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The YSI 2300 Analyzer Replacement Meeting Report

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Abstract

This is a summary report of the most important aspects discussed during the YSI 2300 Analyzer Replacement Meeting. The aim is to provide the interested reader with an overview of the complex topic and propose solutions for the current issue. This solution should not only be adequate for the United States or Europe markets but also for all other countries. The meeting addendum presents three outcomes of the meeting.

Keywords

YSI 2300; glucose; reference; standard; comparator

Introduction

For several decades, the YSI 2300 Stat Plus Glucose Lactate Analyzer (YSI 2300), manufactured by the US Company YSI, has been widely used as a comparator method in clinical and analytical studies of glucose. Meanwhile, even as new glucose analyzers came on line (including small portable ones), glucose meter manufacturers (and later continuous glucose monitoring [CGM] manufacturers) invested internally in YSI instruments, tied their development programs to that device, and thus resisted changing to other methods for comparison studies. The YSI 2300 became used so widely that many glucose meters and CGM manufacturers considered it to be a widely practiced procedure like an actual standard for comparison testing of glucose monitoring devices. This perception has been a barrier discouraging reliance on other candidate comparator devices. Furthermore, this perception has resulted in a standstill in further development of the YSI 2300 for about four decades, and this device has not been substantially improved since the 1970s.

Because glucose measurement represents a core parameter of many activities in the diabetes world, YSI's recent announcement to discontinue the YSI 2300 has stirred multiple activities. A publication by Han et al about this topic provides a good

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Figure 1. Photo of attendees at the YSI 2300 Analyzer Replacement Meeting.
Photo by Dan Shilstone, Diabetes Technology Society.

introduction into the topic and has a list of potential alternate US Food and Drug Administration (FDA) cleared and uncleared glucose analyzers.[1] There is little published information on the accuracy of these devices in the literature.

Thus, the Diabetes Technology Society organized a one-day meeting and invited a group of 60 academic, industry, government, and clinical experts to discuss the topic in a structured manner and propose a solution to two questions: (1) How accurate must a glucose comparator device be? And (2) Should a single comparator device be used by all manufacturers of glucose monitors?

This meeting took place on November 13, 2019, in Bethesda, Maryland. Most participants were from US manufacturers of medical products and the US FDA. However, a number of experts in glucose monitoring from Europe and other parts of the world, such as Germany and Denmark, also attended (see Figure 1).

Sessions during the meeting focused on a wide variety of topics. Oral reports presented various viewpoints and proposed solutions for the problem. After the lunch break, a series of four questions were discussed in separate breakout groups. Moderators and scribes of these groups subsequently presented their groups' views on the questions and discussed them with all the attendees.

US FDA representatives clarified that they have never formally identified a specific laboratory analyzer as the required comparator method for clinical and analytical studies of glucose measurement devices. Nevertheless, many sponsors and companies have perceived that they must use the "preferred" YSI 2300 for clinical studies that they submit to the US FDA. In other words, many companies perceived that the YSI 2300 was the de facto standard for the glucose monitor industry.

The YSI 2300, however, is no longer being produced by its manufacturer, YSI (YSI Incorporated, Yellow Springs, Ohio). According to the manufacturer, "Eventually there comes a point where new technology and innovation provides better features and benefits and those trustworthy meters are retired."[2] On July 2, 2021, YSI will no longer support the YSI 2300 with parts or supplies, such as tubing, reagents, and membranes.[3] Therefore, many manufacturers need to find a replacement for the discontinued YSI 2300 or establish a different procedure.

YSI has developed a successor to the YSI 2300, which is the YSI 2900 Biochemistry Series Analyzer (YSI 2900). This updated analyzer has improved communication and data storage options but has not been cleared by the US FDA. It measures a number of parameters, in addition to glucose. The glucose methodology of the YSI 2900s reported by YSI is identical to that of the YSI 2300.

YSI has also developed the YSI 2500 Glucose/Lactate Analyzer (YSI 2500), which measures glucose (and lactate), but this system is also not US FDA cleared. YSI is considering applying for a 510(k) clearance (statement by K. Schleuter from YSI to Lutz Heinemann during the breakout session). This would require a significant investment. A decision by YSI will be made soon.

Session 1: How is Comparator Performance Defined and Selected?

