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The effect of body mass index and position on blood surface area on sanitary pads

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ABSTRACT

Accurate measurement of postpartum blood loss is crucial for guiding appropriate medical interventions. Digital image processing offers potential to enhance visual estimation accuracy, though refinement is still needed for sanitary pad media. This study examined the effect of body mass index (BMI) and body position on the blood surface area on sanitary pads to support the development of digital image-based measurement methods. An experimental design simulated postpartum blood loss using three BMI categories (underweight, normal, overweight) and three positions (sitting, side-lying, supine), each repeated twice. Blood surface area was measured using digital image processing and analyzed with the Kruskal-Wallis and Friedman tests. The sanitary pads' absorption capacity ranged from 70–80 mL. Blood surface area did not differ significantly by BMI ($p=0.597$) but varied significantly by position ($p=0.000$). A trend of increasing surface area with higher BMI was observed. These findings suggest that both BMI and position should be considered in refining digital image-based methods for accurate and objective postpartum blood loss measurement.

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INTRODUCTION

Obstetric hemorrhage remains the leading direct cause of maternal mortality worldwide, with nearly three-quarters of cases occurring during the postpartum period (Say et al., 2014; World Health Organization, 2024). In 2022, Indonesia's Maternal Mortality Rate (MMR) was 189 per 100,000 live births. Although hemorrhage is no longer the primary cause of maternal death nationally, it remains the largest contributor to MMR (45%) in Maluku Province, which ranks seventh among Indonesian provinces with the highest MMR (Direktorat Statistik Kependudukan dan Ketenagakerjaan, 2023; Kementerian Kesehatan RI, 2023). The consequences of postpartum hemorrhage extend beyond the risk of death; maternal morbidity can be severe and may result in social and psychological complications (Koch et al., 2018). Even when not fatal, postpartum hemorrhage can cause serious and lasting health problems. Given its significant impact, accurate measurement of postpartum blood loss is essential, as it determines the medical interventions needed to safeguard maternal health (Sokoliuk & Levchenko, 2022; Vendittelli et al., 2022).

Postpartum blood loss volume is generally measured through visual estimation, a method that is less accurate and often underestimates the actual amount of blood loss (Blosser et al., 2021). The accuracy of visual estimation is not influenced by the professional background or clinical experience of healthcare workers (Zuckerwise et al., 2014). Moreover, perceptions of blood volume assessed visually can vary among healthcare providers (Khadilkar et al., 2016). Such variability may delay diagnosis and consequently postpone the initiation of hemorrhage management, thereby increasing the risk of maternal morbidity and mortality (Blosser et al., 2021).

Visual estimation remains widely used because it is simple, fast, giving real-time assessment, and does not require special equipment. However, its limitation in providing objective results has created an urgent need for a more accurate and standardized method (Schorn, 2010). The development of digital image processing method offers a promising solution, as it adopts the working principles of visual estimation while producing more objective and precise quantitative data (Fauziah et al., 2018). In comparison, other available methods are often expensive and have limited availability, while some increase the workload or are less practical to use (Lertbunnaphong et al., 2016; Sharareh et al., 2015). Therefore, the digital image processing approach is considered more cost-effective, accessible, and feasible for application in various healthcare settings (Fauziah et al., 2018).

In 2018, Fauziah developed a modified method for measuring blood loss volume using digital image processing. The measurement was conducted within the first 24 hours postpartum (Włodarczyk et al., 2025). Blood loss was assessed immediately after delivery using an underpad, followed by subsequent measurements at the end of the fourth stage of labor and every six hours up to 24 hours postpartum using a sanitary pad (Fauziah, 2018). Blood loss volume is calculated based on the visible blood surface area on the absorbent pad. The study demonstrated that blood surface area can be accurately quantified, and the calculated area can be converted into volume units with an error rate of less than 20%, making it a reliable alternative measurement method (Indrayan, 2013). However, the method was found to be accurate only when applied to underpads (Fauziah et al., 2018). When applied to sanitary pads, the measurements were consistent but consistently overestimated the actual blood loss volume, with an average error rate of 486.94%. This discrepancy was attributed to factors such as gluteal pressure and physical movement, which were not considered in the study, leading to less accurate determination of the measurement parameters for digital image processing using sanitary pads (Fauziah, 2018).

