession and region, $p = 0.001$). For example, Northwestern Switzerland contributed with 7.8% (9/115) of the doctors' survey participants but only with 2.7% (17/624, missing: 2, 0.3%) of the nurses' survey participants. Table 1 shows other demographics.

Dissemination of patient blood management in Switzerland

Hospitals had implemented a patient blood management programme according to 48 out of 115 doctors (41.7%; missing: 2, 1.7%); twenty doctors (17.4%) did not know if their hospital had joined the patient blood management initiative (unknown PBM). Figure 2 shows physicians' answers by region, hospital size and type, and ICU size. Responses regarding PBM in ICUs of different training categories were distributed as follows: Au, 10/18 (55.6%); A, 18/40 (45.0%); B, 7/23 (30.4%); C, 3/15 (20.0%); none, 10/17 (58.8%); $p = 0.054$ for chi-square test of independence between PBM and the training categories; missing: 2, 1.7%. Overall, doctors from the German-speaking re-

gions of Switzerland (odds ratio [OR] of implementation of PBM at 3.39 for German-speaking regions when compared with non-German-speaking regions, 95% CI 1.23–9.35; associated p of the logistic regression coefficient = 0.018) and hospitals with more than 500 beds (OR of implementation of PBM at 3.91 for hospitals with more than 500 beds when compared with hospitals with less than 500 beds, 95% CI 1.48–10.4; associated p of the logistic regression coefficient = 0.006) more commonly reported working in a PBM adherent facility.

Physicians from hospitals with specialities reported limited patient blood management implementation with no significant difference compared with those working in non-speciality hospitals (PBM available, 41/93, 44.1% vs 7/20, 35.0%; no PBM, 33/93, 35.5% vs 12/20, 60.0%; unknown PBM, 19/93, 20.4% vs 1/20, 5.0%). PBM positive answers were distributed as follows: trauma centre, 25/56 (44.6%); haematology/oncology, 41/91 (45.1%); organ transplant surgery, 15/28 (53.6%); cardiac surgery, 24/48, (50.0%).

Among the medical doctors reporting some patient blood management activity in their hospital, 39 (81.3%) mentioned the detection and correction of anaemia before surgery, 45 (93.8%) cited the minimisation of perioperative blood loss and 47 (97.9%) the optimisation of anaemia tolerance.

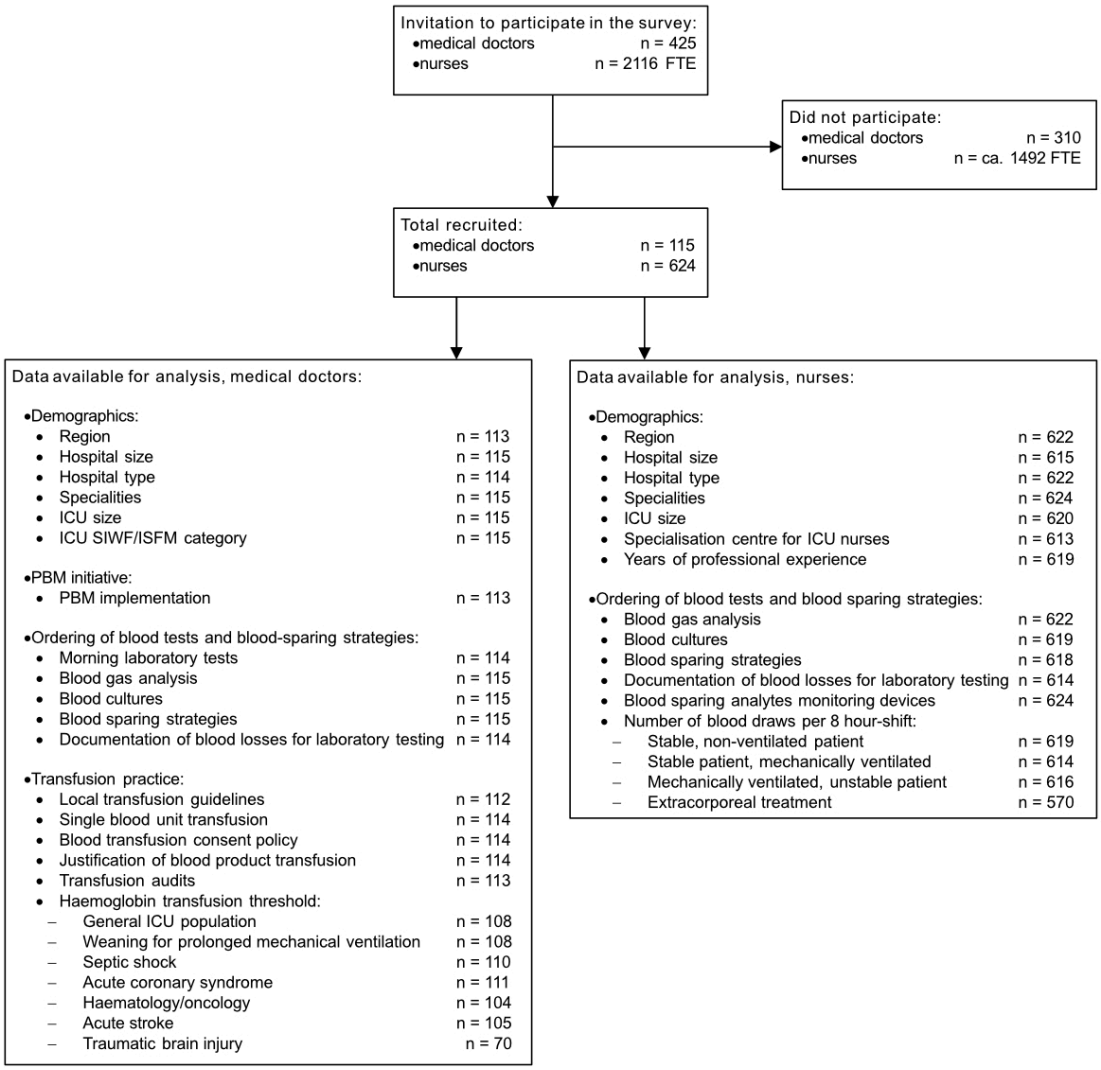
Patient blood management strategies in ICUs