Scientific Approach to Selecting a Comparator by Rolf Hinzmann (Roche Diabetes Care)

In his introductory talk, Rolf Hinzmann, Head of Global Medical & Scientific Affairs Glucose Monitoring & Science at Roche Diabetes Care, summarized the metrological background for glucose measurement. Metrology is the science of measurement. He referred to the International Vocabulary of Metrology (VIM) for an important definition: "2.7 **reference measurement procedure**: Measurement procedure accepted as providing measurement results fit for their intended use in assessing measurement trueness. . ."

Notice that a specification for reference measurement procedure, not a specific device, is suggested by the VIM. A comparison method must have certain features, that is, be "fit for the intended use" to assess the trueness of self-monitoring of blood glucose (SMBG) or CGM.

The term "reference method" is often used differentially in different geographic areas:

- In the European Union (EU), this usually refers to a reference measurement procedure of high metrological order (eg, mass spectrometry).
- In the United States, this usually refers to any method that is used for comparison (eg, the YSI 2300, or "the hospital lab analyzer" is frequently regarded as a reference method).

It is probably best to call glucose analyzers like any lab analyzer or the YSI 2300 a "comparison method." Comparison methods need to have certain features including a high degree of precision and trueness (together resulting in high accuracy) to assess the accuracy of systems used for SMBG or CGM. Therefore, its measurement results must have a suitable measurement uncertainty that is lower than that obtained with the methods it evaluates. However, the method or device (from a given manufacturer) is irrelevant from a metrological point of view. Each comparison method/device with a sufficient performance can be used.

Reasons for not recommending a specific device are:

- This device it is not necessarily the best comparison method.
- The outcome obtained with this device may vary considerably from lab to lab.
- It creates a monopoly for a manufacturer and discriminates all others (this is a legal problem in the EU, driven by the EU competition law).
- It takes the freedom of choice from the manufacturer or evaluating lab to choose their desired method (this is again a legal problem in the EU).
- Different manufacturers/evaluating labs have different requirements in terms of throughput, sample type (whole blood, principal component analysis [PCA] treated blood, plasma), ease of operation, portability, and so on.
- The device might not be readily available everywhere.
- It hinders scientific progress if better comparison methods become available.
- At the end of its life cycle, another Replacement Meeting is required.

In clinical chemistry, two quite different but complementary models are used to describe the error associated with a measurement:

Total error model. This model assumes that random error (imprecision, measured by the coefficient of variation [CV] or standard deviation) and systematic error (trueness, measured by the bias) make up the total error of measurement. While imprecision is easy to measure, bias is not because bias is defined as the difference between the mean of a set of repetitive measurement values and the "true" value. However, what is the "true" value? It is theoretically impossible to measure the true value. In practice, values obtained with the comparison method (or "predicate device" according to the 510(k) approach in the United States) are often defined to be the "true" value, which leads to the situation that different comparison methods lead to different "true" values—a contradiction.

Measurement uncertainty model. This model starts with the reference material, which has an assigned glucose value that has already some uncertainty associated. This material is then used to calibrate a reference method and every step (weighing, filling up a volume, reading a voltage, etc) adds to the uncertainty of the measurement result. The larger the number of steps in the traceability chain, the larger the measurement uncertainty of the result obtained with the method at the end of the chain. The measurement uncertainty model does not require a "true" value. An official Guideline describing how to calculate and estimate the Uncertainty in Measurement (GUM) does exist.

Although total error and measurement uncertainty have the same units (eg, mg/dL, mmol/L, and %), they are not the same. Values obtained for measurement uncertainty are higher than those obtained for the total error.

Traceability is necessary for any comparison method. It is also necessary to know the measurement uncertainty since both are part of the same concept: Stating that a method is traceable without stating the measurement uncertainty is like saying that the water is hot without stating the temperature. The "degree" of traceability is determined by the measurement uncertainty.

For all glucose measurements, a traceability chain needs to be established, linking glucose measurements to the reference material SRM 917 (and the SI units). It consists of a hierarchy of glucose materials (calibrators) and methods. The European IVD Regulation requires manufacturers to establish a traceability chain for all analytes as part of the CE mark process. The need for a traceability chain is also mentioned in the ISO 15197:2013 standard (*in vitro diagnostic test systems—Requirements for blood-glucose monitoring systems for self-testing in managing diabetes mellitus*) and in the ISO 17511:2003 standard (*in vitro diagnostic medical devices—Measurement of quantities in biological samples—Metrological traceability of values assigned to calibrators and control materials*).

