



Attachment Behaviors in Physiological Birth Versus Cesarean Section

Elham Ebrahimi¹, Zahra Karimian², Sakineh Kolahdozan³, Mohammad Hassan Emamian⁴, Nahid Bolbolhaghghi^{5*}

Abstract

Objectives: Attachment can be described as a powerful bond between two individuals, in this case, between the mother and child. This process is started during pregnancy and completed after childbearing. Thus, delivery time, as a turning point between two stages of attachment is very important. Accordingly, the present study aimed to investigate the probable relations between the mother to child attachment and the mode of delivery.

Materials and Methods: In this descriptive-analytical study, 260 pregnant women were included based on specific inclusion criteria, who were in the age range of 15-45 years old and the gestational age between 37 to 42 weeks and were the candidate for physiological delivery or cesarean section. After obtaining the constant written form, the demographic information questionnaire was handed to the participants. One hour after delivery, the attachment questionnaire was completed by the researcher in the postpartum ward. Finally, the Spielberg anxiety inventory for each of the samples was completed up to one hour after delivery.

Results: Based on the findings, the participants of the physiological delivery group showed more positive attachment behaviors in comparison with the other group. Further, some domains of attachment such as looking, caressing and rocking the cradle in the subtypes of emotional behaviors, as well as contiguous behaviors and caring behaviors significantly differed among the participants ($P < 0.05$). Eventually, the participants experienced higher levels of anxiety in the cesarean delivery group, but the differences between the groups were not significant ($P > 0.005$)

Conclusions: In sum, the results of the current study indicated that mothers who engaged in physiological delivery had higher scores regarding mother to child attachment behaviors. In other words, they are more successful to attach their babies compared to the cesarean group. These results are important because various children are born by a cesarean section and an insecure attachment can have many negative effects for the child.

Keywords: Attachment, Behavior, Physiologic delivery, Cesarean section

Introduction

Attachment is described as a strong bond between two individuals, in this case, between the mother and child (1). Through this beautiful connection, mothers react by behaviors such as smiling, calling their names, attentive responses to their movements, touching, hugging, direct eye contact, and kissing. In addition, the baby responds to these behaviors with some defined reactions (2). This process is initiated during pregnancy and completed after childbearing. According to the literature, this relationship has an important role in both child development and maternal stress reduction (3-5). Attachment is very essential because insecure attachment affects social functioning, coping, stress response, psychological well-being, health behavior, and morbidity of children. Some activities can strengthen the attachment mechanism (6). In this way, some literature pointed out the positive roles of maternal relaxation, talking with and touching the

embryos, and paying attention to the fetal movement by the mothers (7). The stress in the mother is among the factors, which has a key role in destroying the attachment. The results of previous studies indicate that mothers with higher levels of anxiety have less attachment to the fetus (8-11). Bowlby explained the development of attachment of the child to the mother in different phases. The first phase is the pre-attachment phase which goes from zero to three months. In this phase, the child shows no real attachment to the mother. The attachment of the child to its mother starts to develop in about 4 months. In this period, the child has a slight preference for his or her caregiver. From seven or eight months to toddlerhood, children are in the clear-cut attachment phase. In this phase, children get really attached to their caregivers, they do not like to be handled by other people than their caregiver, and they get in distress when their caregiver is not physically close. At the age of three, children enter

Received 6 January 2018, Accepted 29 May 2018, Available online 20 July 2018

¹Department of Reproductive Health, School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran. ²School of Nursing and Midwifery, Kashan University of Medical Sciences, Kashan, Iran. ³School of Medicine, Shahrood University of Medical Sciences, Shahrood, Iran.

⁴Department of Epidemiology, Shahrood University of Medical Sciences, Shahrood, Iran. ⁵School of Nursing and Midwifery, Shahrood University of Medical Sciences, Shahrood, Iran.