Ordering of blood tests and blood sparing techniques

The laboratory tests were ordered in the following way: by the intensivist during morning rounds, 82/115 (71.3%); by a trainee, 15/115 (13.0%); according to routine procedures, 9/115 (7.8%) and specific protocols, 8/115 (7.0%); missing: 1 (0.9%). The larger the ICU, the less often the intensivist took direct care of this task (small ICUs, 13/14, 92.9%; small-medium ICUs, 29/36, 80.6%; medium-large ICUs, 15/20, 75.0%; large ICUs, 25/44, 56.8%).

According to the doctors, blood gas analyses were carried out in the following way: on medical indication, 88/115 (76.5%); according to a protocol, 8/115 (7.0%); on nurses' initiative, 19/115 (16.5%). Nurses reported autonomy in deciding on blood gas analysis according to 302 of 624 responses (48.4%; missing: 2, 0.3%; autonomy according

Figure 1: Data flow.



to physicians compared with nurses, p <0.001, chi-square test of independence between profession and the reporting that blood gas analyses are carried out on medical indication). Blood cultures were obtained upon explicit medical request according to 114 of 115 doctors (99.1%) and 560 of 624 nurses (89.7%); missing nurses' answers: 5 (0.8%). ICUs had strategies to reduce blood loss from laboratory tests according to 263 of 624 nurses (42.1%; missing: 6, 1%) and 54 of 115 doctors (47.0%). As reported by the latter, the availability of strategies correlated with the presence of PBM (26/48, 54.2%; no PBM, 13/45, 28.9%; unknown PBM, 15/20, 75%; p = 0.006, Fisher's exact test of independence between PBM and the presence of strategies to reduce blood loss; missing: 2, 1.7%). According to nurses, measures applied were to return the blood withdrawn to clear the line before sampling, use of small volume laboratory tubes and closed blood sampling devices for 74 of 263 (27.8%), 27 of 263 (10.3%), and 200 of 263 (74.5%), respectively. Figure 3 shows the nurse-reported blood draws per 8-hour shift from patients in four different clinical conditions. In a clinically stable, nonventilated patient, 296 of 624 (47.4%, missing: 5, 0.8%) would perform no sampling. In stable, mechanically ventilated patients, 392 of 624 (62.8%, missing: 10, 1.6%) would draw blood

Table 1:
Respondents' demographics.

Demographics		Doctors, n = 115 (%)	Nurses, n = 624 (%)
Number of hospital beds	<200	28 (24.3)	81 (13.0)
	200–500	54 (46.9)	223 (35.7)
	>500	33 (28.7))	311 (49.8)
	Missing	0	9 (1.4)
Type of institution	Regional hospital	33 (28.7)	129 (20.7)
	Cantonal hospital	41 (35.7)	186 (29.8)
	University hospital	23 (20.0)	251 (40.2)
	Private hospital	17 (14.8)	56 (9.0)
	Missing	1 (0.9)	2 (0.3)
Major region of Switzerland (No. of ICUs)	Lake Geneva (13)	24 (20.8)	77 (12.3)
	Midland (14)	23 (20.0)	133 (21.3)
	Northwestern Switzerland (11)	9 (7.8)	17 (2.7)
	Zurich (13)	25 (21.7)	231 (37.0)
	Eastern Switzerland (10)	13 (11.3)	46 (7.4)
	Central Switzerland (10)	11 (9.6)	57 (9.1)
	Ticino (6)	8 (7.0)	61 (9.8)
	Missing	2 (1.7)	2 (0.3)
Medical specialities available in the structure	Cardiac surgery	50 (43.5)	357 (57.2)
	Trauma centre	58 (50.4)	364 (58.3)
	Haematology/oncology	93 (80.9)	464 (74.4)
	Organ transplant surgery	29 (25.2)	250 (40.0)
	None of the above	20 (17.4)	99 (15.9))
	Missing	0	0
Number of ICU beds	<7 (small ICU)	14 (12.2)	52 (8.3)
	7–10 (medium-small ICU)	36 (31.3)	188 (30.1)
	11–15 (medium-large ICU)	20 (17.4)	173 (27.7)
	>15 (large ICU)	45 (39.1)	207 (33.2)
	Missing	0	4 (0.6)
SIWF/ISFM category of the ICU	Au	19 (16.5)	
	A	41 (35.7)	
	B	23 (20.0)	
	C	15 (13.0)	
	None	17 (14.8)	
	Missing	0	
Daily presence of an intensivist in the ICU (h/d)	<12	26 (22.6)	128 (20.5)
	12–18	37 (32.2)	115 (18.4)
	>18	51 (44.3)	377 (60.4)
	Missing	1 (0.9)	4 (0.6)
Specialisation centre for ICU nurses	Yes		569 (91.2)
	No		37 (5.9)
	Unknown		7 (1.1)
	Missing		11 (1.8)
Professional experience (yr)	<2		94 (15.0)
	2–5		113 (18.1)
	5–10		121 (19.4)
	>10		291 (46.6)
	Missing		5 (0.8)

ICU: intensive care unit; SIWF/ISFM: Swiss Institute for Medical Education.

