cobas® pulse

A system for measurement of glucose
manufactured by Roche Diagnostics GmbH

Report from the evaluation

SKUP/2023/130

organised by SKUP at the request of Roche Diagnostics in Norway and Denmark

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Attachments with raw data are included only in the copy to Roche Diagnostics A/S.

1. Summary

cobas pulse, glucose

Manufacturer	Roche Diagnostics GmbH
Supplier in Denmark	Roche Diagnostics A/S
Supplier in Norway	Roche Diagnostics Norge AS
Supplier in Sweden	Roche Diagnostics Scandinavia AB
Launched in Scandinavia	September 2022

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Aim

To assess the analytical performance and user-friendliness of glucose measurements with **cobas pulse** by intended users, which are health care personnel in the hospital as well as in primary health care.
The evaluation was performed by both experienced laboratory personnel in a hospital laboratory and by health care personnel in two primary health care centres.

Performance specifications		**Conclusion and results**
Repeatability	CV ≤4,0 %	Fulfilled by laboratory personnel (CV 1,8 – 2,3 %) Fulfilled by health care personnel (CV 3,1 – 4,0 %)
Accuracy ≥95 % of the results within the specified limits compared to the average result of the comparison method	±0,83 mmol/L at glucose concentration <5,55 mmol/L ±15,0 % at glucose concentration ≥5,55 mmol/L	Fulfilled by laboratory personnel (100 %)
User-friendliness	A total rating of "Satisfactory"	Fulfilled

Additional information

Participants	217 persons with diabetes. 100 from a hospital laboratory and 117 from two primary health care centres.
Evaluated method	**cobas pulse** (FAD-GDH method) on fresh capillary whole blood using two lots of test strips. Intended for professional use.
Comparison method	Roche cobas 8000 c 702 (glucose hexokinase method) on capillary plasma samples.
Bias	A positive bias of 0,16 mmol/L between **cobas pulse** and the comparison method.
Technical errors	1,2 %

Further information about the evaluation and the organisation of SKUP can be found on www.skup.org.

This summary is also published in Danish, Norwegian and Swedish at www.skup.org.

2. Abbreviations and Acronyms

APS	Analytical Performance Specification
BLS	Biomedical Laboratory Scientist
CI	Confidence Interval
C-NPU	Committee on Nomenclature, Properties and Units
CV	Coefficient of Variation
DANAK	The Danish Accreditation Fund
DEKS	Danish Institute of External Quality Assurance for Laboratories in the Health Sector
EDTA	Ethylenediaminetetraacetic acid
EQA	External Quality Assessment
Equalis	External quality assessment in laboratory medicine in Sweden
FAD-GDH	Flavin Adenine Dinucleotide-Dependent Glucose Dehydrogenase
FDA	Food and Drug Administration
HELFO	Norwegian Health Economics Administration
ISO	International Organization for Standardization
LADA	Latent Autoimmune Diabetes in Adults
NFKK	Nordic Federation of Clinical Chemistry
NIST	National Institute of Standards & Technology
Noklus	Norwegian Organization for Quality Improvement of Laboratory Examinations
PHCC	Primary health care centre
SD	Standard deviation
SI	International System of Units
SKUP	Scandinavian evaluation of laboratory equipment for point of care testing
SRM	Standard Reference Material

3. Introduction

The purpose of Scandinavian evaluation of laboratory equipment for point of care testing (SKUP) is to improve the quality of near-patient testing in Scandinavia by providing objective information about the analytical performance and user-friendliness of laboratory equipment. This information is generated by organising SKUP evaluations in point of care settings.

3.1. The concept of SKUP evaluations

SKUP evaluations follow common guidelines and the results from various evaluations are comparable[1]. The evaluation set-up and details are described in an evaluation protocol and agreed upon in advance. The analytical results and user-friendliness are assessed according to pre-set performance specifications. To fully demonstrate the quality of a product, the end-users should be involved in the evaluation. If possible, SKUP evaluations are carried out using three lot numbers of test strips from separate and time-spread productions.

3.2. Background for the evaluation

The **cobas pulse** measuring system for measurement of glucose in whole blood is produced by Roche Diagnostics GmbH. Roche Diagnostics AS Norge and Roche Diagnostics A/S are the requesting companies in this evaluation. The measuring system was launched into the Scandinavian market in September 2022.

3.3. The aim of the evaluation

The aim of the evaluation was to assess the analytical performance and user-friendliness of **cobas pulse** by intended users, which are health care personnel in the hospital as well as in primary health care. The evaluation was performed by both experienced laboratory personnel in a hospital laboratory and by health care personnel in two primary health care centres (PHCCs).

3.4. The model for the evaluation of cobas pulse

SKUP evaluations for quantitative methods are based upon the fundamental guidelines in a book concerning evaluations of laboratory equipment in primary health care [1].
The evaluation consists of two parts (figure 1). One part of the evaluation was carried out by experienced laboratory personnel. This part documents the performance of the measuring system under conditions as favourable as possible for achieving good analytical performance. The other part of the evaluation was carried out by health care personnel. This part documents the performance of the measuring system when used in primary health care. The report for this evaluation is based on the experiences from previous SKUP evaluations of measuring systems for glucose. The examination of bias and accuracy was not possible in primary health care as these capillary plasma samples for the comparison method had to be stored in a low-temperature freezer, which is not available in the PHCCs (see section 5.4.3).

[1] SKUP evaluations are under continuous development. In some cases, it may be difficult to compare earlier protocols, results and reports with more recent ones.

The evaluation included:

- Examination of the analytical performance (precision and accuracy) by experienced laboratory personnel
- Examination of haematocrit effect on the glucose measurements by experienced laboratory personnel
- Examination of analytical performance (precision only) by health care personnel in two PHCCs (PHCC1 and PHCC2)
- Evaluation of the user-friendliness of **cobas pulse** and its user guide.

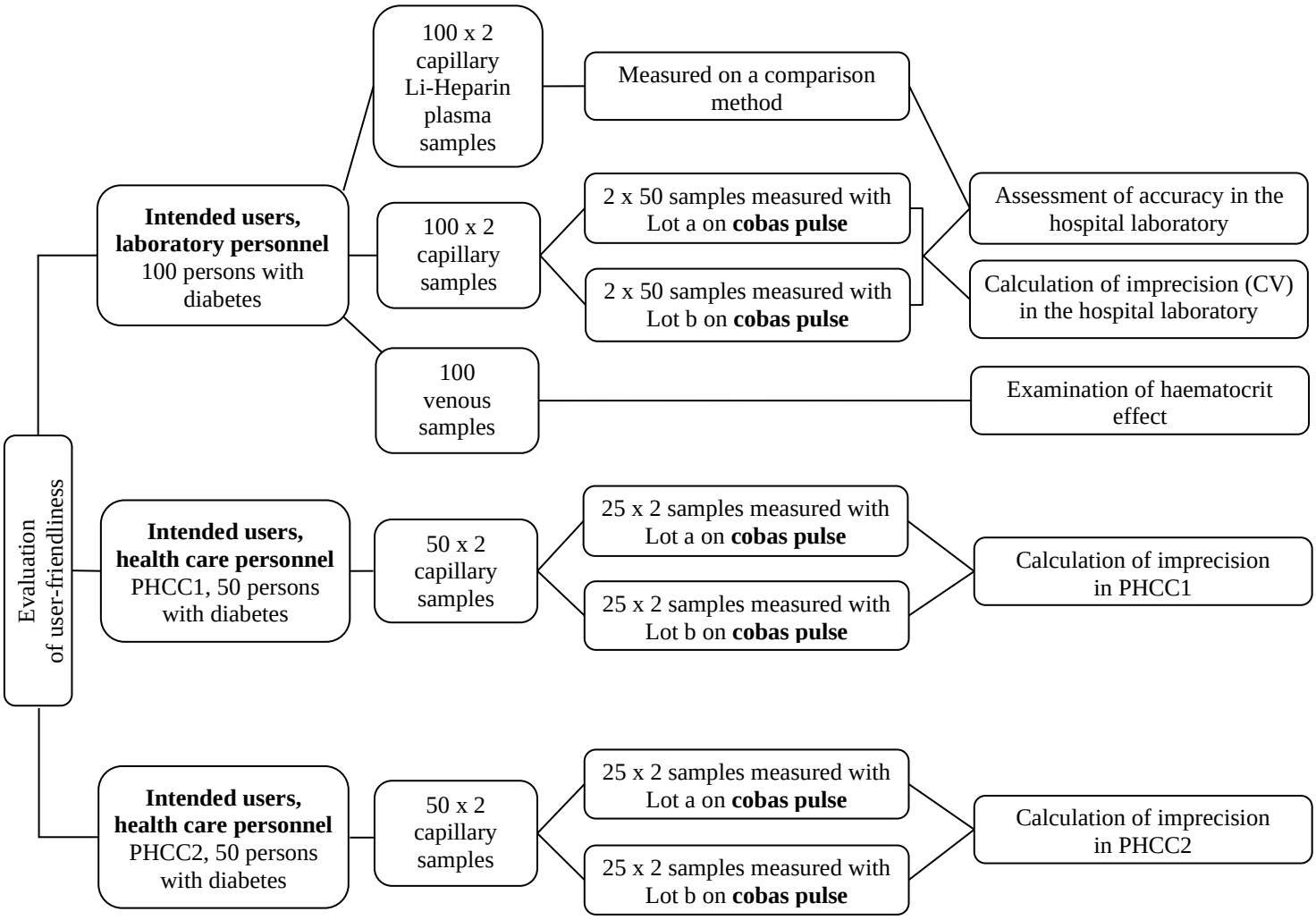

Figure 1. Flowchart illustrating the model for the evaluation of **cobas pulse.**

4. Performance specifications

4.1. Analytical performance specifications

The **cobas pulse** measuring system is designed for monitoring blood glucose near the patient, and the analytical performance specifications (APSs) are set according to this.