The evaluating laboratory should preferably be accredited and have a quality system in place, which includes internal quality controls combined with external quality assurance.

In summary, Rolf Hinzmann suggested that minimum performance criteria for a comparison method should be given (eg, for traceability, uncertainty, and commutability of calibrators). In addition, minimum criteria for the evaluating lab should be defined (eg, accreditation, quality system, internal quality control, and external quality assurance). He also warned against possible bias introduction from method comparisons and automatically trusting the clinical laboratories.

Abbott Method for a Glucose Reference and Potential Alternate Solutions by Shridhara Alva (Abbott Diabetes Care)

For manufacturers of blood glucose monitoring (BGM) and CGM systems such as Abbott, the YSI 2300 has been the essential comparator for four decades. Portability, ease of operation, and cost effectiveness are key benefits. Switching to a new device would be a massive undertaking requiring numerous changes in procedures, training of employees and study sites, standard operating procedures (SOPs), and so on, which would be associated with an increase in costs. This is a concern for all glucose monitor manufacturers.

Abbott performs hundreds of blood glucose test strip validations and CGM validation studies every year. Any new comparator method should be at least as good as the YSI 2300. The big laboratory analyzers that measure numerous other parameters are expensive, complex, not portable, and so on. The 510(k) database of the US FDA lists only Radiometer ABL 90 Flex Plus (see below) and some point-of-care (POC) testing systems with diagnostic claims as alternative comparator method solutions. However, the POC testing systems are cost prohibitive requiring larger sample volumes, and their glucose measurement accuracy is not much better than handheld blood glucose systems. The precision of the Radiometer ABL 90 Flex Plus system was comparable to that of the YSI 2300 over a large glucose range. Abbott's comparison of the analytical performance of the YSI 2300 and the YSI 2900 showed a high degree of accordance, which is not surprising as the methodology is identical in both systems. For Abbott, it would be ideal if YSI gets the YSI 2500 (the YSI 2500 has significantly fewer configurable parameters compared with the YSI 2900) cleared by the US FDA; however, validation of a comparator method based on an agreed protocol would also be an option for them. Such a protocol would include daily quality control measurements.

Roche Method for a Glucose Reference and Potential Alternate Solutions by Matthias Appel (Roche Diabetes Care Quality Control)

Already 20 years ago, Roche established a true reference measurement procedure for glucose measurement with an ID-GC/MS (isotope dilution gas chromatography mass spectroscopy) aligned hexokinase method. According to the ISO 15179 standard for blood glucose systems, the metrological traceability of such systems according to ISO 17511 is required (see above). This includes the use of reference measurement procedures, NIST reference material, evaluation of matrix effects, and demonstrated commutability. Such a procedure fulfills high requirements with respect to minimal and stated uncertainty according to GUM (ISO Guide 98-3), and so on. Measurement uncertainty meant by ISO 17511 and GUM is not just CV or bias or total error but is mathematically more complex, covering all possible input variables of the procedures including blood glucose systems themselves. All blood glucose meters produced by Roche are tested in this established system in order to guarantee that these fulfill high measurement requirements. Mass spectrometry is a quite complex and cumbersome method, which allows 40 measurements per week only, but with an extreme low measurement uncertainty of 1.7%. For practical purposes, the hexokinase method is used, which is linked to mass spectrometry. The hexokinase method is standard in clinical chemistry and allows a high throughput with a very low uncertainty of 3.0% in described setup. For sample preparation, perchloric acid is used to stabilize glucose in deproteinized blood and plasma samples to measure them in a highly standardized and specialized central lab instead on a clinical study site. As can be expected, glucose measurements with this system fulfill all requirements with ease in external ring trials. Alternative available reference materials and reference measurement procedures can be found in the JCTLM database. Roche Diabetes Care is using a Cobas 6000 system for the hexokinase method and calibration of their BG meters.[4]

Regulatory Considerations in Selecting a Comparator Method by Alain Silk (US FDA)

Alain Silk, the Branch Chief for Diabetes Diagnostics at the US FDA, presented the regulatory considerations for a 510(k) Premarket Notification and a Premarket Approval. When discussing different glucose measurement options, he also highlighted that the US FDA has never required or recommended the YSI 2300; that is, they do not favor a single specific comparator method. From a regulatory perspective, the US FDA identified the characteristics of a good comparator method as:

- A laboratory-based method.
- Well validated for precision and accuracy.
- Traceable to a higher order.
- Well-controlled traceability chain.