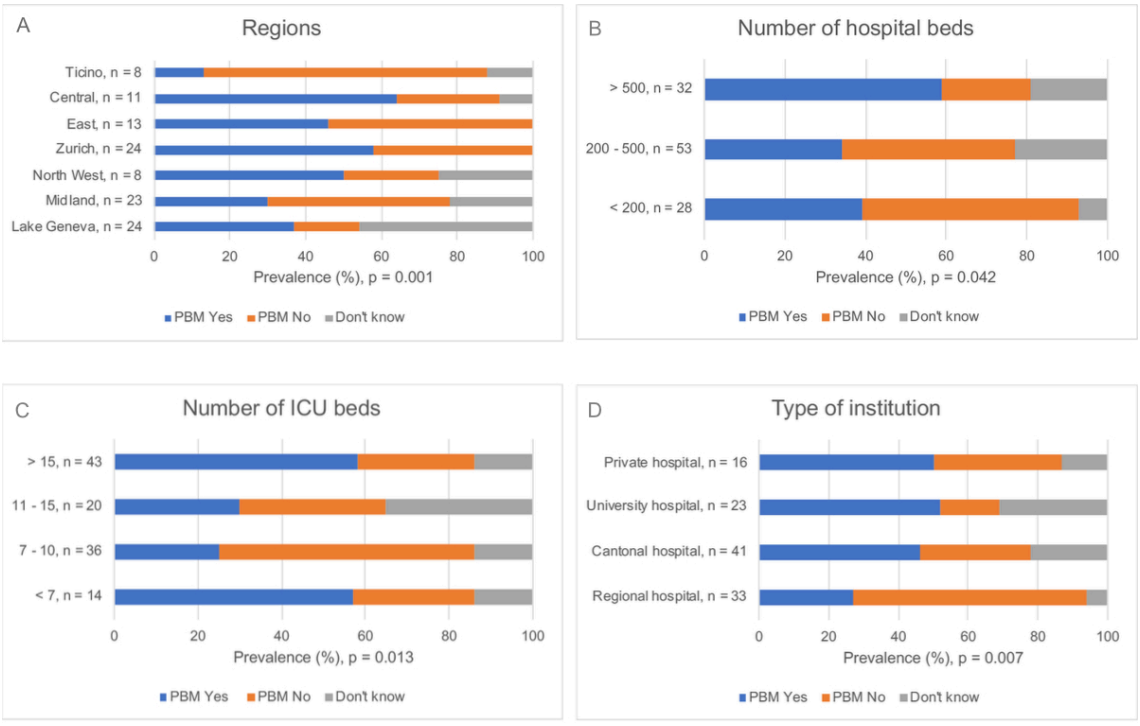
once or twice, and in mechanically ventilated unstable patients, 372 of 624 participants (59.6%, missing: 8, 1.3%) would draw blood between three and five times. Finally, 299 of 624 (47.9%, missing: 54, 8.7%) would draw blood between three and five times from patients undergoing extracorporeal treatment. We found no association between the number of blood draws from patients and the interviewees' work experience or the presence of an intensive care physician in hours per day. Only 2.6% of doctors (3/115, missing: 1, 0.9%) and 3.0% of nurses (19/624, missing: 10, 1.6%) documented daily blood losses for laboratory testing. More than three quarters (484/624, 77.6%) of the nurses used some blood-sparing analyte monitoring devices: end-tidal-CO_2 (430/624, 68.9%); noninvasive haemoglobin monitoring by pulse co-oximetry (50/624, 8.0%); and continuous intravascular glucose monitoring (2/624, 0.4%).

Transfusion practice

Local ICU transfusion guidelines were available according to 67 of 115 intensivists (58.3%; missing: 3, 2.6%), mainly in hospitals adhering to the patient blood management initiative (PBM available, 38/47, 80.9%; no PBM, 23/45, 51.1%; unknown PBM, 6/20, 30.0%; p <0.001, Fisher's exact test of independence between PBM and the presence of ICU transfusion guidelines). The median reported haemoglobin transfusion threshold in nonbleeding ICU patients was 70 g/l in 82/115 (71.3%), below 70 g/l in 15/115 (13.0%), and above 70 g/l in 11/115 (9.6%); (missing: 7,6.1%). Participants applied the same threshold to patients with prolonged weaning from mechanical ventilation (91/115, 79.1%; below 70 g/l, 2/115, 1.7%; and above 70 g/l, 15/115, 13.0%; missing: 7, 6.1%) and to haematology/oncology patients (79/115, 68.7%; below 70 g/l, 13/115, 11.3%; and above 70 g/l, 12/115, 10.4%; missing: 11, 9.6%). Respondents reported higher haemoglobin transfusion thresholds for patients with an acute coronary syndrome (80 g/l, 65/115, 56.5%; below 80 g/l, 5/115, 4.3%; and above 80 g/l, 41/115, 35.7%; missing: 4, 3.5%). We observed the most substantial variation in transfusion thresholds for patients with septic shock (70 g/l, 48/115, 41.7%; below 70 g/l, 2/115, 1.7%; above 70 g/l, 60/115, 52.2%; missing: 5, 4.3%), acute ischaemic stroke (80 g/l, 45/115, 39.1%; below 80 g/l, 32/115, 27.8%; above 80 g/l, 28/115, 24.3%; missing: 10, 8.7%), and traumatic brain injury (80 g/l, 21/115, 18.2%; below 80 g/l, 23/115, 20.0%; above 80 g/l, 26/115, 22.6%; missing: 45, 39.1%).