The International Organization for Standardization (ISO) 15197:2013 standard [2], is an international protocol for evaluating meters designed for glucose monitoring, and gives the following minimum acceptable accuracy requirement for measurements made by trained laboratory staff as well as measurements performed by persons with diabetes: At least 95 % of the individual glucose results shall fall within ±0,83 mmol/L of the average measured values of the reference measurement procedure at glucose concentrations <5,55 mmol/L or within ±15 % at glucose concentrations ≥5,55 mmol/L.

The Food and Drug Administration (FDA) guidance [3] recommends that blood glucose meters intended for professional use must at least have 95 % of the individual glucose results within ±0,67 mmol/L of the average measured values of the reference measurement procedure at glucose concentrations <4,17 mmol/L or within ±12 % at glucose concentrations ≥4,17 mmol/L; they should also achieve 98 % of the individual glucose results within ±0,83 mmol/L of the reference measurement procedure at glucose concentrations <4,17 mmol/L or within ±15 % at glucose concentrations ≥4,17 mmol/L.

In Denmark, the quality goals for point of care glucose measuring systems (capillary whole blood measurements) are a coefficient of variation (CV) <4 % and a bias <3 % [4].

In Norway, the standard protocol of Norwegian Health Economics Administration (HELFO) [5] follows the quality goal in ISO 15197:2013.

In Sweden, national quality goals for glucose measurements follow the requirements in ISO 15197:2013. Glucose meters used for monitoring some groups of patients, for example those using continuous glucose monitoring, where the glucose meter is used as a calibrator unit, and women with gestational diabetes, should fulfil stricter quality goals for accuracy. At least 95 % of the individual glucose results shall fall within ±0,42 mmol/L of the results of the comparison method at glucose concentrations <4,2 mmol/L or within ±10 % at glucose concentrations ≥4,2 mmol/L [6]. This stricter quality goal for accuracy applies to measurements performed in hospital laboratories and laboratories in PHCCs.

4.2. User-friendliness

The evaluation of user-friendliness was carried out by asking the evaluating persons in the hospital laboratory as well as in the PHCCs to fill in a questionnaire, see section 6.4.

Technical errors

SKUP recommends that the fraction of tests wasted due to technical errors should not exceed 2 %.

4.3. Principles for the assessments

To qualify for an overall good assessment in a SKUP evaluation, the measuring system must show satisfactory analytical performance as well as satisfactory user-friendliness.

4.3.1. Assessment of analytical performance

The analytical results were assessed according to APS set for the evaluation.

Precision

The decision whether the achieved CV fulfils the APS or not, is made on a 5 % significance level (one-tailed test). The distinction between the ratings, and the assessment of precision according to the APS, are shown in table 1. Based on the results from each glucose concentration level, an overall conclusion is drawn in the summary of the report.

Table 1. The rating of precision.

Distinction between the ratings	Assessment according to the APS
CV is equal to or lower than the APS (statistically significant)	The APS is fulfilled
CV is equal to or lower than the APS (not statistically significant)	Most likely the APS is fulfilled
CV is higher than the APS (not statistically significant)	Most likely the APS is not fulfilled
CV is higher than the APS (statistically significant)	The APS is not fulfilled

Bias

SKUP does not set a separate APS for bias. The confidence interval (CI) of the measured bias is used for deciding if a difference between the evaluated method and the comparison method is statistically significant (two-tailed test, 5 % significance level). The bias will also be discussed in connection with the accuracy.

Accuracy

The accuracy is illustrated in a difference plot for the results achieved by laboratory personnel with limits for the allowable deviation according to the APS. The fraction of results within the limits is counted. The lot numbers are indicated in the difference plot. The accuracy is assessed as either fulfilling the APS or not fulfilling the APS.

Effect of haematocrit

The effect of haematocrit is shown with a trend-line and a regression equation in a difference plot. The slope of the trend line is calculated with a CI of 95 %, to disclose if the haematocrit in the samples significantly affect the glucose measurements.

4.3.2. Assessment of user-friendliness

The user-friendliness is assessed according to the answers and comments given in the questionnaire (see section 6.4). For each question, the evaluator can choose between three given ratings: satisfactory, intermediate and unsatisfactory. The responses from the evaluators are reviewed and summed up. To achieve the overall rating "satisfactory", the tested equipment must reach the total rating of "satisfactory" in all four subareas of characteristics described in section 6.4.

Technical errors

The evaluating persons register error codes, technical errors and failed measurements during the evaluation. The fraction of tests wasted due to technical errors is calculated and taken into account in connection with the assessment of the user-friendliness. Possible technical errors include errors regarding the reading of the data matrix, errors in detection of the test strips, measuring errors and electronic errors. User errors related to the handling of the samples are not included in the calculation.

4.4. SKUP's performance specifications in this evaluation

As agreed upon when the protocol was drawn up, the results from the evaluation of **cobas pulse** are assessed against the following performance specifications:

Repeatability (CV) ..... ≤4,0 %

Allowable deviation of the individual result from the comparison method result (according to ISO 15197:2013)*
for glucose concentrations <5,55 mmol/L ..... ≤±0,83 mmol/L
and for glucose concentrations ≥5,55 mmol/L ..... ≤±15,0 %

Required percentage of individual results
within the allowable deviation limits……..... ≥95 %

User-friendliness, overall rating..... Satisfactory

*The number of results within a stricter Swedish quality goal (allowable deviation in the individual result from the comparison method result <±0,42 mmol/L at glucose concentration <4,2 mmol/L and <±10 % at glucose concentration ≥4,2 mmol/L) are reported, but not assessed in the report.

5. Materials and methods

5.1. Definition of the measurand

The measuring system intends to measure the substance concentration of glucose in blood plasma. The sample material in this evaluation is capillary blood. The results are traceable to SI (The International System of Units) and are expressed in the unit mmol/L. The Committee on Nomenclature, Properties and Units (C-NPU) systematically describes clinical laboratory measurands in a database [7]. The NPU code related to the measurand in this evaluation is NPU22089 (for random sample). In this report the term "glucose" will be used for the measurand.

5.1.1. Other variables measured

Another variable measured in the evaluation is haematocrit, expressed in %. The NPU code is NPU01961.

5.2. The evaluated measuring system cobas pulse

The information in this section derives from the company's information material.

The **cobas pulse** measuring system consists of:
cobas pulse instrument
cobas pulse charging station

The **cobas** GLU test strips and **cobas** GLU QC kit for the glucose measurement and internal analytical quality control measurement are purchased separately. A carry case for storing and transporting the **cobas pulse** instrument and consumables needed for performing blood glucose measurement is also available for purchase.

The **cobas pulse** measuring system is a hand-held instrument, intended for blood glucose monitoring by health care professionals when blood glucose levels are measured near the patient. The measuring system consists of a blood glucose instrument (figure 2) and a charging station with a power supply. The measurement principle is electrochemical; as glucose in the blood encounters the reagent on the test strip, the flavin adenine dinucleotide-dependent glucose dehydrogenase (FAD-GDH) enzyme oxidizes the glucose. During the reaction electrons are transferred to an electrochemical mediator, which then conveys these electrons to the surface of an electrode on the test strip, generating an electrical current. This current is measured by **cobas pulse**, and the strength of the current is translated into glucose concentration.

Figure 2. The **cobas pulse** instrument

cobas pulse reports the results as plasma glucose values. The measuring range is 0,6 – 33 mmol/L, measurements below are displayed on the instrument as LO <0,6 mmol/L and above as HI >33 mmol/L. After testing, the used test strip can be mechanically ejected from the instrument for disposal using the eject button on the display. The instrument can also be configured to eject the test strip before or after the test result confirmation.
All records stored on the instrument (test results, patient IDs, user IDs, etc.) can be automatically transferred to the data management system through the wireless local area network.