An individual's gluteal pressure can be influenced by their body mass index (BMI), while physical movement during the first 24 hours postpartum generally varies depending on whether the individual is sitting, lying on their side, or lying on their back (Fauziah, 2018; Shibly et al., 2021). This study aims to examine the effects of BMI and body position on the blood surface area on sanitary pads. The findings are expected to serve as a reference for improving the measurement basis of blood loss volume using digital image processing on sanitary pads, thereby enabling this technique to be developed as an accurate, affordable, and user-friendly alternative measurement method.

RESEARCH METHOD

This experimental study was conducted at the Midwifery Laboratory of Poltekkes Kemenkes Maluku from August to October 2025. The study simulated postpartum blood loss using sanitary pads. Artificial blood, prepared from fructose syrup and food coloring, was poured onto a 45 cm Softex Maternity postpartum sanitary pad. The fluid was delivered through an NGT tube onto the sanitary pad worn by subjects with different body mass index (BMI) categories—underweight, normal, and overweight—in various positions, including sitting, side-lying, and supine. The artificial blood was added gradually, starting from 10 mL and increasing in multiples until the sanitary pad appeared saturated (Deloughery et al., 2023; Jeyakanthan et al., 2023). For each volume increment, the subject applied pressure to the gluteal area on the pad for five minutes before image acquisition was performed to measure the blood surface area using digital image processing (Suryono et al., 2015).

Data were analyzed using the Kruskal–Wallis test to assess the effect of BMI on the blood surface area of the sanitary pads, and the Friedman test to examine the effect of body position on the blood surface area of the pad media. Post hoc analyses were conducted when the Kruskal–Wallis or Friedman tests indicated significant differences. Additionally, the Pearson correlation test was performed to determine the relationship between blood surface area and actual blood volume. This study was approved by the Health Research Ethics Committee of the Poltekkes Kemenkes Tasikmalaya, as stated in the Ethical Clearance No. DP.04.03/F.XVIII.20/KEPK/684/2025.

RESULTS AND DISCUSSIONS

Results

This study involved three subjects, each representing a different BMI category: underweight, normal, and overweight. Each subject produced image data for three positions—sitting, side-lying, and supine—with two repetitions for each position. The number of images in each dataset depended on the blood volume increments of 10 mL until the sanitary pad became saturated, resulting in a total of 18 image datasets. These images were then processed to measure the blood surface area using digital image processing. The average blood surface area obtained from the sanitary pads is presented in Table 1.

Table 1. The average of blood surface area on sanitary pads

Subject	BMI Categories	Actual Blood Volume (mL)	Average Blood Surface Area (cm²)		
			Sitting	Side-lying	Supine
P1	Underweight	10	40.04	63.17	60.80
P1	Underweight	20	81.73	110.19	130.04
P1	Underweight	30	101.77	161.16	174.28
P1	Underweight	40	151.30	232.15	243.18
P1	Underweight	50	197.76	291.93	264.91
P1	Underweight	60	250.24	341.80	295.23
P1	Underweight	70	334.87	381.67	389.84
P1	Underweight	80	311.26	346.25	446.28
P2	Nomal	10	54.01	75.68	64.08
P2	Nomal	20	102.82	118.04	103.43
P2	Nomal	30	135.86	142.03	155.41
P2	Nomal	40	175.57	186.60	227.09
P2	Nomal	50	227.34	238.45	244.93
P2	Nomal	60	250.91	250.69	252.80
P2	Nomal	70	316.65	278.44	300.18
P2	Nomal	80	-	318.24	353.68
P3	Overweight	10	46.80	61.60	59.57
P3	Overweight	20	80.19	127.20	114.92
P3	Overweight	30	123.95	171.70	158.87
P3	Overweight	40	147.41	206.39	198.34
P3	Overweight	50	208.56	306.27	200.65
P3	Overweight	60	270.48	363.21	256.16
P3	Overweight	70	308.97	400.14	-