The single-unit blood transfusion policy was associated with a PBM programme (22/48, 45.8%; no PBM, 6/45, 13.3%; unknown PBM, 2/20, 10%; p <0.001, Fisher's exact test of independence between PBM and the presence of a single-unit blood transfusion policy; missing: 2, 1.7%), but only 30 of the 115 intensivists (26.1%; missing: 1, 0.9%) operated it as a standard measure in clinically stable patients. Just 34 of 115 intensivists (29.6%; missing:

Figure 2: Bar graph showing the percentage of physicians working in hospitals that joined the patient blood management initiative according to different institutional characteristics. Panel A shows significant differences in the PBM prevalence between the seven Swiss major regions (p = 0.001, (Fisher's exact test of independence between PBM and the Swiss region). Panel B shows the degree of implementation according to the hospital size. Compared with other respondents, those from hospitals with more than 500 beds more commonly reported the presence of the PBM initiative (OR 3.91, 95% CI 1.48–10.4; p = 0.006, logistic regression coefficient). Panel C shows the degree of PBM implementation according to the number of ICU beds. Participants from large and small ICUs reported more commonly than those from medium-small or medium-large units that their ICU had implemented PBM (p = 0.013, Fisher's exact test of independence between PBM and number of beds in the ICU). Finally, Panel D depicts PBM dissemination according to the type of institution. Regional hospitals less often adhered to the PBM initiative (p = 0.007, Fisher's exact test of independence between PBM and type of hospital). PBM indicates Patient Blood Management, ICU indicates intensive care unit.



1, 0.9%) were able to obtain informed consent before blood transfusions. Among the 115 interviewees, 24 (20.9%; missing: 1, 0.9%) had to provide justifications to blood bank physicians prior to administering allogeneic blood products. This requirement applied to packed red blood cells (20/24, 83.3%), platelet concentrates (24/24, 100%) and fresh frozen plasma (17/24, 70.8%), and regarded underlying clinical conditions (23/24, 95.8%), laboratory values (17/24, 70.8%) and the planned procedure (9/24, 37.5%). Approximately one third of responding physicians (41/115, 35.7%; missing: 2, 1.7%) participated in transfusion audits, mainly if a PBM programme was in place (24/48, 50.0%; no PBM, 13/45, 28.9%; unknown PBM, 4/20, 20.0%; p = 0.005, Fisher's exact test of independence between PBM and presence of transfusion audits; missing: 2, 1.7%).

Discussion

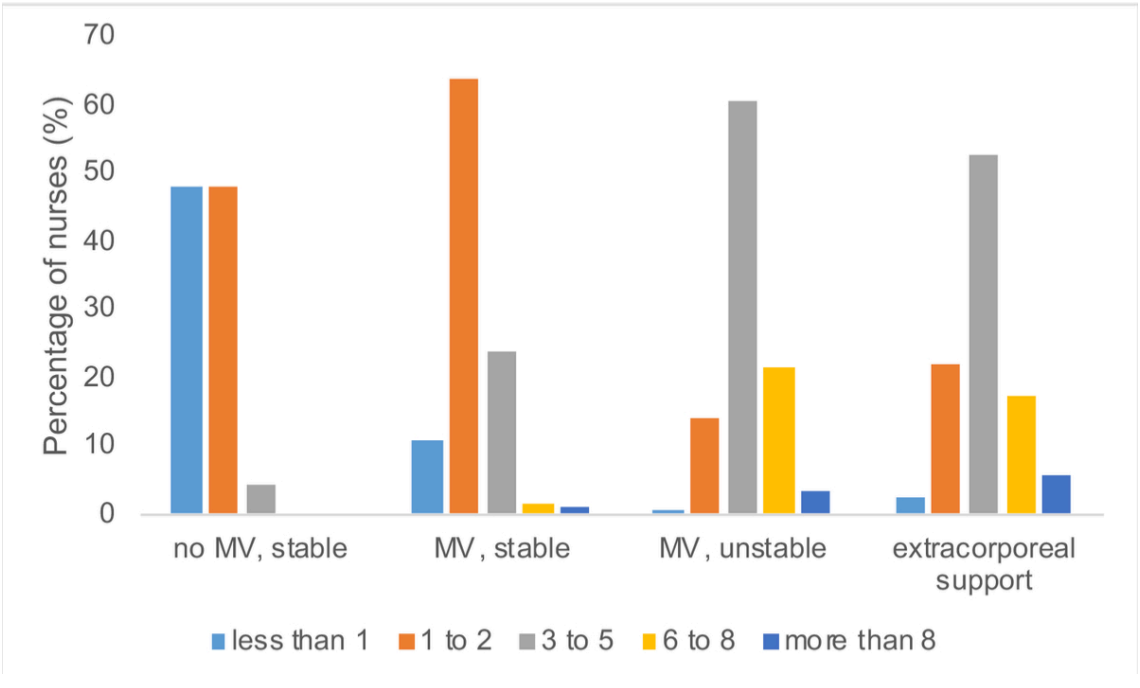
The main findings of our survey are: (1) moderate and variable dissemination of patient blood management strategies in hospitals of different regions and sizes; (2) liberal blood sample collection practice with extensive decision-making autonomy for ICU nurses; (3) lack of blood-sparing strategies regardless of a high number of daily blood draws; and (4) firm adherence to international guidelines on transfusion thresholds.