Glucose analyzers that have 510(k) clearance by the US FDA are listed in a respective database, and this database should be used by manufacturers to identify a comparator. Manufacturers of cleared comparator methods are required to have an established quality system (21 CFR 820) and comply with other regulatory requirements. According to the US FDA, the comparator method should be robust, precise, accurate, and usable at study sites. In his presentation, Silk focused not only on analytical studies for blood glucose meters but also on clinical trials.

Session 2: What is Current Comparator Performance?

View From a Test Lab in San Diego, California by Linda Morrow (Prosciento)

Linda Morrow, the Chief Medical Officer of Prosciento, first described the kind of studies Prosciento performs and why glucose measurements are important for clinical research organizations (CROs). Morrow reiterated the inherent challenges in reference methods and comparator methods that included the need for routine calibration, well-defined SOPs, study site vigilance, and training. From the CRO perspective, the level of accuracy and acceptance among sponsors are strong reasons the YSI 2300 has become ubiquitous. Morrow then showed how Prosciento evaluated the performance of the YSI 2300 in comparison to that of the YSI 2900 in four subjects over several days. A hexokinase method with NIST standard material was used as reference method. Measurements were performed on an ABL 90 FLEX PLUS from Radiometer. The glucose range measured goes up to 900 mg/dL. As to be expected (see above), the measurement results for blood and plasma samples were highly comparable. Measurement quality in the glucose range below 100 mg/dL should also be good although no detailed analysis was presented. Based on this analytical comparability, Morrow recommended YSI to seek clearance according to 510(k) for the YSI 2900.

View From a Test Lab in Ulm, Germany by Stefan Pleus (Institut für Diabetes-Technologie)

In his presentation, Stefan Pleus discussed the Institut für Diabetes-Technologie's experience with different alternative comparator devices. This institute is accredited by the German accreditation body for ISO 15197 studies. Their HemoCue study found that compared to the Roche Integra Cobas 400 plus, the HemoCue 201 RT is easy to use but showed considerable difference in bias. Their study featuring six POC devices (three handheld devices and three bench top chemistry devices) showed that there are considerable differences in bias and in apparent precision of the devices. Their third study comparing the YSI 2300 with the YSI 2900 found considerable systematic difference between the two devices. Pleus ended his presentation by saying that a suitable comparator device should simply show adequate performance, which would be enough as a comparator method.

A Method for Optimizing Comparator Accuracy That is Independent From the Specific Device Used by Guido Freckmann (Institut für Diabetes-Technologie)

Guido Freckmann from the Institute of Diabetes Technology at the University of Ulm discussed methods to optimize comparator accuracy and reduce bias. He showed data of how mass spectrometry can be used to markedly reduce bias. He also showed how using split samples of the NIST material can be used to reduce bias and optimize accuracy. Freckmann emphasized the importance of a lab to verify bias and precision with commutable control material.

Session 2 Panel Discussion

In the panel discussion, speakers talked about importance of quality reference standards, access to reference standards, possible need for daily calibrations, post-hoc versus pre-hoc calibration, and the difficult to obtain but beneficial internal expertise for maintaining comparator methods. Panelists raised the concern that among both current and future comparators, the practicability of the method and routine calibration of methods that is consistent between groups and devices are going to be persistent challenges. A representative of YSI stated that one reason why they did not immediately seek clearance for their next generation glucose analyzers was that clearance would require a software upgrade to the YSI 2300 that would have to include a resource-intensive validation of newer software (over 75 000 lines of code).

Session 3: Potential Future Solutions

Technology for the YSI 2300, 2500, and 2900 by Kevin Schlueter (YSI)

YSI, the manufacturer of the most widely used glucose analyzer for serving as a comparator with glucose monitor studies, gave a detailed review of the history of the YSI 2300. The presentation also highlighted that no significant changes were made to the system for many decades and that little systematic evaluation of the performance of this system was required when it was cleared by the US FDA in 1975. YSI also performed a comparison study between the YSI 2300 and the YSI 2900. As to be expected, there was a high linearity between the measurement results. More relevant were the statements about the YSI 2500: this is not verified for compliance to 21CFR11. The YSI 2500 does not accept custom calibrators. Several changes were made to the YSI 2500 in comparison to the 2900 to reduce the price for the system in order to lower it sales price. From this presentation, it was not clear how the YSI will proceed with their glucose analyzers.