*Corresponding Author: Nahid Bolbolhaghghi, Tel: +989121733544, Email: nbhaghghi349@yahoo.com



the working model phase in which they remember that their caregiver exists even if they do not see him or her. In addition, children understand that their caregiver will return. Eventually, Bowlby grouped these phases into two general categories called “pre and post childbearing” (12). Therefore, delivery time is considered as a turning point between two stages of attachment. Two methods of delivery were considered in this study, including cesarean section and normal vaginal delivery. A cesarean section is a way of birth in which a surgeon makes incisions in the woman’s abdomen and uterus and removes the baby from the abdomen of the mother through these incisions (1). This is in contrast with a vaginal delivery in which the baby is born through the birth canal. A vaginal delivery is considered as the regular way of birth (13). The physiologic labor as a type of vaginal delivery is regarded as a natural and safe method for the mother, with low pain and no medical interventions in an anxiety-free atmosphere in which the mother’s hormonal system modulates the main labor factors (14). According to the basic study reports, some physiological mechanisms are responsible for attachment formation in vaginal delivery and caesarian section. The stimulation of the vagina and cervix during delivery (15, 16). and the high level of oxytocin (17,18) and cortisol (19,20) are the most accepted theories in this field. Thus, the present study was conducted given that the data in this area are limited and considering the importance of attachment and its effects on the future of the fetus is quite obvious.

Objectives

This study aimed to evaluate the probable relations between the mother to child attachment and the mode of delivery.

Materials and Methods

The current descriptive-analytical study was approved by the Ethics Committee of Shahroud University of Medical Sciences (No. 1396.56) and conducted in Shahroud. A total of 260 pregnant women within the age range of 15-45 years old and the gestational age between 37 to 42 weeks were selected based on the inclusion criteria including being primiparous women with a normal singleton pregnancy and having no history of a disease or medication consumption during pregnancy. In addition, the data of those healthy infants who were born with a cesarean section or physiological childbearing methods were analyzed, and their mothers filled related questionnaires. The purposive sampling method was used based on the inclusion criteria and the participants were replaced by the next subject if they represented no desired features.

The demographic data form and Avant’s attachment behavior checklist, and Spielberger state-trait questionnaire for anxiety were used to collect the data. Both the above-mentioned tools are valid and reliable measures that have

repeatedly been used in domestic studies (21-26). The sample size was calculated based on a pilot study on 20 primiparous women using the following formula:

$$n = \left(\frac{Z_{1-\alpha/2} + Z_{1-\beta}}{\omega} \right)^2 + 3$$

(β was estimated at 20% by considering CI = 95%, α = 5%, and power = 80%)

The demographic information questionnaire was administered to the participants after selecting them and obtaining the written consent form. They answered the questionnaires at the presence of the researcher, and the researcher answered their questions. In the physiological delivery group, the babies were placed in the middle of their mother’s chest immediately after delivery so that they were in contact with their mother’s skin. In the other group, the face of neonates was in contact with the mother’s skin. The time of skin contact was 20 minutes in both groups. One hour after delivery, the attachment questionnaire was completed by the researcher in the postpartum ward. When the babies were delivered to their mothers for feeding, the attachment behaviors were observed for 16 minutes. In the first 8 seconds of every minute, the mother’s behaviors were observed and each behavior was recorded once in the next 8 seconds. In this way, every observed behavior was recorded only once per minute. Counting seconds was done by a stopwatch. The total amount of recorded behaviors in 15 minutes was considered as the total attachment score. Furthermore, the Spielberger anxiety inventory for each of the samples was completed up to one hour after delivery completion. Descriptive and inferential statistical methods were used to analyze the data in the SPSS software, version 21. Moreover, frequency tables (absolute and relative) and standard deviation were used for describing the demographic characteristics. Finally, an independent *t* test was used to analyze the research hypotheses and $P < 0.05$ was considered statistically significant.

Results

Based on the results of this study, no significant difference was observed between the two groups in terms of basic variables (e.g., mother’s age, body mass index, job, education, gestational age, neonatal weight, maternal education, job, and the gender of the fetus), the details of which are provided in Table 1.

The results of mother-infant attachment behaviors are shown in Table 2. According to the obtained data, the participants of the physiological delivery group showed more positive attachment behaviors in comparison with the other group. More precisely, some domains of attachment such as looking, caressing and rocking the cradle in the subtypes of emotional behaviors, contiguous behaviors, and caring behaviors significantly differed between the groups ($P < 0.05$).

