Letter to the Editor

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The economic burden of hemolysis

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To the Editor,

The goal of healthcare systems is to provide the optimal treatment to the patient. However, an exact diagnosis is the prerequisite for an effective treatment. It was estimated that 70%–80% of all healthcare decisions that influence the clinical decision making involve one or more laboratory investigations, with individual's treatment decisions and the monitoring of their response to treatment, often dependent on laboratory-based diagnostics [1]. However, as financial resources are limited, economic issues must be considered, in order to achieve best value for the patient, making our healthcare system as efficient as possible and fundable for future generations. A reduction of errors during the laboratory process is one way to reduce costs, since these errors might not only lead to possibly harmful consequences for the patient, but also causes repeated specimen collection and analyses, thus resulting in an unjustifiable increase in costs. It is well documented, that within the total laboratory process, errors most frequently occur in the extranalytical phase with the vast majority within preanalytical processes [2]. Hemolytic blood specimen are the foremost preanalytic cause of sample rejection, which, according to a survey of 453 laboratories, occurs five times more frequently than the second most cited reason, insufficient specimen quantity to perform the requested test [3]. We therefore tried to investigate the economic impact of hemolysis to our budget and screened current literature for respective calculations, aiming to perform similar calculations with our own data. However, to the best of our knowledge, according calculations are rare [4, 5]. We therefore aimed to quantify the consequential costs of hemolytic blood specimen, and to properly illustrate the financial consequences of a change in hemolysis rates. We calculated in a way, so that further investigators are able to apply our findings to their own setting.

We divided these expenses into material, personnel and analytical costs. As blood collection can be performed by needle, butterfly system or IV catheter, three variants of material costs were calculated, always including one tube holder and two collection tubes. To calculate personnel costs, we estimated the time needed for a blood collection, including all steps from test ordering to preparation for transportation. As blood collection in our hospital is performed by the nursing staff, a mean of the respective hourly wages was used for calculation [6]. Analytical costs were calculated using the two most commonly used scales of charges of medical laboratory analyses in Germany [7, 8]. These sums reflect the chargeable prize and not just the laboratory costs of the specific parameter. However, we chose to use these numbers, since laboratory costs depend on reagent prize, personnel costs and costs for the analytical device, all of which varying substantially between laboratories. As also the chargeable amounts in the official two scales differ from each other, we calculated costs and hypothetical cost reductions for both, displaying them as a respective range of costs. As harmonization in hemolysis measurement as well as respective cut-off values are still missing, we chose to refer to the hemolysis index (HI), which is measured by the COBAS analyzers (Roche, Switzerland), with a HI of 1 being equal to a concentration of 1 mg/dL

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of free hemoglobin [9, 10]. As HI cut-off for each parameter measureable on these analyzers, we used the official documents and packaging inserts of the manufacturer. These cut-offs define a HI value for each analyte, which corresponds to the point where the test analyte differs by more than 10% from the respective baseline. In order for the reader of this article to apply our findings to their own setting and to be able to calculate the economic impact of hemolysis reduction within their hospital, we refrained from hemolysis categories like mild, intermediate and severe. We rather grouped hemolysis into 16 HI ranges, and calculated the respective analysis costs (Table 1). To estimate overall costs of hemolysis in a clinical setting, we additionally set up a hypothetical situation. In this setting, which approximately reflects the situation in a common hospital, we assumed 20,000 laboratory orders monthly where blood collection is performed by the nursing staff using a butterfly system. Hemolysis rates were estimated as realistic as possible. Also, we simulated a 10% reduction of hemolysis within this setting, to be able to estimate the financial benefit of efforts towards this goal (Table 2).

Material costs for blood collection using a needle, a butterfly system or an IV catheter were €0.19, €0.35 and €0.76, respectively. Personnel costs for a nurse spending estimated 10 min on average on one blood collection were €4.75. Analyses costs for the different hemolysis groups rise with increasing HI, since more parameters get affected (Table 1). When applying hypothetical percentages for each hemolysis group, the financial burden would range from €67,570 to €122,077, depending on the scale of charge in use. After applying additional percentages, illustrating an assumed reduction of 10% in hemolysis rates, the cost reduction ranges accordingly from €6757 to €12,208 per month (Table 2). These calculations presume that every parameter listed in the respective HI group in Table 1 was measured in every laboratory order and therefore had to be reanalyzed. In a clinical setting this rarely would be the case and therefore the overall costs would diminish respectively.

As hemolytic blood specimen are the most common reason for sample rejection and analyses repetition, a reduction in hemolysis rates should be one of the top goals of a laboratory to be able to provide the highest possible quality in analytics and to prevent possible harm to the patient due to inappropriate further investigations or even wrong treatment. Despite the quality issue, the outcome of our work impressively elucidates the financial impact of this economically underrated issue and reveals a possibility of cost saving to the healthcare system.