Radiometer ABL90+ Analyzer Technology by Stephan Bess (Radiometer)

As the Global Market Leader in Lab/POCT for critical care in clinical settings, Radiometer is a global manufacturer of these blood gas analyzers with 80+ years of experience. They offer a variety of analyzers, but only the ABL

90 Flex Plus is appropriate as a possible comparator. This system measures 17 different parameters rapidly (35 seconds) in a small blood sample (65 µL) with good performance. It is designed for a high throughput, requires no maintenance, and is easy to use. The device runs Automatic QC and internal Calibrations that are NIST Traceable. The device only weighs 11 kg, and it is truly portable and a perfect option for both clinical field trials and bench work taking up minimal space (width 25 cm, height 47 cm, and depth 29 cm). The ABL 90 Flex has already been cleared by the US FDA for whole blood glucose measurements. It has a large dynamic range on glucose of 0-1081 mg/dL. ABL90 measures a glucose activity in the plasma phase but readout is a glucose concentration in plasma. ABL90Flex plus can be interfaced ASTM/HL7/ POCT1-A and is wireless capable. ABL90 Flex plus can operate for one hour on operational battery.

Super GL Technology by Matthias Hartwig (Dr. Müller Gerätebau)

The manufacturer of the Super GL is based in Germany. This company offers different types of glucose analyzers, all with a CE-mark for Europe; however, none of them are US FDA cleared. To obtain a 510(k) approval in the United States, Dr. Müller will have to fulfill several requirements. Super GL's glucose measurement is based on a modified Clark electrode with an enzymatic measurement (glucose oxidase). The current version of the system requires a manual preparation step, that is, a 10 µL blood sample must be diluted in 500 µL hemolysate system solution. After cooling, this hemolysate sample is stable for 12 hours. Ideally, the Super GL (or a successor) would have automatic sample handling in order to reduce the risk of handling errors by the user. The glucose measurements are performed within 30 seconds and the system allows use of glucose standards, that is, the measurements are traceable. The measurement properties were compared with those obtained with a hexokinase method and showed a good agreement. A clear advantage is that the Super GL corrects glucose values to the measured hematocrit and not according to a standard formula or a manual correction.

Accuracy of POC Blood Analyzers for Measuring Glucose by Mark Rice (Vanderbilt University)

POC systems for blood glucose measurement have undergone considerable development in the last decade. Some of these devices now have an analytical performance that is close to that of laboratory systems. They offer several advantages: they are smaller, faster, less complex, more affordable, and often require less blood compared with central laboratory systems. Therefore, certain blood glucose systems and single-use systems may represent an alternative for measurement. Rice went through a series of several different POC options (iStat, HemoCue, and blood gas analyzers), and compared their performance as well as drawbacks with central laboratory devices. He also pointed out that most physicians have a limited understanding of the differences and nuances of comparators used to calibrate devices that they routinely use.

Session 4: How Accurate and Precise Must a Comparator Be? (Panel Discussion)

James Nichols (AACC), David Sacks (CAP), Hubert Vesper (Centers for Disease Control and Prevention), Courtney Lias (US FDA), and Lutz Heinemann (Profil Institut) participated in this panel discussion. There were multiple different perspectives to the same question: "How accurate and precise must a comparator be?" James Nichols highlighted that different types of devices are not directly comparable with each other (some devices only accept plasma samples, whereas others can only utilize whole blood, and there are few that can accept both types of samples). Courtney Lias from the US FDA emphasized once again the importance of a traceability chain. The panel stated that there is no single accuracy consensus for these devices and concluded to leave it up to the manufacturer to choose a comparator method that best fits their intended use. They also mentioned the difficulty of achieving accuracy and precision in clinical trial settings.

Session 5: Breakout Groups

Attendees broke out into four groups to discuss the following four questions:

- How accurate or precise?
- What level of human factors?
- Should every company use the same comparator? (why, why not, advantages, and disadvantages)
- What is the best solution to the current problem?

Session 6: Summaries of Breakout Groups

Moderators from each breakout group summarized main points from each of their discussions.

Groups came up with the following guidelines in choosing a comparator method based on the different perspectives of each attendee:

- Manufacturers need to consider clinical outcome, biological variation, and state of the art.
- Any device that is considered an analyzer may be used as a comparator.
- Manufacturers should assess the analyzer in their intended environment and develop a standardized protocol.