Based on the results of Table 3, although the participants

Table 1. Demographic Characteristics of Participants of the Study

Variable	Physiological Delivery (n=118)	Cesarean Section (n=158)
Mothers age, mean ± SD	27.56±0.25	25.94±0.34
BMI, mean ±SD	83.42±2.25	85.12±1.2
Gestational age, mean ± SD	38.84±0.06	38.46±0.02
Neonatal weight, mean ± SD	66.11±246.15	63.12±356.34
Education, n		
Illiterate	43	67
Literate	75	91
Job, n		
Employed	86	74
Housewife	32	84
Gender of fetus, n		
Male	32	43
Female	86	115

BMI, body mass index.

experienced higher levels of anxiety in the group of cesarean delivery, the differences between the groups were not significant ($P > 0.005$). The attachment model of the study is presented in Table 4.

Discussion

This study was done to investigate the details of mother-infant attachment behaviors in those women who experienced different delivery methods. In the child development domain, attachment is known as one of the basic needs of human beings. In this regard, Bowlby (12) stated that attachment develops when the newborns have a persistent intimate and warm relationship with their mothers, which results in mutual contentment and satisfaction. Accordingly, maternal attachment has profound effects on developing the infant and performing the maternal role (27).

The findings demonstrated that the scores of mother-infant attachment in the physiologic delivery were significantly higher than those of the cesarean section. Considering that no research has so far focused on the attachment of the child to his/her mother after a physiologic delivery, no comparison data were available in this regard. Thus, the data of the normal vaginal delivery and cesarean section were used in this part. According to the results of the study by Van den Hurk, the children born by a cesarean section (C-section) seem to be more anxious-ambivalent attached to their mothers compared to those who were born by a vaginal delivery. It means

Table 2. Results of 7 Tests on the Type of Delivery and Attachment Behaviors

Attachment Behavior Groups		Type of Delivery		P Value
		Physiological Delivery (n=118), No. (%)	Caesarean Section (n=158), No. (%)	
Emotional behaviors				
Kissing	Yes	76 (64.4)	96 (62.7)	0.798
	No	42 (35.6)	57 (37.3)	
Looking	Yes	117 (99.2)	141 (92.2)	0.032
	No	1 (0.8)	12 (7.8)	
Caressing	Yes	93 (78.8)	93 (60.8)	<0.001
	No	25 (21.2)	60 (39.2)	
Talking to	Yes	63 (53.4)	73 (47.7)	0.24
	No	55 (46.6)	80 (52.3)	
Smiling at	Yes	106 (89.8)	130 (85.0)	0.23
	No	12 (10.2)	23 (15.0)	
Rocking the cradle	Yes	62 (52.5)	51 (33.3)	<0.001
	No	55 (46.6)	102 (66.7)	
Contiguous behaviors				
Hugging without body contact	Yes	63 (53.38)	19 (12.02)	<0.001
	No	55 (46.62)	139 (87.98)	
Hugging with the close contact	Yes	98 (83.1)	92 (60.1)	<0.001
	No	20 (16.9)	61 (39.9)	
Hugging in which hands are put around the infant's arms	Yes	62 (52.5)	34 (22.2)	<0.001
	No	56 (47.5)	119 (77.8)	
Caring behaviors				
Changing infant's diapers and clothes	Yes	17 (14.4)	12 (7.8)	0.031
	No	101 (85.6)	141 (92.2)	
Patting the infant on the back to release gas from stomach	Yes	51 (43.2)	44 (28.8)	0.040
	No	67 (56.8)	109 (71.2)	

Table 3. Results of 7 Tests on the Type of Delivery and the Sub-types of Anxiety

Types of Anxiety	Type of Delivery		P-value
	Physiological Delivery (n=118), No. (%)	Cesarean Section (n=158), No. (%)	
State anxiety			0.07
Mild	18 (15.25)	30 (18.98)	
Moderate	100 (84.75)	122 (77.22)	
Severe	0 (0)	6 (3.8)	
Trait anxiety			0.73
Mild	10 (8.5)	21 (13.4)	
Moderate	107 (90.7)	134 (85.4)	
Severe	1 (0.8)	2 (1.3)	

Table 4. The Results of Regression Model Based on Mother-Infant Attachment Behaviors in the Presence of Effective Variables