For technical details about the **cobas pulse** measuring system, see table 2. For more information about the **cobas pulse** measuring system, and name of the manufacturer and the suppliers in the Scandinavian countries, see attachment 1 and 2. For product specifications in this evaluation, see attachment 3.

Table 2. Technical details from the manufacturer.

Technical details for cobas pulse	
Sample material	Venous whole blood, arterial whole blood, capillary whole blood, neonatal heel prick, and neonatal arterial whole blood.
Sample volume	≥0,6 µL
Measuring time	<10 seconds
Measuring range	0,6 – 33,3 mmol/L
Tolerated haematocrit range	5 – 70 %
Storage capacity	2000 patient and 500 QC result records
Electrical power supply	Charging station with electrical cord, rechargeable battery, wireless charging.

5.3. The selected comparison method

A selected comparison method is a fully specified method which, in the absence of a Reference method, serves as a common basis for the comparison of the evaluated method.

5.3.1. The selected comparison method in this evaluation

The selected comparison method in this evaluation was a glucose hexokinase method implemented on Roche cobas 8000 c 702 in the hospital laboratory at the Department of Biochemistry and Immunology in Vejle. The method uses reagents from Roche Diagnostics. The method is accredited according to DS/EN ISO 15189 by The Danish Accreditation Fund (DANAK). The method is hereafter called “the comparison method”.

In addition, the samples for haematocrit were measured with Sysmex XN-9000 in the same laboratory.

Internal analytical quality control

Internal analytical quality control samples, two levels (Autonorm Clin Chem Liq L-2 and L-3, SERO), were measured each evaluation day on the comparison method.

External analytical quality control

The hospital laboratory participates in Labquality external quality assessment (EQA) scheme for glucose (Scheme code 2050, General chemistry, serum B and C) with two levels in six rounds per year. The sample material is fresh frozen pooled human serum, some of them modified to reach pathological levels. The assigned values for glucose are transferred values from the reference material “Serum X” of NFKK (Nordic Federation of Clinical Chemistry) [8].

5.3.2. Verification of the analytical performance of the comparison method

Precision

Repeatability (CV) of the comparison method was calculated from duplicate measurements of capillary Li-heparin plasma samples from participants of the evaluation performed in the hospital laboratory.

Trueness

To document the trueness of the comparison method, standard reference material (SRM) 965b from NIST (National Institute of Standards & Technology) was used [9]. SRM 965b consists of ampoules with human serum with certified concentrations of glucose at four levels with given uncertainties. If necessary, the comparison method results were adjusted according to the NIST-targets using inverse regression. In addition, human serum controls produced by Equalis (External quality assessment in laboratory medicine in Sweden), with glucose concentrations at two levels were analysed. These controls have target values determined with an isotope-dilution gas chromatography/mass spectrometry method in a Reference laboratory in Wales [10]. The target value is given with an expanded uncertainty of <2 % (k=2).

5.4. The evaluation

5.4.1. Planning of the evaluation

Inquiry about an evaluation

Roche Diagnostics Norge AS via Reza Gordan, Product Manager, applied to SKUP in August 2021 for an evaluation of **cobas pulse**. The evaluation was assigned to SKUP in Denmark. The contact person from the requesting company was Kamilla Madsen, Application Specialist from Roche Diagnostics A/S. The evaluation was postponed until 2023 upon request by the manufacturer.

Protocol, arrangements and contract

In February 2023, the protocol for the evaluation was approved, and Roche Diagnostics A/S and SKUP signed a contract for the evaluation. The Department of Biochemistry and Immunology in Vejle agreed to represent the intended users in the hospital laboratory and to analyse the samples for the comparison method. Two PHCCs; Lægehuset Løgumkloster and Lægehuset Padborg from South Jutland County agreed to represent the intended users in primary health care.

Training

Roche Diagnostics A/S was responsible for the necessary training in the use of **cobas pulse**. The training in the laboratory and in the PHCCs reflected the training usually given to the end-users. Roche Diagnostics A/S was not allowed to contact or supervise the evaluators during the evaluation period.

5.4.2. Evaluation sites and persons involved

The practical work, including sampling and measurement on the **cobas pulse**, was carried out at the laboratory for three months, ending in July 2023. Two biomedical laboratory scientists (BLSs) were involved in the practical work, thus representing the intended users in the hospital laboratory. At the hospital laboratory in Vejle, three BLSs were responsible for analysing the samples on the comparison method. The hospital laboratory has approximately 60 employees.

From PHCC1 two BLSs participated in the evaluation and from PHCC2 two nurses and one social and health care assistant participated. Both PHCCs were large medical practices with six to eight physicians.

5.4.3. The evaluation procedure in the hospital laboratory

Internal analytical quality control
Internal analytical quality control samples for **cobas pulse**, two levels (**cobas** GLU QC kit, Roche Diagnostics GmbH), were measured each evaluation day on the **cobas pulse** measuring system. The reproducibility (CV) as achieved with the quality control material was calculated.

Recruitment of participants and ethical considerations
Persons with diabetes, age 18 or older, coming to the hospital for glucose measurements were asked if they were willing to donate one venous blood sample and four capillary samples for the evaluation. The participants were recruited in cooperation with the diabetes outpatient clinic at the hospital. The following personal information were obtained from the participants; age, sex and type of diabetes. Participation was voluntary. The sample for haematocrit was not a part of the measurements prescribed by the treating physician; therefore, a written informed consent was signed with the participants before sampling.

Handling of the samples, and measurements of glucose
The participants washed and dried their hands before sampling. All samples for **cobas pulse**, as well as the glucose samples for the comparison method, were capillary whole blood samples collected from finger pricks. The measurement procedure on the **cobas pulse** was in accordance with the instructions from the manufacturer. The puncture site was disinfected with alcohol pads, and the area completely dried before sampling. Disposable lancing devices (Accu-Chek Safe-T-Pro Plus, Roche Diagnostics GmbH) with depth 2,3 mm was used by the BLS. The first drop of blood was wiped off, then the second drop of capillary blood was allowed to form, before ≥0,6 µL blood was applied from the fingertip to the test strip. The second sample was collected from a new drop of blood, from the same finger prick, if possible, and the measurement procedure was repeated for the second capillary sample. Disposable gloves were worn. The sampling sequence was carried out as quickly as possible in order to reduce possible changes in glucose concentration during sampling. In case of error codes the test was repeated, if possible, until a result was obtained.

Two lot numbers of test strips were used, alternating each day between the lot numbers. The same lot number was used on both internal analytical quality control measurement and measurement of participant samples any given day.

Samples for the comparison method were collected into Microvette Li-heparin tubes (500 µL) from Sarstedt. The tubes were filled dropwise using the collection rim on the tube, then the tubes were inverted 5 – 10 times to ensure thorough mixing. The samples were centrifuged immediately for five minutes at 2.000 g, and plasma was separated into screw cap micro tubes (Sarstedt). The plasma samples were frozen directly and stored at –80°C (according to storing procedure for the SRM from NIST [9]) until analysis took place.
All first samples for the comparison method were analysed once; all second samples were analysed in duplicate (see section 5.3.2). The mean of the comparison method was calculated as the mean value of the first sample result and the average result of the second sample. This mean

is an estimate of the true glucose value and is referred to as the mean result of the comparison method.

Blood sampling and analysis for each participant were carried out in the following order:
1. The BLS collects a venous sample for haematocrit
2. The BLS pricks the participant in a finger and collects a first sample for the comparison method
3. The BLS collects new capillary samples from the first prick, or makes a new prick in another finger, and performs duplicate measurements on **cobas pulse**
4. The BLS pricks the participant in a finger and collects a second sample for the comparison method

Stability of glucose concentration during sampling time
The stability of glucose concentration during sampling was supervised by means of the capillary samples for the comparison method taken at the start and at the end of each sampling sequence. Based on experience from several previous glucose meter user-evaluations, a stability criterion with a change ≤10,0 % between the first and second comparative result is regarded as reasonable. Changes >10,0 % are regarded as unacceptable and these results were excluded. Furthermore, the sampling time between the first and second sample for the comparison method should not exceed 10 minutes.

Handling of samples and measurements of haematocrit
Samples for haematocrit were obtained by venepuncture and collected into 4 mL vacutainer tubes with K_2-ethylenediaminetetraacetic acid (EDTA) (BD Vacutainer, BD Medical). The tubes were inverted 5 – 10 times immediately after blood collection and just before measurement to ensure thorough mixing. The tubes were kept at room temperature until measurement. The samples were measured once for haematocrit within eight hours of collection. All samples were treated according to the internal procedures of the hospital laboratory regarding potential interfering substances.

5.4.4. The evaluation procedure in primary health care

Internal analytical quality control
Internal analytical quality control samples for **cobas pulse**, two levels (**cobas** GLU QC kit, Roche Diagnostics GmbH), were measured each evaluation day on the **cobas pulse** measuring system. The reproducibility (CV) as achieved with the quality control material was calculated.