- Labs need to select a comparator that will work for their clinical trials.
- Manufacturers need to consider skew, bias, and possible interferences to the comparator method.
- The FDA should provide guidance for requirements for initial and interim calibration of a comparator method for accreditation of sites, including sample preparation. This includes clarifying which standard is required to demonstrate accuracy (ie, NIST or commercial calibrators).

Session 7: Where Do We Go Next? (Panel Discussion)

Shridhara Alva (Abbott Diabetes Care), Todd Cullen (ARKRAY), Daniel Brown (Ascensia Diabetes Care), Stayce Beck (Dexcom), David Shearer (LifeScan), Robert Vigersky (Medtronic), Stephan Bess (Radiometer), Rolf Hinzmann (Roche Diabetes Care), Andrew Dehennis (Senseonics), and Kevin Schlueter (YSI) participated in the panel discussion. They concluded that manufacturers should have the freedom to choose a comparator method best fit for their intended use and purpose. Each participant highlighted the importance of communicating with one another. They all emphasized the value and importance of the one-day meeting, which allowed industry leaders to meet and openly communicate with one another.

Session 8: Conclusions by David Klonoff (Mills-Peninsula Medical Center)

Dr. David Klonoff summarized the eleven most important ideas that were presented at the meeting:

1. Every measurement has a measurement uncertainty.
2. The measurement uncertainty of any reference method/comparison method needs to be lower than that of the method it evaluates.
3. Traceability of measurement to a reference method/reference material is needed.
4. In order to define accuracy, we need a comparator.
5. Multiple comparison methods should be used so innovation is not stifled.
6. There is room for new comparator devices in the market since YSI may be leaving.
7. It would be helpful for YSI to stay longer on the market.
8. New comparators must be cleared by the US FDA and cannot be POC products or BGM strip analyzers based on current performance.
9. Companies may choose their own US FDA-cleared comparator for their intended use.
10. There are multiple factors that manufacturer need to consider when choosing a reference method (listed below).
11. Expect that comparator devices might leave the market as YSI has announced they are doing; the days of every glucose monitoring device manufacturer using the same comparator are over.

Thirteen factors that are of relevance when companies choose a comparator method:

1. Precision
2. Accuracy
3. Human factors/ease of use
4. Cost (upfront and disposables)
5. Portability
6. Measurement time
7. Lot-to-lot variability
8. Interfering substances
9. Blood volume
10. Maintenance
11. Calibration process
12. Substrate—plasma/whole blood
13. Training requirement

The attendees stated that the meeting clarified where we are in terms of comparator methods for glucose monitoring products. The attendees hope to receive follow-up soon from the three comparator method manufacturers about their products and plans. The plan for follow-up was for Diabetes Technology Society to prepare a summary of the meeting along with an addendum. This addendum will contain updated plans submitted to Diabetes Technology Society from the three comparator manufacturers who spoke at this meeting (YSI, Radiometer, and Dr. Müller Gerätebau), based on what they learned during this meeting. The plan was for a summary meeting report with an addendum to be distributed to meeting attendees early in 2020.

Addendum

After the YSI 2300 Analyzer Replacement Meeting, Diabetes Technology Society received the following updates from three of the participating comparator manufacturers.

*(*YSI*): As of December 20, 2019, YSI has approved a project to present an instrument to the FDA for validation and is moving it into the next stages of development (per Christopher Warner).

*(*Radiometer*): As of January 7, 2020, Radiometer has seven ongoing product evaluations with BGM and CGM companies comparing ABL90 technology to YSI. They plan to make a three-way method comparison between the YSI 2300, YSI 2950, and ABL90 FLEX PLUS (per Stephan Bess).

*(*Dr. Müller Gerätebau GmbH*): As of January 10, 2020, Dr. Müller Gerätebau GmbH has decided to apply for FDA clearance for selected devices of the SUPER GL series. They plan to have SUPER GL Technology available for the US market in 2021 (per Matthias Hartwig).

Abbreviations

BGM, blood glucose monitoring; CGM, continuous glucose monitoring; CROs, clinical research organizations; CV, coefficient of variation; EU, European Union; FDA, US Food and Drug Administration; GUM, Guideline describing how to calculate and estimate the Uncertainty in Measurement; PCA, principal component analysis; POC, point-of-care; SD, standard deviation; SOPs, standard operation procedures; SMBG, self-monitoring of blood glucose; YSI, Yellow Springs Instrument; VIM, Vocabulary of Metrology

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Declaration of Conflicting Interests

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Disclaimer

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