In this study, the maximum absorption capacity of the sanitary pads was found to range from 70 to 80 mL, depending on the user's BMI and body position. Based on the visible blood surface area on the sanitary pads, differences were observed among BMI categories and body positions. The blood surface area tended to increase with higher BMI, and the largest surface area was observed when the subjects were in side-lying and supine positions. Statistical comparisons of the average blood surface area on sanitary pads based on BMI and position were conducted, and the results are presented in Table 2.

Table 2. Comparison of average of blood surface area on sanitary pads based on BMI and position

Variable	Categories	n	Median (IQR)	Mean Rank	df	*p*-value
	Underweight	24	237.66 (115.15 – 328.96)	37.04		
BMI[1]	Normal	23	227.09 (118.04 – 252.80)	33.26	2	0.597
	Overweight	20	185.02 (117.17 – 266.90)	31.20		
	Sitting	21	151.30 (91.75 – 250.57)	1.24		
Position[2]	Side-lying	21	206.39 (122.62 – 299.10)	2.43	2	0.000*
	Supine	21	200.65 (122.48 – 260.53)	2.33		

[1]*Kruskal-Wallis test*
[2]*Friedman test*

Based on the Kruskal–Wallis test, no significant difference was found in the blood surface area on sanitary pads among different BMI categories. In contrast, the Friedman test indicated that position had a significant effect on the blood surface area. A post hoc analysis using the Wilcoxon signed-rank test was conducted to identify which positions showed significant differences. The results are presented in Table 3.

Table 3. Post hoc analysis among different body positions

Pair of Body Position	Z	*p*-value	Description
Side-lying vs Sitting	-3.717	0.000*	Significant difference
Supine vs Sitting	-3.458	0.001*	Significant difference
Supine vs Side-lying	-0.016	0.987	Not significant

The Wilcoxon signed-rank test showed that the blood surface area in the supine and side-lying positions was significantly greater than in the sitting position ($p < 0.05$), whereas no significant difference was found between the supine and side-lying positions. Subsequently, a Pearson correlation test was conducted to assess the linear relationship between the actual blood volume and the blood surface area on the absorbent medium. The correlation coefficient (*r*) indicates the direction and strength of the relationship, while the *p*-value represents its statistical significance. The results of the Pearson correlation test are presented in Table 4.

Table 4. Pearson correlation analysis between actual blood volume and blood surface area on sanitary pads

Variable	n	*r*	*p*-value
Blood surface area for underweight BMI category in sitting position	8	0.982	0.000
Blood surface area for underweight BMI category in side-lying position	8	0.967	0.000
Blood surface area for underweight BMI category in supine position	8	0.991	0.000
Blood surface area for normal BMI category in sitting position	7	0.996	0.000
Blood surface area for normal BMI category in side-lying position	8	0.994	0.000
Blood surface area for normal BMI category in supine position	8	0.985	0.000
Blood surface area for overweight BMI category in sitting position	7	0.993	0.000
Blood surface area for overweight BMI category in side-lying position	7	0.993	0.000
Blood surface area for overweight BMI category in supine position	6	0.980	0.001

The results of the Pearson correlation test revealed a very strong and significant relationship between the actual blood volume and the blood surface area on the pad. This finding indicates that an increase in blood volume is accompanied by a corresponding increase in the visible blood surface area. The strong positive correlation suggests that blood volume directly influences the distribution of blood on the pad, although physiological variations related to BMI and position may still affect the results.