Recruitment of participant and ethical considerations
Persons with diabetes, age 18 or older, coming to the PHCC for glucose measurements were asked if they were willing to donate two capillary samples for the evaluation. The following personal information were obtained from the participants; age, sex and type of diabetes. Participation was voluntary and verbal consent was considered sufficient based on national regulations.

Handling of the samples and measurements
The participant washed and dried their hands before sampling. The samples for **cobas pulse** were capillary whole blood samples collected from the finger. The measurement procedure on the **cobas pulse** was in accordance with the instructions from the manufacturer. The puncture site was disinfected with alcohol pads, and the area completely dried before sampling. Disposable

lancing devices (Accu-Chek Safe-T-Pro Plus, Roche Diagnostics GmbH) with depth 1,8 mm was used by the evaluator. The first drop of blood was wiped off, then the second drop of capillary blood was allowed to form, before ≥0,6 µL blood was applied from the fingertip to the test strip. The second sample was collected from a new drop from the same finger prick, if possible, and the measurement procedure was repeated for the second capillary sample.
Disposable gloves were worn. The sampling sequence was carried out as quickly as possible in order to reduce possible changes in glucose concentration during sampling. In case of error codes the test was repeated, if possible, until a result is obtained.

Two lot numbers of test strips were used, alternating each day between the lot numbers. The same lot number was used on both internal analytical quality control measurement and measurement of participant samples any given day.

6. Results and discussion

Statistical expressions and calculations used by SKUP are shown in attachment 4.

6.1. Number of samples and study population characteristics

Scheduled number of samples in this evaluation was 100 samples from persons with diabetes measured in duplicate by laboratory personnel and 100 samples from persons with diabetes measured in duplicate in the PHCCs. At the end of the evaluation, a total of 217 participants were enrolled.
In the hospital laboratory, 100 participants were recruited (SKUP ID 100 – 199). PHCC1 recruited 56 participants (SKUP ID 300 – 358) and PHCC2 recruited 61 participants (SKUP ID 380 – 442).

The measurement on **cobas pulse** was performed on capillary samples from 125 men and 92 women with diabetes. The average age of the participants was 66 years (range 18 – 91 years). A total of 26 participants had Type 1 diabetes, 181 had Type 2 diabetes and 10 had latent autoimmune diabetes in adults (LADA). The concentration range for the glucose samples was 4,0 – 31,9 mmol/L (results from the comparison method). The concentration range for the haematocrit samples was 19 – 80 %. Two lots of test strips were used in this evaluation.

An account of the number of samples not included in the calculations is given below.

Missing results

- On two occasions there were no results from an internal quality control the same day as analysis of participant samples. The results from the participant samples these days were still included in the calculations.
- ID 310, ID 325 ID 336, and ID 409 were not used.
- ID 156; the second measurement of the second sample on the comparison method was missing, due to insufficient sample. The single value was included in the calculation of bias and the assessment of accuracy, but not in repeatability.

Omitted results

- ID 425; the participant withdrew consent; thus, these results were omitted from all calculations.
- ID 100 and ID 190; the sampling time between the first and second sample for the comparison method exceeded the time limit of 10 minutes. The results from the comparison method were omitted from all calculations. The results from **cobas pulse** were included in the calculation of repeatability.
- ID 120 and ID 125; the sampling time between the first and second sample on **cobas pulse** was over 10 minutes, thus exceeding the time limit of 10 minutes between the first and second sample for the comparison method. All results were omitted from the calculations.
- ID 188; the deviation between the first and the second sample for the comparison method was >10,0 %, which means that the participants had unstable glucose concentrations during the sampling sequence time. The results from the comparison method were omitted from all the calculations. The results from **cobas pulse** were included in the calculation of repeatability.

- ID 122 had a haematocrit value >70 %, thus outside the tolerated haematocrit range of **cobas pulse**. The results from **cobas pulse** were omitted from all calculations. The results from the comparison method were included in the calculation of repeatability.

Excluded results (statistical outliers)
Statistical outliers in SKUP evaluations are detected by the criterion promoted by Burnett [11].

- On three dates the results from the internal quality controls (level 1 and/or 2) analysed on lot a or b (in the PHCCs) were outliers and therefore excluded from the calculation of control reproducibility. However, the results were within the allowable range and thus participant data from those dates were included in all calculations.
- ID 118 and ID 160; the capillary results from **cobas pulse** were classified as outliers according to Burnett's model in the calculation of repeatability. The results were not included in the calculation of bias, but their first of the duplicate results was included in the assessment of accuracy (see omitted results).
- ID 162 and ID 164; the capillary results from **cobas pulse** were classified as outliers according to Burnett's model in the calculation of bias. The results were not included in the calculation of bias, but they were included in the assessment of accuracy (the first of the duplicate measurements).

Recorded error codes, technical errors and failed measurements
There were 7 error codes, concerning test strip was inserted too early. There were 9 error codes concerning the test strip being placed incorrectly and 16 error codes, due to incorrect (manual) removal of the test strip. There was 1 error code, caused by the instrument was placed into the charging station after the measurement had started. There were 19 error codes concerning an unsteady sample application or insufficient sample. There were 3 error codes concerning the instrument not detecting the test strip and 2 error codes due to an instrument failure. Finally, there were 22 error codes concerning a test strip failure caused by sudden movements of the test strip. This adds up to 79 recorded error codes, 37 of them were considered pre-analytical handling errors, 21 were considered handling errors during measurement and 16 were considered post-analytical handling errors. Of those 74 handling errors, 52 occurred in the first three weeks of the evaluation. The remaining 5 errors were considered as technical errors. This amounts to 1,2 % technical errors (5 out of 2*217 glucose measurements on **cobas pulse**). The SKUP recommendation of a fraction of ≤2 % tests wasted due to technical errors was achieved.

6.2. Analytical performance of the selected comparison method

6.2.1. Internal analytical quality control

All results from the internal analytical quality control (Autonorm Clin Chem Liq L-2 and L-3, SERO), two levels, were within the allowable control limits (data not shown).

6.2.2. The precision of the comparison method

Duplicate measurements of the second capillary blood participant samples were performed on the comparison method. The results were checked to meet the imposed condition for using formula 1 in attachment 4. There were no systematic differences pointed out between the paired measurements (data not shown).

The precision is presented as repeatability (CV). The CV with a 90 % CI is shown in table 3. The results were sorted and divided into three glucose concentration levels according to the mean of the results. Raw data is attached for the requesting company only, see attachment 5.

Table 3. Repeatability (CV) of the comparison method for glucose measured in capillary blood samples.

Glucose level, Comparison method, mmol/L	n	Excluded results (statistical outliers)	Mean value glucose, mmol/L	CV (90 % CI), %
<7	27	0	6,1	1,9 (1,6 – 2,5)
7 – 10	36	0	8,5	1,4 (1,1 – 1,7)
>10	31	0	13,7	1,3 (1,1 – 1,7)

Discussion

The CV for the comparison method was between 1,3 and 1,9 % depending on the concentration level.

6.2.3. The trueness of the comparison method

To demonstrate the trueness of the comparison method, SRM 965b standards from NIST were analysed. All analyses were performed within one day in July 2023, where the standards and controls (table 4 and 5) were analysed five times in two batches alongside the participant samples. The agreement between the comparison method and the NIST-standards is shown in table 4.

Table 4. SRM 965b measured on the comparison method.

SRM 965b	Date	Certified glucose concentration, (uncertainty) mmol/L	n	Mean value glucose, mmol/L	Deviation from target value, %
Level 1	2023-07-13	**1,836** (1,809 – 1,863)	5	1,83	–0,4
			5	1,84	+0,2
			10	**1,83**	**–0,1**
Level 2	2023-07-13	**4,194** (4,135 – 4,253)	5	4,29	+2,2
			5	4,30	+2,6
			10	**4,29**	**+2,4**
Level 3	2023-07-13	**6,575** (6,481 – 6,669)	5	6,53	–0,7
			5	6,60	+0,3
			10	**6,57**	**–0,2**
Level 4	2023-07-13	**16,35** (16,15 – 16,55)	5	16,27	–0,5
			5	16,35	+0,0
			10	**16,31**	**–0,2**

Comments
Table 4 shows that the glucose results for the NIST-standards were above the upper uncertainty limit for level 2. All results from the comparison method were therefore adjusted according to the certified NIST-targets. The adjustment was carried out by means of inverse calibration [12, 13] by the following regression equations: **y = 1,0053x – 0,0505.**
Further on in the report, whenever a result from the comparison method is presented, the result has been adjusted according to this.

To verify the trueness of the adjusted comparison method results, human serum controls produced by Equalis, were analysed. The agreement between the comparison method and target values from the Reference laboratory in Wales is shown in table 5.

Table 5. Trueness of the comparison method.