Model Variables	Coefficients		95% CI		P Value
	Adjusted beta	SE	Minimum	Maximum	
Mother's age	0.123	0.126	-0.300	0.435	0.435
BMI	0.193	0.197	-.221	0.321	0.324
Gestational age	0.234	0.239	-.324	0.352	0.123
Education	0.321	0.054	0.112	0.559	0.006
Job	1.305	2.130	6.760	-2.534	0.594
Gender of the fetus	1.766	1.622	-4.109	0.478	0.766

BMI: body mass index; SE: standard error

that they react clingily and get in great distress when their caregiver leaves (28). Additionally, Olza-Fernández et al found that a C-section could directly result in a more insecure attachment of the child to his/her mother. They further concluded that neonates born by vaginal delivery (64.8 ± 8.6) took longer to calm down compared to those born by cesarean section (0.9 ± 1.4) ($P=0.004$). A correlation was observed between cortisol concentrations at birth and the time required to calm down the baby ($r=0.41$, $P=0.02$) (29,30). In this regard, Hergüner et al believed that cesarean delivery had a negative effect on maternal attachment (31). However, several other studies emphasized the positive role of vaginal delivery on maternal-infant attachment (32-34), which is in line with the results of the present study.

On the other hand, some studies reported that there is no relation between the delivery methods and mother-infant attachment. According to these studies, attachment is a long and deep reaction that occurs long before delivery. Therefore, it is unlikely that the mode of delivery can undergo such a profound reaction (35-39). It is assumed that some of the observed differences between the results of our study and those of the above-mentioned studies are attributed to the impact of some affecting factors mentioned in the articles (40-43). Therefore, the effect of these variables was examined in the regression analysis, but no effect was observed in this regard.

Although this study verified the positive roles of physiologic delivery in the mother-infant attachment, no knowledge is available about these mechanisms and

more research should be done accordingly. The evaluation of this subject could consider a research design for comparing the attachment of siblings, who were born by a vaginal delivery and a C-section to their mother. The present stud had some limitations such as including small sample size, which is related to the cross-sectional study, not measuring hormones levels, and altering the attachment behavior at the presence of the observer.

Our findings can help the obstetricians and midwives to guide the pregnant women about the possible negative effects of a C-section on the attachment of the child to his/her mother, and mothers can make a good decision about vaginal delivery and C-section.

Conflict of Interests

Authors declare that they have no conflict of interests.

Financial Support

Research Deputy and Council of Shahroud University of Medical Sciences, Shahroud.

Acknowledgments

Hereby, we express our deepest sense of gratitude and indebtedness to the Research Deputy and Council of Shahroud University of Medical Sciences for their financial support.