Discussion

Accurate measurement of blood loss volume plays a critical role in obstetric care, as it determines appropriate medical interventions that directly affect maternal outcomes (Katz et al., 2020; McLintock, 2020; Vendittelli et al., 2022). Visual estimation is the most commonly used method in clinical practice because it is simple and inexpensive (Blosser et al., 2021). However, numerous studies have demonstrated that this method is unreliable. Health workers often underestimate the volume of severe bleeding and overestimate minor bleeding, and this inaccuracy is independent of their educational background or clinical experience (Hire et al., 2020; Lumbreras-Marquez et al., 2020). Traditionally, health workers rely on the apparent blood surface area absorbed by underpads or linens to visually estimate blood loss. Differences in individual perception can lead to inconsistent clinical judgments and potentially delaying appropriate diagnosis and management (Khadilkar et al., 2016).

Bleeding that initially appears normal may progress to abnormal levels and often goes unnoticed; consequently, inadequate documentation can lead to potential medicolegal implications. Observation of postpartum blood loss, both at the end of the fourth stage of labor and within the first 24 hours after delivery, is often suboptimal. Postpartum mothers commonly use sanitary pads to absorb blood and prevent vaginal discharge from staining their clothing. Midwives typically assess bleeding by visually checking the condition of the pad to ensure it is not saturated too quickly, without accurately determining the volume of blood loss. Consequently, bleeding may be misjudged as normal, leading to inaccurate documentation (Katz et al., 2020; McLintock, 2020; Vendittelli et al., 2022).

Although the accuracy of the visual estimation method can be improved, its inherent limitations cannot be completely eliminated. One approach to enhance its accuracy is through digital image processing. In this method, the blood-absorbing medium is photographed and then converted into a grayscale image. During the image acquisition stage, a coin with a diameter of 2.45 cm is used as a reference to determine spatial resolution in image data processing. The region of interest is then selected by cropping the image, and the object is separated from the background to produce a binary image in which the object appears white (value = 1) and the background black (value = 0). This process allows clear identification of object boundaries and facilitating spatial resolution calculation. The pixel resolution value is obtained by comparing the pixel area of the coin to its actual area, while the blood surface area is calculated as the difference between the total area and the coin area. The final spatial resolution result is determined by multiplying the resolution value per pixel by the measured blood surface area (Fauziah et al., 2018).

The blood absorption pattern observed in this study showed that blood quickly seeped into the bottom and sides of the sanitary pad worn by the subject. The blood surface area on the sanitary pad in the sitting position tended to be smaller compared to the other two positions. The blood surface area increased in proportion to the added blood volume. At a certain point, the sanitary pad reached its maximum capacity, after which the blood surface area no longer increased, and leakage began to occur. These findings are consistent with those reported by Treetampinich et al. (2007), who found that most sanitary pad models exhibit a similar absorption pattern—blood is absorbed and gradually spreads toward the side edges and longitudinal ends until reaching maximum capacity (Treetampinich et al., 2007). The present results remain relevant, as more recent studies by Shibly et al. (2021) and Harter et al. (2024) also reported that once maximum capacity is reached, absorption ceases and leakage occurs. Previous research found that the maximum capacity of a sanitary pad of the same brand and size, without gluteal pressure, was 200 mL (Fauziah, 2018), whereas this study found a maximum capacity of 70–80 mL depending on the user's BMI and position. However, the maximum capacity obtained in this study cannot be generalized to all types of sanitary pads, as further testing is required to consider variations in pad size and material characteristics (Deloughery et al., 2023).