The World Health Organization (WHO) has been urging member countries to implement patient blood management since 2010 [24]. Nevertheless, its prevalence in Swiss adult ICUs and hospitals is still low, with significant variability between regions and hospital types. The fragmented Swiss federal healthcare system, where each of the twenty-six cantons is responsible for organising hospital services in its territory, might explain why only half of the participants from large hospitals and private institutions and a quarter from regional hospitals had a well-structured patient blood management programme. In approximately two thirds of European countries, several hospitals, professional societies and medical associations currently endorse patient blood management. Italy has even imposed its widespread introduction by law [25]. However, patient blood management implementation in Europe is still limited, and considerable variations exist [18, 26].

The WHO defines anaemia as a condition in which the number of red blood cells is insufficient to meet the body's physiological needs, with a haemoglobin level of less than 130 g/l in men and 120 g/l in women at sea level [27,28]. It is considered an epidemic that affects a large proportion of hospitalised patients. Accordingly, upon admission to the ICU, mean haemoglobin levels vary between 100 and 115 g/l, depending on the origin and age of the patients, with approximately two thirds having haemoglobin less than 120 g/l [29]. Over time, the haemoglobin levels converge towards 90–100 g/l irrespective of the admitting value [30–32]. Critically ill patients are among the primary recipients of allogeneic blood transfusions, with ICU transfusion rates ranging between 33% and 75% [33, 34], which is of concern, both in terms of safety and efficacy and for economic reasons [35–37]. Since low haemoglobin and anaemia have a central role in increasing the risk of transfusion and adverse outcomes [38], their prevention and optimal management are cornerstones of patient blood management. A routine application of this strategy can benefit patients admitted to surgical ICUs and generate fewer transfusions, better outcomes and reduced costs [39]. Probably other patients admitted to ICU can also take advantage of careful management of all the factors favouring anaemia.

One potentially modifiable risk factor for developing hospital-acquired anaemia is unnecessary diagnostic blood draws. In our survey, blood sample collection was handled rather liberally and seemed poorly regulated by protocols. Nurses managed independently about half of arterial blood

Figure 3: Number of blood draws per 8-hour shift in four clinical settings. MV: mechanical ventilation



gas tests, which doctors might not be fully aware of, given the difference on this point recorded in the nurses' and medical doctors' investigation. Of note, the number of necessary samples is unclear and depends on many factors, such as the clinical picture, the therapies applied (e.g., anticoagulation) and, potentially, the availability of noninvasive methods for monitoring specific parameters. In line with the literature [30, 40], our investigation revealed increasing diagnostic blood draws with the severity of patients' disease. Several approaches have shown the potential to avoid excessive laboratory tests. A set of changes encompassing physician and nursing staff education and several structural modifications (elimination of standing orders, laboratory order review during daily rounds, limitation of gasometer cartridges to those for blood gas analysis) reduced blood test orders by one third [41]. Additionally, group assessments of the potential of each arterial blood gas test to change patient management achieved a 60% assay reduction with no negative impact on the patient outcome [42].

According to the survey results, there was virtually no documentation of the daily iatrogenic blood loss, even in centres participating in the patient blood management initiative, suggesting it is still considered unavoidable or negligible. Only one third of survey participants had closed blood sampling devices available, and less than 5% used small laboratory tubes, a valuable way to reduce blood waste and the need for blood transfusion [40, 43, 44]. The discarded first millilitres of the infusate-blood mixture obtained when collecting blood from a fluid-infusing catheter represent avoidable waste that causes significant blood loss [45]. In addition, most blood collected in standard volume laboratory tubes will be discarded as current laboratory instruments require only a small amount of dead volume and process only a few microlitres.

Local ICU transfusion guidelines were available for only approximately 60% of respondents, mainly in centres with patient blood management. These crucial recommendations promote implementation and process and enhance sustainability. They should emphasise the need to individualise procedures, including not only haemoglobin-based transfusion triggers but also the patient's risk profile, laboratory values (e.g., platelet count, coagulation testing, lactate), the presence of active bleeding, and physiological factors.

General transfusion guidelines may not apply to critically ill patients for many reasons, such as frequent imbalances between tissue oxygen supply and requirements during critical illness, impaired erythropoiesis secondary to inflammation and iron sequestration, risk of iatrogenic anaemia, and increased risk of transfusion-related morbidity and mortality [46]. Furthermore, uncertainties remain regarding optimal transfusion thresholds for some everyday situations in the ICU, such as acute neurological injury, acute coronary syndrome, critically ill adults with malignancies, elderly patients or those undergoing extracorporeal membrane oxygenation (ECMO). According to our respondents, the median haemoglobin transfusion threshold for the nonbleeding ICU population was 70 g/l and, for the other investigated subcategories, it was consistently at the lower limit of those proposed by current ICU-specific guidelines [47]. This shows that staff training and education may lead to tangible results. Furthermore, it might partially explain the year-long decline in demand for packed red blood cells observed by the Swiss Red Cross [48].