References

1. Belsky J. Experiencing the Lifespan. New York: Mosby; 2003.

2. Carter-Jessop L. Promoting maternal attachment through prenatal intervention. *MCN Am J Matern Child Nurs.* 1981;6(2):107-112. doi:10.1097/00005721-198103000-00009
3. Keverne EB, Levy F, Poindron P, Lindsay DR. Vaginal stimulation: an important determinant of maternal bonding in sheep. *Science.* 1983;219(4580):81-83. doi:10.1126/science.6849123
4. Behrman RE, Kliegman RM, Jenson HB. *Nelson Textbook of Pediatrics.* 17th ed. Philadelphia: Elsevier Health Sciences; 2004:230-243.
5. Schanler RJ. The use of human milk for premature infants. *Pediatr Clin North Am.* 2001;48(1):207-219. doi:10.1016/s0031-3955(05)70295-9
6. Nissen E, Uvnäs-Moberg K, Svensson K, Stock S, Widström AM, Winberg J. Different patterns of oxytocin, prolactin but not cortisol release during breastfeeding in women delivered by caesarean section or by the vaginal route. *Early Hum Dev.* 1996;45(1-2):103-118. doi:10.1016/0378-3782(96)01725-2
7. Kim JS, Cho KJ. The effect of mother-fetus interaction promotion program of talking and tactile stimulation on maternal-fetal attachment. *Korean J Child Health Nurs.* 2004;10(2):153-164. [Korean].
8. Akbarzadeh M, Toosi M, Zare N, Sharif F. Effect of relaxation and attachment behaviors training on anxiety in first-time mothers in Shiraz city, 2010: a randomized clinical trial. *Qom University of Medical Sciences Journal.* 2013;6(4):14-23. [Persian].
9. Scott JR, Gibbs RS, Karlan BY, Haney AF. *Danforth's Obstetrics and Gynecology.* 9th ed. Philadelphia: Lippincott Williams & Wilkins; 2003.
10. Yarcheski A, Mahon NE, Yarcheski TJ, Hanks MM, Cannella BL. A meta-analytic study of predictors of maternal-fetal attachment. *Int J Nurs Stud.* 2009;46(5):708-715. doi:10.1016/j.ijnurstu.2008.10.013
11. Alder J, Urech C, Fink N, Bitzer J, Hoesli I. Response to induced relaxation during pregnancy: comparison of women with high versus low levels of anxiety. *J Clin Psychol Med Settings.* 2011;18(1):13-21. doi:10.1007/s10880-010-9218-z
12. Bowlby J. *Attachment and Loss.* New York: Basic Books; 1969.
13. Widmaier EP, Raff H, Strang KT. *Vander's Human Physiology: The Mechanisms of Body Function.* New York: McGraw-Hill; 2011:112-119.
14. Declercq ER, Sakala C, Corry MP, Applebaum S. *Listening to Mothers II: Report of the Second National U.S. Survey of Women's Childbearing Experiences.* New York: Childbirth Connection; 2006:1-9.
15. Bolbol-Haghighi N, Masoumi SZ, Kazemi F. Effect of massage therapy on duration of labour: a randomized controlled trial. *J Clin Diagn Res.* 2016;10(4):QC12-15. doi:10.7860/jcdr/2016/17447.7688
16. Polderman N, Kellaert-Knoll MG, Storsbergen H, Bongaerts WB, Corts M, De Pagter JN. *Manual of the attachment difficulties screening inventory 2-5 years (AISI 2-5 years).* Haarlem, The Netherlands: Basic Trust; 2008.
17. Bosch OJ, Neumann ID. Both oxytocin and vasopressin are mediators of maternal care and aggression in rodents: from central release to sites of action. *Horm Behav.* 2012;61(3):293-303. doi:10.1016/j.yhbeh.2011.11.002
18. Ebrahimi H, Amanpour F, Bolbol Haghighi N. Prevalence and risk factors of varicose veins among female hairdressers: a cross sectional study in north-east of Iran. *J Res Health Sci.* 2015;15(2):119-123.
19. Graham MD, Rees SL, Steiner M, Fleming AS. The effects of adrenalectomy and corticosterone replacement on maternal memory in postpartum rats. *Horm Behav.* 2006;49(3):353-361. doi:10.1016/j.yhbeh.2005.08.014
20. Fleming AS, Steiner M, Corter C. Cortisol, hedonics, and maternal responsiveness in human mothers. *Horm Behav.* 1997;32(2):85-98. doi:10.1006/hbeh.1997.1407
21. Zeraati H, Nasimi F, Milan Dalei M, Shahinfar J, Momenizade A, Barfidokht A. The effect of family-centered care program on maternal attachment in mothers of premature infants. *Journal of Babol University of Medical Sciences.* 2017;19(6):22-27. doi:10.22088/jbums.19.6.3
22. Taffazoli M, Montakhab Asadi M, Aminyazdi SA, Shakeri MT. The relationship between maternal-fetal attachment and mother-infant attachment behaviors in primiparous women referring to Mashhad health care centers. *J Midwifery Reprod Health.* 2015;3(2):318-327. doi:10.22038/jmrh.2015.3949
23. Keramat A, Younesian M, Gholami Fesharaki M, et al. Inactive hepatitis B carrier and pregnancy outcomes: a systematic review and meta-analysis. *Iran J Public Health.* 2017;46(4):468-474.
24. Alavian SM, Ebrahimi E, Abedini M. Necessity for hepatitis B surface antigen screening in pregnant females in Iran. *Iran Red Crescent Med J.* 2016;18(9):e40844.
25. Borimnejad L, Mehrnush N, Seyed-Fatemi N, Haghani H. The effect of empowerment program on mother-infant interaction and weight gain in preterm infants. *Zahedan Journal of Research in Medical Sciences.* 2012;14(9):19-23.
26. Sahranavard M. The Investigation of Construct Validity of Trait Anxiety Inventory among Iranian Students. *General Scientific Researches.* 2015;3(3):16-20.
27. Hoseini VM, Nejhad FJ, Soltanifar A. Impact of maternal attachment style on mother to infant attachment. *Qom University of Medical Sciences Journal.* 2011;5(3):87-92. [Persian].
28. van den Hurk BPJ. *The Effect of a Caesarean Section on Attachment of Child to Mother.* Clinical Health Psychology, Department Developmental Psychology, Tilburg University; 2015.
29. Olza Fernández I, Marín Gabriel MA, García Murillo L, Malalana Martínez AM, Costarelli V, Millán Santos I. Mode of delivery may influence neonatal responsiveness to maternal separation. *Early Hum Dev.* 2013;89(5):339-342. doi:10.1016/j.earlhumdev.2012.11.005
30. Olza-Fernández I, Marín Gabriel MA, Gil-Sanchez A, Garcia-Segura LM, Arevalo MA. Neuroendocrinology of childbirth and mother-child attachment: the basis of an etiopathogenic model of perinatal neurobiological disorders. *Front Neuroendocrinol.* 2014;35(4):459-472. doi:10.1016/j.yfrne.2014.03.007
31. Hergüner S, Çiçek E, Annagür A, Hergüner A, Örs R. Association of delivery type with postpartum depression, perceived social support and maternal attachment. *Düşünen*

