**Appendix 6. Additional analyses**

A. Sensitivity analysis and subgroup analysis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Number of patents | Number of studies | Bias ± SD | 95% LOA | I2 (%) | |
| Bias | SD |
| Removing data from studies in which SDs were calculated from SE1-31 | 4339 | 31\* | 0.11 ± 1.34 | −2.53 to 2.74 | 96.1 | 95.3 |
|  |  |  |  |  |  |  |
| By risk of bias |  |  |  |  |  |  |
| Low risk of bias in all domains2,10,11,16,22,26 | 407 | 6 | 0.08 ± 1.46 | −2.79 to 2.94 | 94.7 | 87.1 |
|  |  |  |  |  |  |  |
| By number of measurement per patient |  |  |  |  |  |  |
| Single1,3,6,7,14,15,20,21,26-28,30 | 3660 | 12 | 0.14 ± 1.43 | −2.66 to 2.94 | 98.0 | 96.4 |
| Multiple2,4,5,8-13,16-19,22-25,29,31,32 | 765 | 20 | −0.09 ± 1.31 | −2.66 to 2.48 | 83.4 | 92.3 |
|  | 4425 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| By funding |  |  |  |  |  |  |
| No industry funding1,3,4,6,8-12,14-22,24-27,30-32 | 3603 | 25 | −0.08 ±1.50 | −3.02 to 2.87 | 96.2 | 94.6 |
| Industry funding sponsored2,5,7,13,23,28,29 | 822 | 7 | 0.24 ±1.02 | −1.76 to 2.25 | 95.6 | 94.5 |
|  | 4425 | 32 |  |  |  |  |
|  |  |  |  |  |  |  |
| By country |  |  |  |  |  |  |
| US2,5,7-9,12,21,23,24,26-28 | 1303 | 12 | −0.04 ± 1.39 | −2.77 to 2.68 | 95.4 | 91.9 |
| France10,11,13-16,22,32 | 1112 | 8 | −0.30 ± 1.62 | −3.47 to 2.88 | 96.5 | 98.1 |
| Europe3,4,6,18,29-31 | 1283 | 7 | 0.12 ± 1.19 | −2.21 to 2.46 | 97.6 | 86.4 |
| Asia and Middle East1,17,19,20,25 | 727 | 5 | 0.42 ± 1.27 | −2.06 to 2.90 | 88.1 | 89.8 |
|  | 4425 | 32 |  |  |  |  |
|  |  |  |  |  |  |  |
| By setting |  |  |  |  |  |  |
| OR2,5,7-9,12,16,19,22,24,25,30,31 | 841 | 13\*\* | 0.39 ± 1.32 | −2.21 to 2.98 | 93.0 | 71.4 |
| ICU8,10,11,13,32 | 215 | 5\*\* | −0.51 ± 1.59 | −3.63 to 2.62 | 83.7 | 96.4 |
| ED14,15,21,29 | 1002 | 4 | −0.39 ± 1.73 | −3.78 to 2.99 | 98.1 | 97.7 |
| OPD and Ward1,6,17,26-28 | 913 | 6 | −0.14 ± 1.35 | −2.78 to 2.50 | 94.9 | 95.2 |
| BD3,20 | 1414 | 2 | −0.05 ± 1.04 | −2.10 to 1.99 | 98.7 | 71.6 |
| Volunteers4,18,23 | 40 | 3 | −0.19 ± 1.01 | −2.16 to 1.78 | 0 | 0 |
|  | 4425 | 33 |  |  |  |  |
|  |  |  |  |  |  |  |
| Radical-7 sensor version (Rev E)2,4,5,7,9,12,13,16,24,25,29-31 | 854 | 13 | 0.37 ± 1.24 | −2.06 to 2.80 | 94.8 | 93.9 |
|  |  |  |  |  |  |  |
| Sampling blood\*\*\* |  |  |  |  |  |  |
| Venous1,3,4,6,7,10,11,14,15,17,18,20-22,26,28-31 | 3775 |  | 0.10 ± 1.35 | −2.55 to 2.74 | 97.0 | 94.7 |
| Arterial2,8,9,12,13,16,19,23-25,27,32 | 621 |  | −0.16 ± 1.48 | −3.07 to 2.75 | 91.7 | 96.0 |
|  | 4396 |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Invasive Hb measurement |  |  |  |  |  |  |
| Central laboratory analyzer1-7,10,11,13-18,20-26,28-30,32 | 4101 | 26 | 0.10 ± 1.35 | −2.54 to 2.74 | 96.4 | 95.3 |
| Satellite Co-oximetry8,9,12,19,27,31 | 324 | 6 | −0.44 ± 1.57 | −3.52 to 2.64 | 85.7 | 88.1 |

\*, Bias and SD from Causey study performed in the OR was included; \*\*, Causey study was regarded as two studies which were performed in OR and ICU; \*\*\*, Berkow 20115 used both central venous and arterial and is not included.