Our survey indicated poor adherence to the single-unit transfusion policy. Nevertheless, the nonemergent administration of single units consistently reduced the consumption of allogeneic blood products in several observational studies, proving to be of greater health and economic interest [49–51] and finding a place in transfusion guidelines as a crucial element of the Optimal Blood Use concept [52, 53].

According to our investigation, transfusion medicine personnel only marginally supervised blood transfusions, and only a minority of institutions performed transfusion audits. However, the collaboration between clinicians and blood bank physicians could help optimise transfusion practice and set up medical logic and best practice alerts in the electronic medical records to audit blood products. In addition, it might be a prerequisite for developing a PBM-related metrics programme to identify potential areas for improvement and allow continuous benchmarking between PBM centres.

This survey's strengths are the broad but careful look at many aspects of patient blood management in Swiss ICUs and hospitals, and the substantial number of respondents from the medical and nursing categories. However, some limitations must be listed. First, the survey response rate among doctors was approximately 27%, and that of nurses can only be estimated based on full-time equivalents (30%). Although in line with other incentive-free surveys directly involving the hospital staff [54–58], our survey's response rate shows that patient blood management has not yet gained the attention of the broad medical establishment and limits the representativeness of our results. Second, the anonymous nature of the survey precludes determination of the number of participants per hospital or how many hospitals have implemented a patient blood management programme. The survey was open to all ordinary medical members of the Swiss Society of Intensive Care Medicine and all registered ICU nurses, and we did not attempt to limit the number of responses from any one institution. Therefore, the results might overly represent certain hospitals. A top-down survey approach addressed to unit heads might have avoided sampling bias and obtained more comprehensive data about patient blood management dissemination in the hospitals, but compromised the participants' anonymity. Additionally, our inquiry also aimed to investigate the actual practice in the departments, where the management can vary at least in part depending on the people involved. Third, an excess of professional caregivers with a particular interest in patient blood management may have participated in the survey, potentially influencing some conclusions, such as a more frequent implementation of patient blood management in the German-speaking regions of Switzerland. Fourth, the interviewees might be unaware of aspects unrelated to the ICU, such as detecting and treating preoperative anaemia before hospitalisation. Therefore, some survey results may only illustrate the participants' level of knowledge on some protocols and not the objective situation per se. Fifth, we evaluated the preferred transfusion trigger by asking for

the haemoglobin threshold in patients without inadequate oxygen delivery. We did not further investigate the role of comorbidities or other clinical markers (e.g., hypotension, tachycardia, elevated lactate level, significant ECG changes), which most intensivists consider crucial, together with haemoglobin levels, to guide transfusion [59]. Sixth, due to the study design, multivariate analysis was not appropriate. As a result, it was impossible to exclude confounding variables from the observed associations. Finally, as with any clinical practice survey, the participants' responses might differ from actual practices.

Conclusion

The reported prevalence of patient blood management in Swiss ICUs and hospitals is limited and displays significant variability between regions and hospital types. The risk of iatrogenic anaemia is relevant because of liberal blood sample collection practices and the underuse of blood-sparing techniques. The reported transfusion thresholds suggest excellent adherence to current international ICU-specific transfusion guidelines.

The Swiss Society for Intensive Care Medicine should coordinate a national multidisciplinary collaborative to identify patient blood management practice gaps and critical organisational issues to implement a Swiss patient blood management programme, overcoming the difficulties caused by a fragmented health system. The group's main working area should be developing patient blood management guidelines covering the appropriate management of preoperative anaemia and haemostasis, implementing blood-sparing strategies, creating PBM-specific protocols and updating transfusion guidelines on optimal blood use.

Individual hospitals should incorporate the collaborative group's advice and invest in employee training.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Author contributions

MP helped conceptualise and design the study, acquire and analyse the data, draft and revise the manuscript and approved the final version to be published. JC helped conceptualise and design the study, acquire the data, draft and revise the manuscript and approved the final version to be published. BC helped design the study, acquire and analyse the data, draft and revise the manuscript and approved the final version to be published. BG helped draft the manuscript and approved the final version to be published. AH helped conceptualise the study, draft the manuscript and approved the final version to be published. AFC helped draft the manuscript and approved the final version to be published. AS helped draft the manuscript and approved the final version to be published. DLR helped draft the manuscript and approved the final version to be published. SC helped draft the manuscript and approved the final version to be published. MPa helped draft the manuscript and approved the final version to be published. AP helped conceptualise and design the study, acquire and analyse the data, draft and revise the manuscript and approved the final version to be published.

Conflicts of interests

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. BC reports consulting fees paid to his institution from the Swiss Society of Intensive Care Medicine and having stocks from Air Liquide. BG reports grants (unrestricted research grant) and personal fees from Pfizer; personal fees and funding for accredited continuing medical education from Sanofi, Alnylam and Thermo Fisher Scientific; during the conduct of the study, funding for an accredited continuing medical education programme from Axonlab, Bayer, Bristol Myers Squibb, Daiichi-Sankyo, Janssen, Mitsubishi Tanabe Pharma, NovoNordisk, Octapharma, Takeda, Sanofi, SOBI; nonfinancial support from Axonlab and Thermo Fisher from outside the submitted work. AH reports personal fees and financial support during the past 36 months from Celgene, G1 Therapeutics, PBMe Solutions, Takeda SA, Vifor Pharma AG, Vision Plus, Werfen; personal honoraria for lectures from Heart Team Education Association Switzerland, Korean Surgical Society, Med Ed Global Solutions France; Takeda SA, Vifor Pharma AG, Vision Plus and Werfen. AS reports that Alliance Rouge currently supports implementing a PBM programme in his institution. No potential conflict of interest was disclosed.