Control	Date	Target value glucose, (expanded uncertainty) mmol/L	n	Mean value glucose, mmol/L	Deviation from target value, %
Equalis 1	13.07.23	**4,60** (4,48 – 4,72)	5	4,63	+0,7
			5	4,66	+1,3
			10	**4,64**	**+1,0**
Equalis 2	13.07.23	**15,10** (14,80 – 15,40)	5	14,99	–0,8
			5	15,12	+0,2
			10	**15,02**	**–0,5**

Discussion
When adjusted, the comparison method gave glucose values in agreement with the glucose values from the Reference laboratory in Wales. The trueness of the comparison method was confirmed.

6.3. Analytical performance of cobas pulse in the hospital laboratory

The results below reflect the analytical performance of **cobas pulse** in the hands of the intended users 'laboratory personnel' in a hospital laboratory. The results document the performance of the measuring system under conditions as favourable as possible for achieving good analytical performance.

6.3.1. Internal analytical quality control

All results from the internal analytical quality control (**cobas** GLU QC kit), two levels, were within the allowable control limits (data not shown). The reproducibility (CV) achieved with the internal analytical quality control samples were 1,99 % for level 1 (n=20) and 0,84 % for level 2 (n=20). Raw data is attached for the requesting company only, see attachment 6.

6.3.2. The precision of cobas pulse

Duplicate measurements of fresh capillary blood from each participant were performed on **cobas pulse**. The results were checked to meet the imposed condition for using formula 1 in attachment 4. There was a significant systematic difference pointed out between the paired measurements for the low level (data not shown). The difference was small, but statistically significant. The systematic differences pointed out lead to a minor overestimation of CV in the low level on **cobas pulse**.

The precision is presented as repeatability (CV). The CV with a 90 % CI is shown in table 6. The results were sorted and divided into three concentration levels according to the mean of the results of **cobas pulse**. Raw data is attached for the requesting company only, see attachment 7.

Table 6. Repeatability (CV) of **cobas pulse** for glucose measured in capillary samples. Results achieved by intended users in the hospital laboratory.

Level	Glucose level, mmol/L	n*	Excluded results (statistical outliers)	Mean value glucose, mmol/L	CV (90 % CI), %
Low	<7	30	2**	6,1	2,0 (1,7 – 2,6)
Medium	7 – 10	32	0	8,6	2,3 (1,9 – 2,9)
High	>10	35	0	13,7	1,8 (1,5 – 2,2)

*The given number of duplicate results (n) were counted before the exclusion of statistical outliers. Mean and CV were calculated after the exclusion of statistical outliers. An account of the number of samples is given in section 6.1.
**ID 118 and ID 160 were statistical outliers according to Burnett's model [11] in the calculation of repeatability and therefore excluded.

Discussion

The CV achieved by intended users in the hospital laboratory was between 1,8 and 2,3 % depending on the concentration level. As the upper CI values for all levels are ≤4,0 %, the CVs are statistically significant below the APS.

Conclusion

The APS for repeatability (CV ≤4,0 %) was fulfilled for all glucose concentration levels in the hospital laboratory.

6.3.3. The bias of cobas pulse

The mean deviation (bias) of **cobas pulse** results from the comparison method was calculated. The bias is presented with a 95 % CI in table 7. The results were sorted and divided into three concentration levels according to the mean results of the comparison method. Raw data is attached for the requesting company only, see attachment 5 and 7.

Table 7. Bias of **cobas pulse** for glucose measured in capillary samples. Results achieved by intended users in the hospital laboratory.

Level	Glucose level Comparison method, mmol/L	n*	Excluded results (statistical outliers)	Mean value Comparison method, glucose mmol/L	Mean value cobas pulse, glucose mmol/L	Bias (95 % CI), mmol/L	Bias, %
Low	<7	27	0	6,19	6,21	0,02 (–0,06 – 0,10)	0,3
Medium	7 – 10	34	0	8,58	8,74	0,16 (0,06 – 0,26)	1,8
High	>10	31	2**	13,76	13,34	0,15 (–0,01 – 0,31)	1,1

*The given number of duplicate results (n) were counted before the exclusion of statistical outliers. Mean and bias were calculated after the exclusion of statistical outliers. An account of the number of samples is given in section 6.1.
**ID 162 and ID 164 were statistical outliers according to Burnett's model [11] in the calculation of bias and therefore excluded.

Discussion

cobas pulse gave systematically higher results than the comparison method in all concentration levels. The bias was only statistically significant at medium level, with an average bias of 0,16 mmol/L in the hospital laboratory.

6.3.4. The accuracy of cobas pulse

To evaluate the accuracy of glucose results on **cobas pulse**, the agreement between **cobas pulse** and the comparison method is illustrated in a difference plot (figure 3). The limits for the allowable deviation according to the APS (ISO 15197:2013), are shown with stippled lines. All the first measurements from **cobas pulse** are included in the plot. The plot illustrates both random and systematic errors, reflecting the total measuring error in the **cobas pulse** results. The accuracy is summarised in table 8. Raw data is attached for the requesting company only, see attachment 5 and 7.

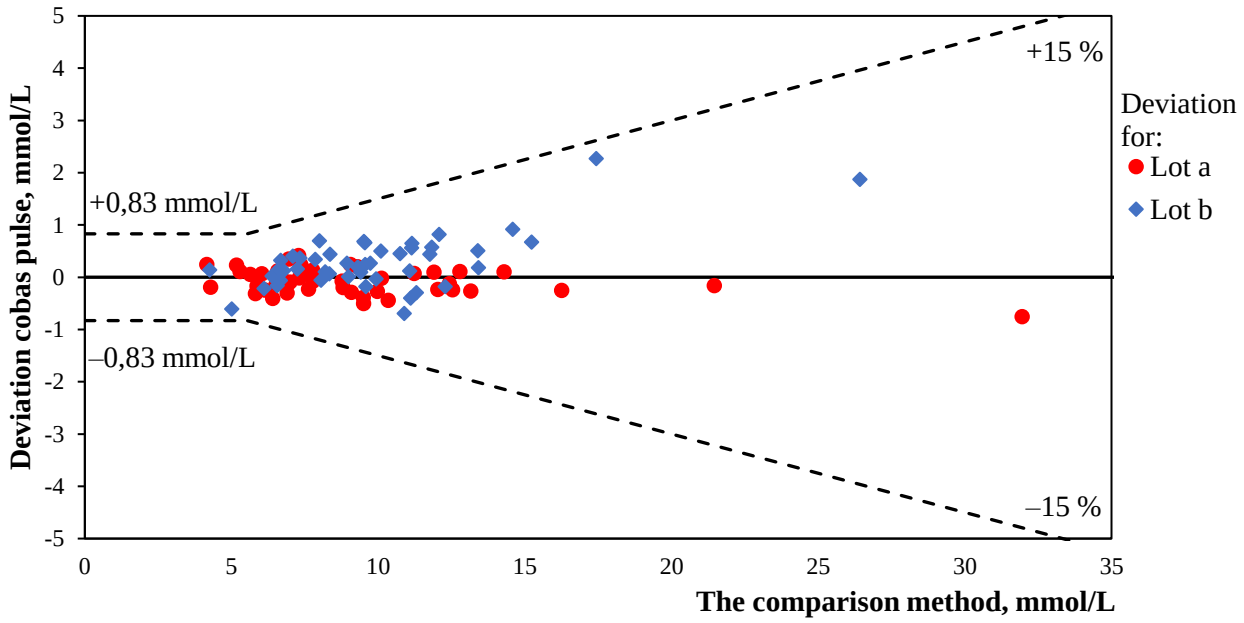

Figure 3. Accuracy of glucose results on **cobas pulse** achieved by intended users in the hospital laboratory. The x-axis represents the mean glucose result of the comparison method. The y-axis represents the glucose deviation in mmol/L of the first capillary measurement on **cobas pulse** from the mean result of the corresponding samples of the comparison method. The different lots of test strips are illustrated with the symbols ● (lot a) and ♦ (lot b). Stippled lines represent the allowable deviation limits set in ISO 15197:2013 (within ±0,83 mmol/L of the results of the comparison method for glucose concentrations <5,55 mmol/L and within ±15 % for glucose concentrations ≥5,55 mmol/L). The calculation of accuracy included measurement results from samples collected from 94 participants. An account of the number of samples is given in section 6.1.

Table 8. Accuracy of **cobas pulse** for glucose measured in capillary samples. Results achieved by intended users in the hospital laboratory.

Lot	n	Percentage of results within given limits, % (n)	
		ISO 15197:2013[1]	**Stricter Swedish quality goal[2]**
a	47	100 (47)	100 (47)
b	47	100 (47)	96 (45)

[1] ISO 15197:2013: <±0,83 mmol/L at conc. <5,55 mmol/L and <±15 % at conc. ≥5,55 mmol/L
[2] Stricter Swedish quality goal: <±0,42 mmol/L at conc. <4,2 mmol/L and <±10 % at conc. ≥4,2 mmol/L
An account of the number of samples is given in section 6.1.