Although there was no statistically significant difference in the blood surface area of sanitary pads across BMI categories, a trend was observed in which the blood surface area increased with higher BMI. This tendency is supported by the finding that the maximum absorption capacity of sanitary pads was lower in the overweight group compared to other BMI groups. Treetampinich et al. (2007) reported that body weight pressure can influence the absorption and distribution of blood in sanitary pads (Treetampinich et al., 2007). Several previous studies have also included object weight as a variable in retention tests to evaluate pad capacity under pressure (Jeyakanthan et al., 2023; Madhu & Patel, 2024). When weight was applied to the sanitary pad, some blood leaked out, indicating that the maximum capacity of pads without pressure is greater than that of pads under pressure or actual use conditions. Therefore, further research with a larger sample size is needed to confirm the effect of BMI on the blood surface area of sanitary pads.

In contrast to BMI, the findings of this study indicate that body position significantly affects the blood surface area on the pad, with larger surface areas observed when users were in side-lying and supine positions. These results are consistent with those of Clancy et al. (1991), who reported that the volume of fluid absorbed by pads is greater when used in side-lying or supine positions compared to the sitting position. Pad leakage was also found to occur more frequently in side-lying and supine positions than in the sitting position (Clancy et al., 1991). Shibly et al. (2021) further explained that physical movement can exert external pressure on pads, contributing to leakage. This suggests that the pressure generated by body movement and positional changes facilitates faster blood absorption, increases the visible blood surface area, and accelerates the pad's saturation (Shibly et al., 2021).

Pearson's correlation test revealed a very strong and significant positive relationship between the actual blood volume and the blood surface area on the sanitary pad. This finding indicates that the greater the amount of blood absorbed, the larger the visible blood surface area on the sanitary pad. The relationship remains linear until the pad's absorbency limit is reached. These results are consistent with the theory of fluid absorption in fibrous materials, which states that an increase in fluid volume is directly proportional to the increase in contact area until the saturation point is achieved (Harter et al., 2024; Shibly et al., 2021). Therefore, the principle of estimating blood loss volume can be based on the visible blood surface area, although it is still affected by other factors such as BMI, body position, and the characteristics of the sanitary pad (Fauziah, 2018).

This study has several limitations. First, the number of research subjects was limited to three individuals, each representing a different BMI category; therefore, the results cannot be widely generalized. Second, the findings are applicable only to the specific type and brand of sanitary pad used in this study, as each product possesses distinct material characteristics and absorbency levels. Further testing using various types of sanitary pad media is therefore necessary. In addition, the use of sanitary pads by the subjects closely approximated actual conditions of postpartum use, although refinements are still needed regarding blood absorption time intervals and image acquisition procedures. Consequently, future studies involving a larger number of subjects and a wider range of sanitary pad types are expected to yield more comprehensive and generalizable results.

CONCLUSION

The results of this study indicate that body position significantly affects the blood surface area on sanitary pads. Although no statistically significant difference was found across BMI categories, there was a tendency for the blood surface area to increase with higher BMI. Therefore, in developing a method to measure blood loss volume using digital image processing on sanitary pads, both factors should be carefully considered. Future studies are recommended to conduct laboratory experiments similar to the present study, but with a larger number of subjects and a greater variety of sanitary pad types. Furthermore, a comparison between blood surface area and actual blood volume should be performed to establish a more accurate basis for estimating blood loss volume using digital image processing methods. This approach has the potential to serve as an accurate and objective alternative for assessing postpartum blood loss in the future.

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References

Blosser, C., Smith, A., & Poole, A. T. (2021). Quantification of Blood Loss Improves Detection of Postpartum Hemorrhage and Accuracy of Postpartum Hemorrhage Rates: A Retrospective Cohort Study. *Cureus*. https://doi.org/10.7759/cureus.13591

Clancy, B., Rgn, B., Malone-Lee, J., & Mrcp, M. B. (1991). Reducing the leakage of body-worn incontinence pads. In *Joumal of Advanced Nurstng* (Vol. 16).