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Variability Among Modalities, Practices, Indications, Requests of haEmatic products and blood Samplings in Swiss ICUs – the Swiss VAMPIRES Cross-sectional Survey on Patient Blood Management

Appendix A. Medical doctors' survey

1. General questions

1.1. In what kind of hospital do you work (please select the highest degree)?
- ☐ Regional hospital
- ☐ Cantonal hospital
- ☐ University hospital
- ☐ Privat clinic

1.2. How many beds are there in your hospital?
- ☐ less than 200 beds
- ☐ between 200 and 500 beds
- ☐ more than 500 beds

1.3. In which region of Switzerland is your hospital situated?
- ☐ Lac Leman (GE, VD, VS)
- ☐ North-west (AG, BL, BS)
- ☐ East (AI, AR, GL, GR, SG, SH, TG)
- ☐ "Mittelland" (BE, FR, SO, JU, NE)
- ☐ Ticino (TI)
- ☐ Zurich (ZH)
- ☐ Central Switzerland (LU, OW, NW, SZ, UR, ZG)

1.4. Which of the following specialities are present in your hospital (multiple answers possible)?
- ○ Cardiac surgery
- ○ Polytrauma (Highly specialized medicine)
- ○ Haematology/Oncology
- ○ Organ transplantation surgery
- ○ None of the above

2. Blood management at the hospital level

2.1. Does your hospital run an institutional initiative to implement Patient Blood Management (PBM) principles broadly?
- ☐ Yes
- ☐ No
- ☐ I don't know

2.2. If yes, which parts of PBM are concerned (multiple answers allowed)?
- ○ Preoperative detection and correction of anaemia
- ○ Minimization of intra-/ and postoperative blood loss
- ○ Optimization of anaemia tolerance and transfusion reduction

2.3. Has your hospital implemented a “single blood unit transfusion policy” as an institutional guideline?

- Yes
- No
- I don’t know

2.4. Does your hospital have the policy to inform patients before transfusion (e.g. consent form)?

- Yes
- No
- I don’t know

2.5. If yes, how do you estimate the rate of patients/next of kin in your ICU who signs a consent form for blood and blood products?

- 80%
- 50-79%
- 20-49%
- <20%
- I don’t know

2.6. Do you have to document and justify the prescription of blood products to the blood bank physicians?

- Yes
- No
- I don’t know

2.7. If yes, for which product (multiple answers possible)

- Packed red blood cells
- Platelet concentrate
- Fresh frozen plasma
- Other

2.8. If “Other”, please specify: _____

2.9. If yes, what justification is required (multiple answers possible)

- Clinical condition
- Laboratory values
- Scheduled surgery/procedure
- Other

2.10. If “Other”, please specify: _____

2.11. Are clinical transfusion audits performed at your hospital?

- Yes
- No
- I don’t know

3. Questions regarding your Intensive Care Unit (ICU)

3.1. How many beds are there in your ICU?
- ☐ 1 to 6 beds
- ☐ 7 to 10 beds
- ☐ 11 to 15 beds
- ☐ 16 or more beds

3.2. Which is the SIWF/ISFM category (postgraduate training) of your intensive care unit?
- ☐ Au
- ☐ A
- ☐ B
- ☐ C
- ☐ none

3.3. Laboratory tests (apart from blood gas analyses) are usually:
- ☐ Discussed and determined by the intensivist during the rounds
- ☐ Defined by a protocol tailored to the clinical condition
- ☐ Determined and requested by the trainee on duty
- ☐ Performed by default (ICU routine)
- ☐ Other

3.4. If “Other”, please specify: _____

3.5. Are blood gas analyses usually made after medical requests?
- ☐ Yes, only after a medical request
- ☐ Yes, but sometimes they are decided by nurse staff on their own
- ☐ No, there is a medical nursing protocol
- ☐ No, blood gas analyses are usually decided by nurse staff

3.6. Are blood cultures usually made after medical requests?
- ☐ Yes, only after a medical request
- ☐ Yes, but sometimes they are decided by nurse staff on their own
- ☐ No, there is a medical nursing protocol
- ☐ No, blood cultures are usually decided by nurse staff

3.7. Does your ICU provide strategies to minimize blood loss when taking samples for lab tests?
- ☐ Yes
- ☐ No
- ☐ I don’t know

3.8. If yes, which strategies (multiple answers allowed)?
- o Paediatric tubes are used routinely also for adults patients
- o Blood conservation devices (e.g. *view image*)
- o The blood used to prime the line of an indwelling vascular catheter is returned to the patient
- o Other

3.9. If “Other”, please specify: _____

3.10. Is the daily blood loss due to blood samplings quantified and charted?
- ☐ Yes
- ☐ No
- ☐ I don't know

3.11. Are there standard operating procedures available in your ICU regarding transfusion practices?
- ☐ Yes
- ☐ No
- ☐ I don't know

3.12. If yes, what protocols are available (multiple answers possible)?
- ○ Management of anaemia
- ○ Coagulation management
- ○ Massive haemorrhage
- ○ Peripartum haemorrhage