BD = blood donation; ED = emergency department; ICU = intensive care unit; LOA = limits of agreement; OPD = outpatient department; OR = operating room; QUADAS = Quality Assessment of Diagnostic Accuracy Studies; SD = standard deviation; SE = standard error

B. Meta-regression analysis.



efigure 1 Meta-regression by publication year.

Bias tends to be positive direction as publication year progress.

Each bubble indicates individual study. Bubble size is weight of the individual study in the analysis.

References

1. Al-Khabori M, Al-Hashim A, Jabeen Z, Al-Farsi K, Al-Huneini M, Al-Riyami A, Al-Kemyani N, Daar S: Validation of a noninvasive pulse CO-oximetry-based hemoglobin estimation in patients with sickle cell disease. Int J Lab Hematol 2013

2. Applegate RL, 2nd, Barr SJ, Collier CE, Rook JL, Mangus DB, Allard MW: Evaluation of pulse cooximetry in patients undergoing abdominal or pelvic surgery. Anesthesiology 2012; 116:65-72

3. Belardinelli A, Benni M, Tazzari PL, Pagliaro P: Noninvasive methods for haemoglobin screening in prospective blood donors. Vox Sang 2013

4. Bergek C, Zdolsek JH, Hahn RG: Accuracy of noninvasive haemoglobin measurement by pulse oximetry depends on the type of infusion fluid. Eur J Anaesthesiol 2013; 30:73-9

5. Berkow L, Rotolo S, Mirski E: Continuous noninvasive hemoglobin monitoring during complex spine surgery. Anesth Analg 2011; 113:1396-402

6. Bruells CS, Menon AK, Rossaint R, Goetzenich A, Czaplik M, Zoremba N, Autschbach R, Schaelte G: Accuracy of the Masimo Pronto-7(R) system in patients with left ventricular assist device. J Cardiothorac Surg 2013; 8:159

7. Butwick A, Hilton G, Carvalho B: Non-invasive haemoglobin measurement in patients undergoing elective Caesarean section. Br J Anaesth 2012; 108:271-7

8. Causey MW, Miller S, Foster A, Beekley A, Zenger D, Martin M: Validation of noninvasive hemoglobin measurements using the Masimo Radical-7 SpHb Station. Am J Surg 2011; 201:592-8

9. Colquhoun DA, Forkin KT, Durieux ME, Thiele RH: Ability of the Masimo pulse CO-Oximeter to detect changes in hemoglobin. J Clin Monit Comput 2012; 26:69-73

10. Coquin J, Bertarrex A, Dewitte A, Lefevre L, Joannes-Boyau O, Fleureau C, Winnock S, Leuillet S, Janvier G, Ouattara A: Accuracy of determining hemoglobin level using occlusion spectroscopy in patients with severe gastrointestinal bleeding. Anesthesiology 2013; 118:640-8

11. Coquin J, Dewitte A, Manach YL, Caujolle M, Joannes-Boyau O, Fleureau C, Janvier G, Ouattara A: Precision of noninvasive hemoglobin-level measurement by pulse co-oximetry in patients admitted to intensive care units for severe gastrointestinal bleeds. Crit Care Med 2012; 40:2576-82

12. Dewhirst E, Naguib A, Winch P, Rice J, Galantowicz M, McConnell P, Tobias JD: Accuracy of Noninvasive and Continuous Hemoglobin Measurement by Pulse Co-Oximetry During Preoperative Phlebotomy. J Intensive Care Med 2013

13. Frasca D, Dahyot-Fizelier C, Catherine K, Levrat Q, Debaene B, Mimoz O: Accuracy of a continuous noninvasive hemoglobin monitor in intensive care unit patients. Crit Care Med 2011; 39:2277-82

14. Gayat E, Aulagnier J, Matthieu E, Boisson M, Fischler M: Non-invasive measurement of hemoglobin: assessment of two different point-of-care technologies. PLoS One 2012; 7:e30065