Discussion

As shown in figure 3, the glucose results from **cobas pulse** tend to be higher than the results from the comparison method, which is consistent with the calculated bias. The difference between the methods is small, but is more apparent for lot b, than for lot a.

All 94 participant results (47 and 47 for lot a and lot b, respectively) were inside the limits for allowable deviation of ±0,83 mmol/L of the results of the comparison method for glucose concentrations <5,55 mmol/L and within ±15 % for glucose concentrations ≥5,55 mmol/L,

corresponding to 100 % within the limits. Table 8 also shows the number of participant results within the stricter Swedish quality goal (see section 4.1). These results are for information only.

Conclusion
The APS for accuracy was fulfilled in the hospital laboratory.

6.3.5. Effect of haematocrit

According to the technical specifications for **cobas pulse**, the glucose measurements are not affected by haematocrit values from 5 to 70 %. To measure the effect of haematocrit on **cobas pulse**, a venous sample for haematocrit was collected from the participants. The effect of haematocrit is shown with a trend-line (CI 95 %) and a regression equation in figure 4. Raw data is attached for the requesting company only, attachment 5, 7 and 8.

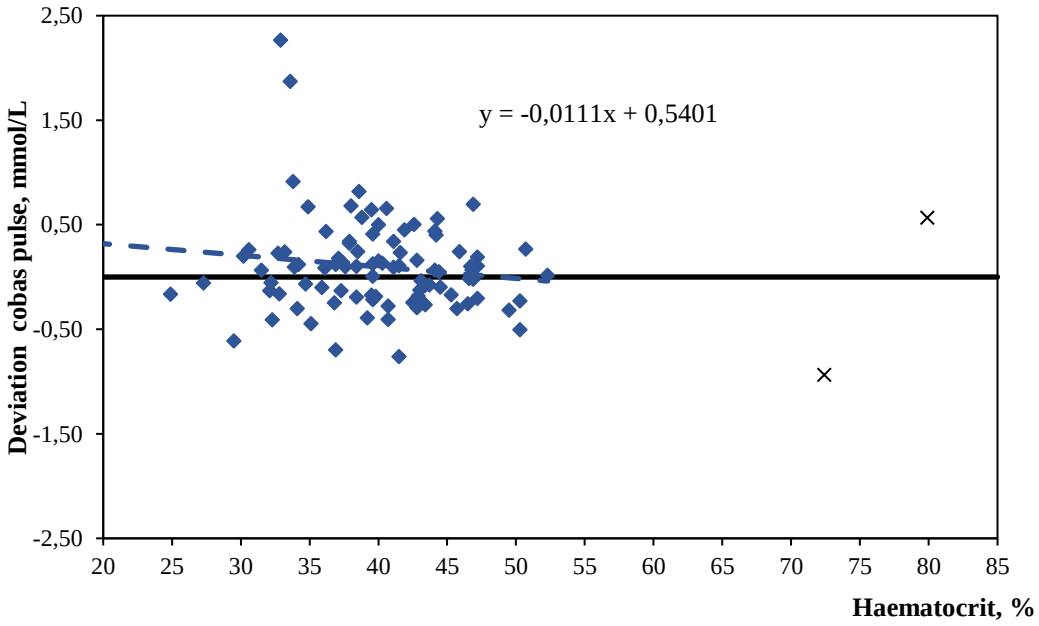

Figure 4. The effect of haematocrit on glucose measurements on **cobas pulse** measured by intended users in the hospital laboratory. The x-axis shows the haematocrit value in percent. The y-axis shows the difference in glucose concentration between the mean result of **cobas pulse** and the mean result of the corresponding sample of the comparison method in mmol/L. Samples that were outside the haematocrit range of **cobas pulse** (ID 122 and ID 125) are illustrated with ×, these are not included in the calculation. The calculation of the effect of haematocrit included measurement results from samples collected from 94 participants. An account of the number of samples is given in section 6.1.

Discussion
The slope of the trend-line in figure 5 is (–0,011), with a 95 % CI from (–0,026) to (+0,004). The slope is not statistically significant different from zero. Glucose measurements on **cobas pulse** were not affected by haematocrit within the included range tested (19 – 52 %).

6.4. Analytical performance of cobas pulse in primary health care

The results below reflect the analytical performance of **cobas pulse** in the hands of intended users 'health care personnel' in primary health care. The results may deviate from the results achieved by intended users in the hospital laboratory.

6.3.6. Internal analytical quality control

All results from the internal analytical quality control (**cobas** GLU QC kit), two levels, were within the allowable control limits (data not shown). On two separate dates the internal analytical quality control was not measured, the participant data from those dates are still included in all calculations. The reproducibility (CV) achieved with the internal analytical quality control samples were 2,44 % for level 1 (n=41) and 1,10 % for level 2 (n=39). Raw data is attached for the requesting company only, attachment 8.

6.3.7. The precision of cobas pulse

Duplicate measurements of fresh capillary blood from each participant were performed on **cobas pulse**. The results were checked to meet the imposed condition for using formula 1 in attachment 4. There was a small, but statistically significant, systematic difference pointed out between the paired measurements for the low and medium level for PHCC2 (data not shown).

The precision is presented as repeatability (CV). The CV with a 90 % CI is shown in table 9. The results were sorted and divided into three concentration levels according to the mean of the results of **cobas pulse**. Raw data is attached for the requesting company only, attachment 9.

Table 9. Repeatability (CV) of **cobas pulse** for glucose measured in capillary samples. Results achieved by intended users in primary health care.

Place	Glucose level, mmol/L	n*	Excluded results (statistical outliers)	Mean value glucose, mmol/L	CV (90 % CI), %
PHCC 1	<7	22	0	6,1	3,9 (3,1 – 5,3)
	7 – 10	20	0	8,3	3,2 (2,5 – 4,4)
	>10	14	0	12,9	4,3 (3,3 – 6,4)
PHCC 2	<7	16	0	6,1	3,0 (2,3 – 4,3)
	7 – 10	26	0	8,2	3,0 (2,5 – 4,0)
	>10	19	0	12,0	3,7 (2,9 – 5,1)
PHCC All	<7	38	0	6,1	3,6 (3,0 – 4,4)
	7 – 10	46	0	8,2	3,1 (2,7 – 3,8)
	>10	33	0	12,5	4,0 (3,3 – 5,0)

*An account of the number of samples is given in section 6.1.

Discussion
The CV achieved in the PHCCs was between 3,0 and 4,3 % depending on the concentration level.
At level <7 mmol/L, the CV achieved in PHCC 1 and 2 was lower, but not statistically significantly lower than the APS.
At level 7 – 10 mmol/L, the CV achieved in PHCC1 was lower, but not statistically significantly lower, CV than the APS at level 7 – 10 mmol/L. At the same level in PHCC2, the achieved CV was statistically significantly lower than the APS.
At level >10 mmol/L, the CV achieved in PHCC1 was higher, but not statistically significantly higher than the APS. At the same level in PHCC2, the achieved CV was lower, but not statistically significantly lower than the APS.

Since the results, per concentration level, had overlapping CIs, the results from both PHCCs were merged into CV All. The CV for all results was equal or lower than the APS at level <7, 7 – 10 mmol/L and >10 mmol/L, but only statistically significantly lower at level 7 – 10 mmol/L.

Conclusion
When the PHCCs results were merged per level to CV All, the APS for repeatability (CV ≤4,0 %) was fulfilled at level 7 – 10 and most likely fulfilled at level <7 mmol/L and >10 mmol/L. In all, the APS for repeatability was fulfilled in primary health care.

6.4. Evaluation of user-friendliness

6.4.1. Questionnaire to the evaluators

The most important response regarding user-friendliness comes from the intended users themselves. The intended users of **cobas pulse** are laboratory personnel as well as health care personnel, the questionnaire about the user-friendliness of the measuring system was filled by all evaluation sites.

At the end of the evaluation period, the intended users filled in a questionnaire about the user-friendliness of the measuring system.

The questionnaire is divided into four subareas:

Table A) Rating of ease of operation. Is the measuring system easy to handle?
Table B) Rating of the information in the user guide / insert / quick guide
Table C) Rating of time factors for the preparation and the measurement
Table D) Rating of performing internal and external analytical quality control

The intended users filled in table A and B. SKUP filled in table C and D and in addition, topics marked with grey colour in table A and B.

In the tables, the first column shows what is up for consideration. The second column in table A and B shows the rating by the users at the evaluation sites. The rest of the columns show the rating options. The total rating is an overall assessment by SKUP of the described property, and not necessarily the arithmetic mean of the rating in the rows. Consequently, a single poor rating can justify an overall poor rating, if this property seriously influences on the user-friendliness of the measuring system.

Unsatisfactory and intermediate ratings are marked with a number and explained below the tables. The intermediate category covers neutral ratings assessed as neither good nor bad.