Deloughery, E., Colwill, A. C., Edelman, A., & Samuelson Bannow, B. (2023). Red blood cell capacity of modern menstrual products: considerations for assessing heavy menstrual bleeding. *BMJ Sexual and Reproductive Health*, *50*(1), 21–26. https://doi.org/10.1136/bmjsrh-2023-201895

Direktorat Statistik Kependudukan dan Ketenagakerjaan. (2023). *Mortalitas di Indonesia*.

Fauziah, S. F. (2018). *Pengukuran Volume Perdarahan Pascasalin Menggunakan Pengolahan Citra Digital*. Poltekkes Kemenkes Semarang.

Fauziah, S. F., Suryono, S., & Widyawati, M. N. (2018). Postpartum Blood Loss Measurement Using Digital Image Processing. *E3S Web Conf.* https://doi.org/10.1051/e3sconf/201873

Harter, T., Wagner, A., Wolfbauer, A., Bernt, I., Mautner, A., Kriechbaum, M., Nevosad, A., & Hirn, U. (2024). The influence of viscose fibre properties on the absorbency of feminine hygiene tampons: the pivotal role of cross-sectional geometry. *Cellulose*, *31*(2), 1139–1158. https://doi.org/10.1007/s10570-023-05641-7

Hire, M. G., Lange, E. M. S., Vaidyanathan, M., Armour, K. L., & Toledo, P. (2020). Effect of Quantification of Blood Loss on Activation of a Postpartum Hemorrhage Protocol and Use of Resources. *JOGNN - Journal of Obstetric, Gynecologic, and Neonatal Nursing*, *49*(2), 137–143. https://doi.org/10.1016/j.jogn.2020.01.002

Indrayan, A. (2013). Clinical agreement in quantitative measurements: Limits of disagreement and the intraclass correlation. In *Methods of clinical epidemiology* (pp. 17–27). Springer. https://doi.org/10.1007/978-3-642-37131-8_2

Jeyakanthan, D. M., Schuster, J., & Shaik, Y. P. (2023). Development of Ecological Absorbent Core Sanitary Pads in Combination of Kenaf and Chitosan Fibers. *Materials Sciences and Applications*, *14*(07), 363–381. https://doi.org/10.4236/msa.2023.147023

Katz, D., Wang, R., O'Neil, L., Gerber, C., Lankford, A., Rogers, T., Gal, J., Sandler, R., & Beilin, Y. (2020). The association between the introduction of quantitative assessment of postpartum blood loss and institutional changes in clinical practice: an observational study. *International Journal of Obstetric Anesthesia*, *42*, 4–10. https://doi.org/10.1016/j.ijoa.2019.05.006

Kementerian Kesehatan RI. (2023). *Profil Kesehatan Indonesia 2022*.

Khadilkar, S. S., Sood, A., & Ahire, P. (2016). Quantification of Peri-partum Blood Loss: Training Module and Clot Conversion Factor. *Journal of Obstetrics and Gynecology of India*, *66*, 307–314. https://doi.org/10.1007/s13224-016-0888-9

Koch, A. R., Roesch, P. T., Garland, C. E., & Geller, S. E. (2018). Implementing Statewide Severe Maternal Morbidity Review: The Illinois Experience. *Journal of Public Health Management and Practice*, *24*(5), 458–464. https://doi.org/10.1097/PHH.0000000000000752

Lertbunnaphong, T., Lapthanapat, N., Leetheeragul, J., Hakularb, P., & Ownon, A. (2016). Postpartum blood loss: visual estimation versus objective quantification with a novel birthing drape. *Singapore Medical Journal*, *57*(6), 325.