15. Gayat E, Bodin A, Sportiello C, Boisson M, Dreyfus JF, Mathieu E, Fischler M: Performance evaluation of a noninvasive hemoglobin monitoring device. Ann Emerg Med 2011; 57:330-3

16. Giraud B, Frasca D, Debaene B, Mimoz O: Comparison of haemoglobin measurement methods in the operating theatre. Br J Anaesth 2013

17. Hadar E, Raban O, Bouganim T, Tenenbaum-Gavish K, Hod M: Precision and accuracy of noninvasive hemoglobin measurements during pregnancy. J Matern Fetal Neonatal Med 2012; 25:2503-6

18. Hahn RG, Li Y, Zdolsek J: Non-invasive monitoring of blood haemoglobin for analysis of fluid volume kinetics. Acta Anaesthesiol Scand 2010; 54:1233-40

19. Isosu T, Obara S, Hosono A, Ohashi S, Nakano Y, Imaizumi T, Mogami M, Murakawa M: Validation of continuous and noninvasive hemoglobin monitoring by pulse CO-oximetry in Japanese surgical patients. J Clin Monit Comput 2013; 27:55-60

20. Kim MJ, Park Q, Kim MH, Shin JW, Kim HO: Comparison of the Accuracy of Noninvasive Hemoglobin Sensor (NBM-200) and Portable Hemoglobinometer (HemoCue) with an Automated Hematology Analyzer (LH500) in Blood Donor Screening. Ann Lab Med 2013; 33:261-7

21. Knutson T, Della-Giustina D, Tomich E, Wills B, Luerssen E, Reynolds P: Evaluation of a new nonnvasive device in determining hemoglobin levels in emergency department patients. West J Emerg Med 2013; 14:283-6

22. Lamhaut L, Apriotesei R, Combes X, Lejay M, Carli P, Vivien B: Comparison of the accuracy of noninvasive hemoglobin monitoring by spectrophotometry (SpHb) and HemoCue(R) with automated laboratory hemoglobin measurement. Anesthesiology 2011; 115:548-54

23. Macknet MR, Allard M, Applegate RL, 2nd, Rook J: The accuracy of noninvasive and continuous total hemoglobin measurement by pulse CO-Oximetry in human subjects undergoing hemodilution. Anesth Analg 2010; 111:1424-6

24. Miller RD, Ward TA, Shiboski SC, Cohen NH: A comparison of three methods of hemoglobin monitoring in patients undergoing spine surgery. Anesth Analg 2011; 112:858-63

25. Park YH, Lee JH, Song HG, Byon HJ, Kim HS, Kim JT: The accuracy of noninvasive hemoglobin monitoring using the radical-7 pulse CO-Oximeter in children undergoing neurosurgery. Anesth Analg 2012; 115:1302-7

26. Raikhel M: Accuracy of noninvasive and invasive point-of-care total blood hemoglobin measurement in an outpatient setting. Postgrad Med 2012; 124:250-5

27. Ruppel GL, Wilson HA, Gall VK, Hempkens JA: Multi-wavelength pulse oximeter is not suitable for adjusting D(LCO) measurements. Respir Care 2011; 56:1115-21

28. Shah N, Osea EA, Martinez GJ: Accuracy of noninvasive hemoglobin and invasive point-of-care hemoglobin testing compared with a laboratory analyzer. Int J Lab Hematol 2013

29. Sjostrand F, Rodhe P, Berglund E, Lundstrom N, Svensen C: The use of a noninvasive hemoglobin monitor for volume kinetic analysis in an emergency room setting. Anesth Analg 2013; 116:337-42

30. Skelton VA, Wijayasinghe N, Sharafudeen S, Sange A, Parry NS, Junghans C: Evaluation of point-of-care haemoglobin measuring devices: a comparison of Radical-7 pulse co-oximetry, HemoCue((R)) and laboratory haemoglobin measurements in obstetric patients\*. Anaesthesia 2013; 68:40-5

31. Vos JJ, Kalmar AF, Struys MM, Porte RJ, Wietasch JK, Scheeren TW, Hendriks HG: Accuracy of non-invasive measurement of haemoglobin concentration by pulse co-oximetry during steady-state and dynamic conditions in liver surgery. Br J Anaesth 2012; 109:522-8

32. Nguyen BV, Vincent JL, Nowak E, Coat M, Paleiron N, Gouny P, Ould-Ahmed M, Guillouet M, Arvieux CC, Gueret G: The accuracy of noninvasive hemoglobin measurement by multiwavelength pulse oximetry after cardiac surgery. Anesth Analg 2011; 113:1052-7