An assessment of the user-friendliness is subjective, and the topics in the questionnaire may be emphasised differently by different users. The assessment can therefore vary between different persons and between the countries. This will be discussed and taken into account in the overall assessment of the user-friendliness.

Comment
In this evaluation, the user-friendliness was assessed by:
Hospital laboratory; two BLSs
PHCC1; two BLSs
PHCC2; two nurses and one social and health care assistant

Table A. Rating of ease of operation

Topic	Rating	Rating	Rating	Rating	Option
To measure the sample	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
To insert the test strip	**I[1], S, S**	**Satisfactory**	**Intermediate**	Unsatisfactory	No opinion
To apply blood	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Specimen volume	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Instrument / test strip design	**S, S, I[2]**	**Satisfactory**	**Intermediate**	Unsatisfactory	No opinion
Reading of the test result	**E, E, E**	**Easy**	Intermediate	Difficult	No opinion
Sources of errors	**I[3], S, S**	**Satisfactory**	**Intermediate**	Unsatisfactory	No opinion
Cleaning / Maintenance	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Hygiene, when using the test	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Size and weight of the package	**S, S, I[2]**	**Satisfactory**	**Intermediate**	Unsatisfactory	No opinion
In total; how easy did you find the usage of the instrument	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Storage conditions for tests, unopened package	**S**	**+2 to +30°C**	+2 to +8°C	–20°C	
Storage conditions for tests, opened package	**S**	**+15 to +30°C max. 20 min.**	+2 to +8°C	–20°C	
Environmental aspects: waste handling	**S**	**No precautions**	Sorted waste	Special precautions	
Intended users	**S**	**Health care personnel or patients**	Laboratory experience personnel	Biomedical laboratory scientists	
Total rating by SKUP		**Satisfactory**			

[1)] The instrument does not always detect the test strip after inserting the test strip into the instrument.
[2)] The instrument feels a little too large when held compared to other glucose meters.
[3)] The instrument displayed an error although the test strip was inserted.

Additional positive comments to the ease of operation:
The instrument had a good grip when held and the touch screen made the information easily accessible for the user. The Glucose app on the instrument was very intuitive. The instrument needed only a small drop of blood to measure a sample and responded quickly after applying blood to the test strip. It was easy to apply the blood to the test strip. Because the test strip was mechanically ejected from the instrument, it was easy to remove the test strip without getting blood on your fingers.

Additional negative comments to the ease of operation:
The instrument did sometimes not detect the test strip or displayed an insertion error after insert. This happened too often.

Table B. Rating of the information in the quick guide and user guide

Topic	Rating	Rating	Rating	Rating	Option
Table of contents/Index	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Specimen collection; description and illustrations	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Description of how to insert a test strip	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Description of measurement procedure	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Description of how to read the result	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Description of the sources of error	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Help for troubleshooting	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Readability/Clarity of presentation	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
General impression	**S, S, S**	**Satisfactory**	Intermediate	Unsatisfactory	No opinion
Measurement principle		**Satisfactory**	Intermediate	Unsatisfactory	
Available insert in Danish, Norwegian, Swedish		**Satisfactory**	Intermediate	Unsatisfactory	
Total rating by SKUP		**Satisfactory**			

Additional positive comments to the quick guide and user guide:
The quick guide was easy to understand and easy to use with good illustrations. The user guide was accessed directly on the instrument. The user guide was easy to understand with good illustrations and guidance step-by-step.

Table C. Rating of time factors (filled in by SKUP)

Topic	Rating	Rating	Rating
Required training time	**<2 hours**	2 to 8 hours	>8 hours
Durations of preparations / Pre-analytical time	**<6 min.**	6 to 10 min.	>10 min.
Duration of analysis	**<10 sec.**	10 to 30 sec.	>30 sec.
Stability of test, unopened package	**>5 months**	3 to 5 months	<3 months
Stability of test, opened package	**>30 day or disposable**	14 to 30 days	<14 days
Stability of quality control material, unopened	**>5 months**	3 to 5 months	<3 months
Stability of quality control material, opened	**>6 days or disposable**	2 to 6 days	≤1 day
Total rating by SKUP	**Satisfactory**		

Table D. Rating of analytical quality control (filled in by SKUP)

Topic	Rating	Rating	Rating
Reading of the internal quality control	**Satisfactory**	Intermediate	Unsatisfactory
Usefulness of the internal quality control	**Satisfactory**	Intermediate	Unsatisfactory
External quality control	**Satisfactory**[1]	Intermediate	Unsatisfactory
Total rating by SKUP	**Satisfactory**		

[1)] External control materials containing iodoacetate or fluoride are not recommended and may cause a bias due to matrix effects.

Additional positive comments to analytical quality control:
When the internal quality control was analysed not only was the result shown on the display, but it was also indicated if the control passed or not.

6.4.2. Assessment of the user-friendliness

Assessment of the ease of operation (table A)
The ease of operation was in total assessed as satisfactory, since there were only a few intermediate ratings, mainly concerning the size of the instrument and insertion of the test strip. One evaluation site rated the instrument / test strip design and sources of errors as intermediate; this was because it was often difficult for the instrument to detect the test strip after inserting it into the instrument, which is consistent with some of pre-analytical errors that occurred in the evaluation. In addition, a lot of the handling errors occurred in the beginning of the evaluation, suggesting that the user needed time to get familiar with the instrument. The users had both positive and negative comments regarding the ease of operation.

Assessment of the information in the manual (table B)
The quick guide was assessed as satisfactory with positive comments that it was well written and rich in clarifying illustrations. The user guide can be assessed directly on the instrument which was considered convenient for the users.

Assessment of time factors (table C)
The time factors were assessed as satisfactory.

Assessment of analytical quality control possibilities (table D)
The analytical quality control possibilities were assessed as satisfactory with the positive comment that the result of internal quality control analysis is addressed as approved or not approved on the display.

Conclusion
In all, the user-friendliness of the ease of operation as well as the quick guide / user guide, the time factors and the analytical quality controls were rated as satisfactory. To achieve the overall rating “satisfactory”, the tested equipment must reach a total rating of “satisfactory” in all four subareas of characteristics. The performance specification for user-friendliness of **cobas pulse** was fulfilled.

7. References

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Attachments

1. Facts about **cobas pulse**
2. Information about manufacturer, retailers and marketing
3. Product specifications for this evaluation, **cobas pulse**
4. Statistical expressions and calculations
5. Raw data glucose, results from the comparison method
6. Raw data glucose, internal analytical quality control results, **cobas pulse**, hospital laboratory
7. Raw data glucose, **cobas pulse** results, hospital laboratory
8. Raw data haematocrit
9. Raw data glucose, internal analytical quality control results, **cobas pulse**, primary health care centres
10. Raw data glucose, **cobas pulse** results, primary health care centres

Attachments with raw data are included only in the copy to Roche Diagnostics A/S.

Facts about cobas pulse

This form is filled in by Roche Diagnostics A/S.

Table 1. Basic facts

Name of the measurement system:	**cobas**® **pulse**
Dimensions and weight:	Width: 77 mm Depth: 30 mm Height: 210 mm Weight: 390 g (incl. **cobas**® **pulse** battery)
Components of the measurement system:	Instrument, charging station, power supply, test strips.
Measurand:	Blood glucose
Sample material:	Venous whole blood, arterial whole blood, capillary whole blood, neonatal heel stick, and neonatal arterial whole blood. Acceptable anticoagulants are lithium heparin, sodium heparin, K_2-EDTA, or K_3-EDTA.
Sample volume:	≥0.6 µL
Measuring principle:	FAD-dependent glucose dehydrogenase (FAD-GDH), electrochemical
Traceability:	The system (instrument and test strips) is traceable to the primary NIST standard via the ID-GCMS and plasma-based hexokinase method.
Calibration:	The system is factory calibrated and does not require any calibration by the end user.
Measuring range:	0.6 – 33.3 mmol/L (10 – 600 mg/dL)
Haematocrit range:	5 – 70 %
Measurement time:	<10 seconds
Operating conditions:	Ambient temperature: 12 – 40 °C Ambient humidity: 10 – 90 % (non-condensing)
Electrical power supply:	Yes, DC connector and replaceable AC input contacts.
Recommended regular maintenance:	Clean the instrument to remove visible soil and organic material for safe handling and/or prior to disinfection. Disinfect the instrument when it is soiled as per your healthcare facility's guidelines. Frequency: - As specified by your healthcare facility. - As configured on the instrument.
Package contents:	**cobas**® **pulse** instrument with **cobas**® **pulse** battery pre-installed.
Necessary equipment not included in the package:	**cobas**® **pulse** charging station **cobas**® **pulse** power supply **cobas**® GLU test strips **cobas**® GLU QC kit