Lumbreras-Marquez, M. I., Reale, S. C., Carusi, D. A., Robinson, J. N., Scharf, N., Fields, K. G., & Farber, M. K. (2020). Introduction of a nove system for quantitating blood loss after vaginal delivery: A retrospective interrupted time series analysis with concurrent control group. *Anesthesia and Analgesia*, *130*(4), 857–868. https://doi.org/10.1213/ANE.0000000000004560

Madhu, C., & Patel, B. (2024). Designing pH-responsive SAP-coated menstrual pads and comparing them to marketable products through quality analysis. *Bulletin of the National Research Centre*, *48*(1). https://doi.org/10.1186/s42269-024-01196-0

McLintock, C. (2020). Prevention and treatment of postpartum hemorrhage: focus on hematological aspects of management. *Hematology 2014, the American Society of Hematology Education Program Book*, *2020*(1), 542–546.

Say, L., Chou, D., Gemmill, A., Tunçalp, Ö., Moller, A.-B., Daniels, J., Gülmezoglu, A. M., Temmerman, M., & Alkema, L. (2014). Global Causes of Maternal Death: A WHO Systematic Analysis. *The Lancet Global Health*, *2*(6), e323–e333. https://www.thelancet.com/action/showPdf?pii=S2214-109X%2814%2970227-X

Schorn, M. N. (2010). Measurement of blood loss: review of the literature. *Journal of Midwifery & Women's Health*, *55*(1), 20–27.

Sharareh, B., Woolwine, S., Satish, S., Abraham, P., & Schwarzkopf, R. (2015). Real time intraoperative monitoring of blood loss with a novel tablet application. *The Open Orthopaedics Journal*, *9*, 422.

Shibly, Md. M. H., Hossain, M. A., Hossain, M. F., Nur, M. G., & Hossain, M. B. (2021). Development of biopolymer-based menstrual pad and quality analysis against commercial merchandise. *Bulletin of the National Research Centre*, *45*(1). https://doi.org/10.1186/s42269-021-00504-2

Sokoliuk, V., & Levchenko, O. (2022). Blood loss estimation techniques. In *Transfusion Practice in Clinical Neurosciences* (pp. 409–416). Springer.

Suryono, S., Kusminarto, K., Suparta, G. B., & Sugiharto, A. (2015). Ultrasound ComputerTomography Digital Image Processing for Concrete Hole Inspection. *International Journal of Applied Engineering Research*, *10*(15), 35499–35503.

Treetampinich, C., Suwannarurk, K., Chanthasenanont, A., Fongsupa, S., Tamrongterakul, T., & Rattanachaiyanont, M. (2007). Blood Absorption Capacity of Various Sanitary Pads Available in Thailand. *Siriraj Med J*, *59*(6). https://he02.tci-thaijo.org/index.php/sirirajmedj/article/view/246164

Vendittelli, F., Barasinski, C., Rivière, O., Da Costa Correia, C., Crenn-Hébert, C., Dreyfus, M., Legrand, A., & Gerbaud, L. (2022). Does the Quality of Postpartum Hemorrhage Local Protocols Improve the Identification and Management of Blood Loss after Vaginal Deliveries? A Multicenter Cohort Study. *Healthcare (Switzerland)*, *10*(6). https://doi.org/10.3390/healthcare10060992

Włodarczyk, Z., Śliwka, A., Maciocha, H., Paruszewski, S., Wyszyńska, J., Kłopecka, M., Afrykańska, G., Śliwińska, M., Ludwin, A., & Stanirowski, P. J. (2025). The Role of Accurate Estimations of Blood Loss and Identification of Risk Factors in the Management of Early Postpartum Hemorrhage in Women Undergoing a Cesarean Section. *Journal of Clinical Medicine*, *14*(6), 1861. https://doi.org/https://doi.org/10.3390/jcm14061861

World Health Organization. (2024, April 26). *Maternal Mortality*. https://www.who.int/news-room/fact-sheets/detail/maternal-mortality

Zuckerwise, L. C., Pettker, C. M., Illuzzi, J., Raab, C. R., & Lipkind, H. S. (2014). Use of a novel visual aid to improve estimation of obstetric blood loss. *Obstetrics and Gynecology*, *123*(5), 982–986. https://doi.org/10.1097/AOG.0000000000000233