Jacobs et al. estimated monthly analytical costs of £4355 (~€6000) due to repeated measurements of hemolytic specimen, based on 60 emergency admissions per day, not taking material or personnel costs into account [4]. Lippi et al. calculated overall material and personnel costs of €19,535 for 38,009 samples which had to be recollected due to hemolysis over a 12-month period, accounting for 22.8% of all samples collected in this time [5]. When trying to project these numbers on our hypothetical setting of 20,000 orders per month, monthly analytical costs of Jacobs et al. are approximately €66,667, whereas material and personnel costs by the work of Lippi et al. sum up to €2348 per month. Separately calculating costs in our own study yielded €58,348 for material and personnel, and a range from €9223 to €63,729 for analytical costs. This demonstrates clearly, that the financial impact of hemolysis is highly dependent on the respective setting and the extent of hemolyis. We hope that our work can serve as basis for calculation of consequential costs due to hemolytic specimen in different settings.

As limitation to this work, it should be mentioned, that we focused on frequently ordered analytes in clinical chemistry. Analytes from other laboratory specialties, which are also influenced by hemolysis, such as coagulation parameters, were not taken into account, as we had no defined HI cut-off levels [11]. Also, as described above, the analytic costs used in our setting reflect the chargeable prize, rather than sole laboratory costs. Additionally, our calculations might not be adaptable to settings using different analytical measurements and estimations of hemolysis, apart from the one described above, as there is no harmonization between these measurements yet [9]. Also the analytical interference of hemolysis differs between the tests and reagents in use. Finally, we only calculated primary costs of hemolysis. Secondary costs have to be considered, but are very hard to put in numbers. Such costs could be caused by prolonged time to diagnosis and subsequent delayed treatment onset with a respectively extended hospital stay or by further inappropriate investigations.

In conclusion, the financial importance of hemolysis has been demonstrated. To further reduce hemolysis on a larger scale, harmonization of hemolysis measurements and defined HI cut-offs are desperately needed. One first approach to compare hemolysis rates all over the world could be the quality indicators project of the IFCC Working Group “Laboratory Errors and Patient Safety” [12, 13]. We want to urge each laboratory to measure hemolysis as a quality indicator and to further depict how a respective

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Table 1: Analytical costs of hemolysis.

Parameter	HI cut-off[a]	HI group													
		10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–100	101–200	201–300	301–400	401–500	500–999
Lactate dehydrogenase	10	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Aspartate aminotransferase	25		*	*	*	*	*	*	*	*	*	*	*	*	*
Bilirubin (direct)	25		*	*	*	*	*	*	*	*	*	*	*	*	*
Bilirubin (total)	50					*	*	*	*	*	*	*	*	*	*
Alanine aminotransferase	60						*	*	*	*	*	*	*	*	*
Iron	80								*	*	*	*	*	*	*
Potassium	100									*	*	*	*	*	*
Creatine kinase	100									*	*	*	*	*	*
Hs-Troponin T	100									*	*	*	*	*	*
g-Glutamyltransferase	200										*	*	*	*	*
Phosphorus	300											*	*	*	*
Magnesium	400														*
Alkaline phosphatase	500														*
Amylase	500														*
Ferritin	500														*
Lipase	500														*
Triglyceride	500														*
Total Protein	650														*
Cholesterin	700														*
Creatinine (Jaffé)	750														*
Cholinesterase	850														*
Glucose	850														*
CRP	950														*
Analysis costs (GOÄ)		2.33	8.74	8.74	8.74	11.07	13.41	13.41	15.74	31.48	33.81	36.14	36.14	36.14	80.44
Analysis costs (EBM)		0.25	0.90	0.90	0.90	1.15	1.40	1.40	1.65	13.40	3.65	14.05	14.05	14.05	23.50

*Affected by hemolysis; [a]HI cut-off at which the respective parameter is altered by more than 10% compared to baseline. GOÄ and EBM are scales of charge for Germany – GOÄ, Gebührenordnung für Ärzte [7]; EBM, Einheitlicher Bewertungsmaßstab [8].

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Table 2: Hypothetical model for estimation of the financial impact of hemolysis.

Hemolysis index (HI)	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–100	101–200	201–300	301–400	401–500	500–999	
HI, %	35	12	4.5	1.8	1.2	0.8	0.5	0.2	0.3	0.6	0.2	0.1	0.05	0.01	
€[a] GOÄ	51.985	33.211	12.454	4.982	3.881	2.960	1.850	833	2.194	4.668	1.649	825	412	171	**€122.077**
€[a] EBM	37.415	14.388	5.396	2.158	1.499	1.039	650	270	1.110	2.249	766	383	191	57	**€67.570**
HI, % reduced	31.5	10.8	4.05	1.62	1.08	0.72	0.45	0.18	0.27	0.54	0.18	0.09	0.045	0.009	
€[a] GOÄ	46.787	29.890	11.209	4.484	3.493	2.664	1.665	750	1.975	4.201	1.484	742	371	154	**€109.869**
€[a] EBM	33.674	12.949	4.856	1.942	1.349	935	585	243	999	2.024	689	345	172	51	**€60.813**
											Cost reduction/month (GOÄ)				**€12.208**
											Cost reduction/month (EBM)				**€6.757**

[a]Hypothetical amount, calculated with 20,000 orders per month; blood collection by nursing staff using a butterfly system. HI, Hemolysis index. GOÄ and EBM are scales of charge for Germany – GOÄ, Gebührenordnung für Ärzte [7]; EBM, Einheitlicher Bewertungsmaßstab [8].

reduction of hemolysis rates would contribute not only to their quality improvement, but also to their economic situation.

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