- Adam. 2014;27:15-20. doi:10.5350/dajpn2014270102
32. Kelmanson IA. Emotional and behavioural features of preschool children born by Caesarean deliveries at maternal request. *Eur J Dev Psychol.* 2013;10(6):676-690. doi:10.1080/17405629.2013.787024
 33. Keverne EB, Levy F, Poindron P, Lindsay DR. Vaginal stimulation: an important determinant of maternal bonding in sheep. *Science.* 1983;219(4580):81-83. doi:10.1126/science.6849123
 34. Lobel M, DeLuca RS. Psychosocial sequelae of cesarean delivery: review and analysis of their causes and implications. *Soc Sci Med.* 2007;64(11):2272-2284. doi:10.1016/j.socscimed.2007.02.028
 35. Özyurt G, Özyurt A, Ozturk T, Yaman A, Berk AT. Evaluation of maternal attachment, self-efficacy, levels of depression, and anxiety in mothers who have babies diagnosed with retinopathy of prematurity. *Ophthalmic Epidemiol.* 2018;25(2):140-146. doi:10.1080/09286586.2017.1372487
 36. Muller ME. Development of the prenatal attachment inventory. *West J Nurs Res.* 1993;15(2):199-211. doi:10.1177/019394599301500205
 37. Ghasab Shirazi M, Kohan S, Firoozehchian F, Ebrahimi E. Experience of childbirth with birth ball: a randomized controlled trial. *Int J Womens Health Reprod Sci.* 2019;7(3):301-305. doi:10.15296/ijwhr.2019.50
 38. Ravitz P, Maunder R, Hunter J, Sthankiya B, Lancee W. Adult attachment measures: a 25-year review. *J Psychosom Res.* 2010;69(4):419-432. doi:10.1016/j.jpsychores.2009.08.006
 39. Roumen FJ, Luyben AG. Safety of term vaginal breech delivery. *Eur J Obstet Gynecol Reprod Biol.* 1991;40(3):171-177. doi:10.1016/0028-2243(91)90114-z
 40. Adult attachment and birth experience: importance of a secure base and safe haven during childbirth. *Journal of Reproductive and Infant Psychology.* 2019;37(1):26-43. doi: 10.1080/02646838.2018.1509303
 41. Graham MD, Rees SL, Steiner M, Fleming AS. The effects of adrenalectomy and corticosterone replacement on maternal memory in postpartum rats. *Horm Behav.* 2006;49(3):353-361. doi:10.1016/j.yhbeh.2005.08.014
 42. Shariat M, Abedinia N. The effect of psychological intervention on mother-infant bonding and breastfeeding. *Iranian Journal of Neonatology IJN.* 2017;8(1):7-15. doi:10.22038/ijn.2017.16673.1191
 43. Sigurdardottir VL, Gamble J, Gudmundsdottir B, Kristjansdottir H, Sveinsdottir H, Gottfredsdottir H. The predictive role of support in the birth experience: A longitudinal cohort study. *Women Birth.* 2017;30(6):450-459. doi: 10.1016/j.wombi.2017.04.003

© 2020 The Author(s); This is an open-access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.