Table 2. Post analytical traceability

Is input of patient identification possible?	Yes
Is input of operator identification possible?	Yes
Can the instrument be connected to a bar-code reader?	N/A. **cobas**® **pulse** has an integrated barcode camera and RFID / NFC sensor.
Can the instrument be connected to a printer?	No
What can be printed?	Data can be printed from the data management system (DMS).
Can the instrument be connected to a PC?	Wireless connectivity allows **cobas**® **pulse** to connect to a DMS on a PC/tablet/mobile device.
Can the instrument communicate with LIS (Laboratory Information System)? If yes, is the communication bidirectional?	Yes, **cobas**® **pulse** can communicate with LIS/HIS through a DMS, i.e., **cobas**® **infinity** POC or third-party DMS.
What is the storage capacity of the instrument and what is stored in the instrument?	- up to 100 proficiency test results - up to 2000 patient result records - up to 3 comments for each test record - up to 500 glucose QC result records - up to 50 linearity test results - up to 300 test strip lot code containers - up to 15000 user ID records - up to 15000 patient records - up to 200 OTE reagents records - up to 50 QC lot records - up to 10 linearity lot records - up to 5000 entries audit trail records
Is it possible to trace/search for measurement results?	Yes

Table 3. Facts about the reagent/test strips/test cassettes

Name of the reagent/test strips/test cassettes:	**cobas**® GLU test strips
Stability in unopened sealed vial:	The test strips are stable up to the expiration date specified on the container (up to 24 months), when stored in the original container under the recommended storage conditions.
Stability in opened vial:	The test strips are stable up to the expiration date specified on the container (up to 24 months), when stored in the original container under the recommended storage conditions.
Package contents:	2 x 50 **cobas**® GLU test strips

Table 4. Quality control

Electronic self check:	Yes - during start-up and assay runs.
Recommended control materials and volume:	**cobas**® GLU QC kit, 2 x 2.5 mL. 0.6 µL required per control test.
Stability in unopened sealed vial:	The QC material is stable up to the expiration date specified on the bottle label (up to 24 months).
Stability in opened vial:	3 months from the date the bottle is opened or the expiry date on the bottle label, whichever comes first.
Package contents:	2 bottles of 2.5 mL **cobas**® GLU QC solutions (level 1 + 2)

Information about manufacturer, retailers and marketing

This form is filled in by Roche Diagnostics A/S.

Table 1. Marketing information

Manufacturer:	Roche Diagnostics GmbH
Retailers in Scandinavia:	Denmark: Roche Diagnostics A/S Norway: Roche Diagnostics Norge AS Sweden: Roche Diagnostics Scandinavia AB
In which countries is the system marketed:	Globally ☒ Scandinavia ☒ Europe ☒
Date for start of marketing the system in Scandinavia:	2022-09-01
Date for CE-marking:	2021-12-15
In which Scandinavian languages is the manual available:	Danish, Norwegian, Swedish

Product specifications for this evaluation, cobas pulse

cobas pulse instrument serial numbers

Serial number	Used by
A101002306	Laboratory
A101002357	PHCC1
A101002358	PHCC2
A101002307	Spare

cobas GLU test strips

Lot no.	Alias	Expiry date	Used by
59560209	Lot a	2023-11-01	All evaluation sites
70498503	Lot b	2024-12-10	All evaluation sites

Allowable range of the **cobas** GLU QC kit

Control	Lot no	Expiry date	Allowable range		Used by
Level 1	10092775	2023-09-30	2,6 – 4,0	mmol/L	All evaluation sites
Level 2			10 – 19,8	mmol/L	

Other equipment used in the evaluation

Equipment	Penetrating depth (mm)	Expiry date	Manufacture	Used by
cobas pulse charging station			Roche Diagnostics	All evaluation sites
Accu-Chek Safe-T-Pro Plus	1,3/1,8/2,3	2026-12-01	Roche Diagnostics	All evaluation sites*
Alcohol Pads		2025-11-01		All evaluation sites
Screw cap micro tubes		2025-08-31	Sarstedt	Laboratory
Disposable pipettes			Sarstedt	Laboratory
Mini centrifuge			Neuation Technologies	Laboratory

* Evaluation sites may have used their own lancing devices.

Statistical expressions and calculations

This chapter with standardised text deals with the statistical expressions and calculations used by SKUP. The statistical calculations will change according to the type of evaluation. The descriptions in this document are valid for evaluations of quantitative methods with results on the ratio scale.

Statistical terms and expressions

The definitions in this section come from the International Vocabulary of Metrology – Basic and general concepts and associated terms; VIM [a].

Precision

Definition: Precision is the closeness of agreement between measured quantity values obtained by replicate measurements on the same or similar objects under stated specified conditions.

Precision is measured as *imprecision*. Precision is descriptive in general terms (good, poor e.g.), whereas the imprecision is expressed by means of the standard deviation (SD) or coefficient of variation (CV). SD is reported in the same unit as the analytical result. CV is usually reported in percent.

To be able to interpret an assessment of precision, the precision conditions must be defined.
Repeatability is the precision of consecutive measurements of the same component carried out under identical measuring conditions (within the measuring series).
Reproducibility is the precision of discontinuous measurements of the same component carried out under changing measuring conditions over time.

Trueness

Definition: Trueness is the closeness of agreement between the average of an infinite number of replicate measured quantity values and a reference quantity value.

Trueness is inversely related to systematic measurement error. Trueness is measured as *bias*. Trueness is descriptive in general terms (good, poor e.g.), whereas the bias is reported in the same unit as the analytical result or in percent.

Accuracy

Definition: Accuracy is the closeness of agreement between a measured quantity value and the true quantity value of a measurand.

Accuracy is not a quantity and cannot be expressed numerically. Accuracy is descriptive in general terms (good, poor e.g.). A measurement is said to be more accurate when it offers a smaller measurement error. Accuracy can be illustrated in a difference plot.

a. International vocabulary of metrology – Basic and general concepts and associated terms, VIM, 3rd edition, JCGM 200;2012. www.bipm.org

Statistical calculations

Statistical outliers

The criterion promoted by Burnett [b] is used for the detection of outliers. The model takes into consideration the number of observations together with the statistical significance level for the test. The significance level is set to 5 %. The segregation of outliers is made with repeated truncations, and all results are checked. Where the results are classified according to different concentration levels, the outlier-testing is carried out at each level separately. Statistical outliers are excluded from the calculations.

Calculation of imprecision

The precision of the evaluated method is assessed by use of paired measurements of genuine patient sample material. The results are usually divided into three concentration levels, and the estimate of imprecision is calculated for each level separately, using the following formula [c,d,e]:

$$SD = \sqrt{\frac{\sum d^2}{2n}}$$

d = difference between two paired measurements (formula 1)
n = number of differences

This formula is used when the standard deviation can be assumed reasonable constant across the concentration interval. If the coefficient of variation is more constant across the concentration interval, the following formula is preferred:

$$CV = \sqrt{\frac{\sum (d/m)^2}{2n}}$$

m = mean of paired measurements (formula 2)

The two formulas are based on the differences between paired measurements. The calculated standard deviation or CV is still a measure of the imprecision of single values. The imposed condition for using the formulas is that there is no systematic difference between the 1st and the 2nd measurement of the pairs. The CV is given with a 90 % confidence interval.

Calculation of bias

The mean deviation (bias) at different concentration levels is calculated. A paired t-test is used with the mean values of the duplicate results on the comparison method and the mean values of the duplicate results on the evaluated method. The mean difference is shown with a 95 % confidence interval.

Assessment of accuracy

The agreement between the evaluated method and the comparison method is illustrated in a difference plot. The x-axis represents the mean value of the duplicate results on the comparison method. The y-axis shows the difference between the first measurement on the evaluated method and the mean value of the duplicate results on the comparison method. The number of results within the analytical performance specification limits is counted and assessed.

b. Burnett RW. Accurate estimation of standard deviations for quantitative methods used in clinical chemistry. *Clin Chem* 1975; 21 (13): 1935 – 1938.
c. Dahlberg G. Statistical methods for medical and biological students, 1940. Chapter 12, Errors of estimation. George Allen & Unwin Ltd.
d. Saunders E. Tietz textbook of clinical chemistry and molecular diagnostics, 2006. Chapter 14, Linnet K., Boyd J. Selection and analytical evaluation of methods – with statistical techniques. Elsevier Saunders ISBN 0-7216-0189-8.
e. Fraser C.G. Biological variation: From principles to practice, 2006. Chapter 1, The Nature of Biological Variation. AACC Press ISBN 1-890883-49-2.

Raw data glucose, results from the comparison method

Shown to the requesting company only.

Raw data glucose, internal analytical quality control results, cobas pulse, hospital laboratory

Shown to the requesting company only.

Raw data glucose, cobas pulse results, hospital laboratory

Shown to the requesting company only.

Raw data haematocrit

Shown to the requesting company only.

Raw data glucose, internal analytical quality control results, cobas pulse, primary health care centres

Shown to the requesting company only.

Raw data glucose, cobas pulse results, primary health care centres

Shown to the requesting company only.