3.13. Does your ICU receive a periodic report from the blood bank?
- ☐ Yes
- ☐ No
- ☐ I don't know

3.14. If yes, what information is part of the report (multiple answers possible):
- ○ Consumption of blood concentrates
- ○ Consumption of coagulation factor concentrates
- ○ Rate of transfusion episodes with one unit
- ○ Indications for transfusion
- ○ Indications for coagulation factor concentrates
- ○ Blood products discard rate
- ○ Number of transfusion complications
- ○ Other

3.15. If "Other", please specify: _____

3.16. Which is in daily routine your actual transfusion trigger apart from inadequate O2-delivery?

g/l	< 60 ± 5	60 ± 5	70 ± 5	80 ± 5	90 ± 5	100 ± 5	Not applicable
General ICU population	○	○	○	○	○	○	○
Weaning from mechanical ventilation	○	○	○	○	○	○	○
Septic shock with inadequate O2-delivery	○	○	○	○	○	○	○
Acute coronary syndrome with ischemia	○	○	○	○	○	○	○
Traumatic brain injury	○	○	○	○	○	○	○
Acute ischemic stroke	○	○	○	○	○	○	○
Haematology/ oncology	○	○	○	○	○	○	○

Variability Among Modalities, Practices, Indications, Requests of haEmatic products and blood Samplings in Swiss ICUs – the Swiss VAMPIRES Cross-sectional Survey on Patient Blood Management

Appendix B. Nurses' survey

1. General questions

1.1. In what kind of hospital do you work (please select the highest degree)?
- ☐ Regional hospital
- ☐ Cantonal hospital
- ☐ University hospital
- ☐ Private clinic

1.2. How many beds are there in your hospital?
- ☐ Less than 200 beds
- ☐ Between 200 and 500 beds
- ☐ More than 500 beds

1.3. In which Swiss region is your hospital situated?
- ☐ Lac Leman (GE, VD, VS)
- ☐ Noth-west (AG, BL, BS)
- ☐ East (AI, AR, GL, GR, SG, SH, TG)
- ☐ „Mittelland" (BE, FR, JU, NE, SO)
- ☐ Ticino (TI)
- ☐ Zurich (ZH)
- ☐ Central Switzerland (LU, OW, NW, SZ, UR, ZG)

1.4. Which of the following specialities are present in your hospital (multiple answers possible)?
- ○ Cardiac surgery
- ○ Polytrauma (Highly specialized medicine)
- ○ Haematology/Oncology
- ○ Organ transplantation surgery
- ○ None of the above

1.5. How many years have you been working as a nurse with an intensive care certificate in this department?
- ☐ Less than two years
- ☐ Between two and five years
- ☐ Between five and ten years
- ☐ More than ten years

1.6. How many beds are there in your ICU?
- ☐ 1 to 6 beds
- ☐ 7 to 10 beds
- ☐ 11 to 15 beds
- ☐ More than 15 beds

2. Blood draws

2.1. Are blood gas analyses usually made after medical requests?
- ☐ Jes, only after medical request
- ☐ Jes, but sometimes they are decided by nurse staff on ist own
- ☐ No, there is a medical nursing protocol
- ☐ No, blood gas analyses are usually decided by nurse staff

2.2. How many times on average do you draw blood (including blood gas analysis) from a **patient who receives no mechanical ventilation and is clinically stable** during an eight-hour work shift?
- ☐ Less than once
- ☐ Once to two times
- ☐ Three to five times
- ☐ Six to eight times
- ☐ More than eight times

2.3. How many times on average do you draw blood (including blood gas analysis) from a **patient who receives mechanical ventilation and is clinically stable** during an eight-hour work shift?
- ☐ Less than once
- ☐ Once to two times
- ☐ Three to five times
- ☐ Six to eight times
- ☐ More than eight times

2.4. How many times on average do you draw blood (including blood gas analysis) from a **patient who receives mechanical ventilation and is clinically unstable** during an eight-hour work shift?
- ☐ Less than once
- ☐ Once to two times
- ☐ Three to five times
- ☐ Six to eight times
- ☐ More than eight times

2.5. How many times on average do you draw blood (including blood gas analysis) from a **patient on extracorporeal support** (e.g. continuous renal replacement therapy) during an eight-hour work shift?
- ☐ Less than once
- ☐ Once to two times
- ☐ Three to five times
- ☐ Six to eight times
- ☐ More than eight times

2.6. The collection of blood cultures (timing, number, sampling point) is usually:
- ☐ Decided by the medical doctor
- ☐ Regulated by a protocol
- ☐ I don’t know

2.7. Does your ICU provide strategies to minimize blood loss when taking samples for blood tests?
- ☐ Yes
- ☐ No
- ☐ I don’t know

2.8. If yes, which strategies (multiple answers allowed)?
- o Paediatric tubes are used routinely also for adults
- o Blood conservations devices (e.g. view image)
- o The blood used to prime the line on an indwelling vascular catheter is returned to the patient
- o Other

2.9. If “Other”, please specify: _____

2.10. Is the daily blood loss due to blood samplings quantified and charted?
- □ Yes
- □ No
- □ I don’t know

2.13. Which non-invasive/continuous methods for measuring biological variables do you use in your intensive care unit (multiple answers allowed)?
- o None
- o Masimo SpHb
- o etCO2
- o Braun Space GlucoseControl
- o GlySure (kontinuerliche Blutzuckermessung)
- o OptiScanner 5000 (Blutzucker Monitoring)
- o OptiScanner 6000 (Blutzucker und Laktat Monitoring)
- o Other

2.14. If “Other”, please specify: _____