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Multifactorial Validation of the BAFRIC Battery for Breast Cancer Risk: Integration of the Delphi Method and Dermatoglyphic Pattern Analysis

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Abstract

Purpose

Breast cancer has a multifactorial etiology, involving genetic, epigenetic, behavioral, environmental, and psychosocial determinants, which reinforces the need for integrated instruments to assess vulnerabilities associated with the disease. This study aimed to analyze the reliability and objectivity of the Battery of Integrated Risk Factors for Breast Cancer (BAFRIC), define interpretation standards, and incorporate dermatoglyphic analysis as a complementary and exploratory biological marker.

Methods

This is a methodological, quantitative study, developed in two stages: evaluation of intra- and inter-rater reliability in 35 women without a history of breast cancer; and establishment of BAFRIC standards and dermatoglyphic description in 100 women diagnosed with breast cancer, registered with the Association of Friends of Oncology (AMO), a Brazilian non-governmental organization (NGO).

Results

Reliability was estimated using the Intraclass Correlation Coefficient, with ICC(3,1) and ICC(2,1) models. The results indicated good to excellent reliability per item and excellent per dimension, with dimensional ICCs between 0.975 and 1.000. Dermatoglyphic analysis considered arches, loops, whorls, D10, and SQTL.

Conclusion

It is concluded that BAFRIC presents promising metric properties, stability, and reproducibility, configuring itself as an auxiliary, non-diagnostic instrument for multidimensional assessment of vulnerabilities associated with breast cancer.

INTRODUCTION

Breast cancer constitutes a significant public health problem due to its high incidence, impact on morbidity and mortality, and social, economic, and psychosocial repercussions associated with the disease [11]. Its occurrence results from the interaction between genetic, epigenetic, environmental, behavioral, and psychosocial factors, highlighting its multifactorial nature and the need for integrated approaches to assess associated vulnerabilities [29, 4, 26].

Established risk assessment tools, such as the Gail, TyrerCuzick/IBIS, and BOADICEA models, have made significant contributions to the clinical and epidemiological stratification of breast cancer.

However, these instruments tend to prioritize clinical, familial, hormonal, and genetic variables, failing to comprehensively consider behavioral, environmental, psychosocial dimensions, and complementary phenotypic markers. This gap underscores the relevance of multidimensional instruments aimed at a broader characterization of vulnerabilities, especially in the contexts of prevention, health education, and population-based research [21, 9, 23].

In the health field, assessment instruments need to demonstrate scientific validity, reliability, and standardization in order to guarantee the quality of the information produced and its applicability in research and daily clinical practice [25, 28]. In the oncology field, although there are instruments geared towards specific domains, there are still limited tools capable of bringing together, in a single proposal, clinical, behavioral, environmental, and psychosocial dimensions related to breast cancer [24, 3].

To this end, the Integrated Risk Factor Assessment Battery for Breast Cancer (BAFRIC) was developed, designed to assess, in a multidimensional way, factors associated with oncological vulnerability in adult women. The battery includes dimensions related to diet, epigenetics and dermatoglyphics, physical exercise, environment, mental health and clinical history, allowing for a broader analysis of the participants' profile [2, 10, 15, 17, 20].

The Delphi technique was incorporated into the content development and validation process because it allows for consensus among experts and the systematic refinement of the proposed items [30]. Associated with reliability, objectivity, and interpretative standardization analyses, this step strengthens the methodological robustness of BAFRIC and supports its use as an auxiliary, non-diagnostic instrument in the integrated study of vulnerabilities associated with breast cancer.

Thus, the present study aimed to analyze the reliability and objectivity of the BAFRIC, define interpretation standards for the instrument in women with breast cancer, and describe dermatoglyphic parameters as complementary exploratory biological markers.

METHODS

Study design

This is a methodological study, with a quantitative approach, aimed at evaluating the reliability, objectivity, and definition of standards for the Battery of Integrated Risk Factors for Breast Cancer (BAFRIC), including dermatoglyphic analysis as a complementary biological marker. The study was structured in two stages: (1) analysis of the reliability and objectivity of the instrument; and (2) establishment of interpretative standards for BAFRIC, with descriptive dermatoglyphic analysis in women with breast cancer.

Content validation using the Delphi method.

The construction and refinement of the BAFRIC items were conducted using the Delphi technique, with the participation of experts in the fields of oncology, women's health, physical activity, nutrition, mental health, epidemiology, psychometrics, and/or related areas.

Participants and recruitment

The sample was composed of two distinct groups, according to the objectives of each stage of the study. In the first stage, 35 women with no history of breast cancer participated, selected by convenience, with the aim of evaluating the reliability and objectivity of the instrument through test-retest and inter-rater analysis.

In the second stage, 100 women diagnosed with breast cancer participated, including patients undergoing treatment and survivors of the disease, registered with the Association of Friends of Oncology (AMO), a Brazilian non-governmental organization (NGO)

The inclusion criteria covered women aged 18 years or older, diagnosed with primary breast cancer for the second stage, who agreed to participate voluntarily in the research and presented medical authorization for participation. The exclusion criteria included lack of authorization from the oncologist, severely compromised immunity, and serious comorbidities that could interfere with the application of the instrument or the collection of fingerprints.

Instrument

The instrument used was the Battery of Integrated Risk Factors for Breast Cancer (BAFRIC), composed of a structured questionnaire that assesses multiple dimensions related to risk and vulnerability factors for breast cancer, including diet, epigenetics, physical exercise, environment, mental health, and clinical history. The items are organized on a Likert-type scale, allowing for the quantification of the evaluated factors and the construction of standardized indicators.

The BAFRIC questionnaire and accompanying manual were developed specifically for this study. An English-language version is provided as Supplementary Material (https://heyzine.com/flip-book/c8381326ea.html).

Collection procedures

In the reliability phase, each participant was evaluated by two previously trained independent evaluators. For the intra-rater analysis, one of the evaluators repeated the application of the instrument after a standardized interval. For the inter-rater analysis, the applications performed by different evaluators were compared, maintaining similar application conditions.

In the BAFRIC pattern definition phase, the instrument was applied to 100 women with breast cancer. Before data collection began, information was provided to the participants and their physicians, ensuring informed consent and understanding of the study's objectives.

Data analysis

In addition to the questionnaire, dermatoglyphic patterns were analyzed as an indirect biological marker for exploratory and descriptive purposes. Dermatoglyphics were used based on literature that describes digital patterns as possible indicators of interactions between genetic and environmental factors during embryonic development, without attributing isolated diagnostic or prognostic value.

The Salus method was used to evaluate dermatoglyphic patterns, considering arches (A), loops (L), whorls (W), number of deltas in the ten fingers (D10), and total sum of lines (SQTL). These parameters were analyzed to describe the dermatoglyphic profile of the sample and explore possible relationships with the factors evaluated by BAFRIC.

The fingerprint collection followed the classic Cummins and Midlo (1961) protocol, using a roller optical reader to capture the images. The analysis was performed using Salus® software, capturing fingerprints from all fingers of both hands, processing the images, marking the core and delta points, counting the digital lines, and organizing the results in spreadsheets generated by the system.

Ethical aspects

The study followed the ethical principles of research involving human beings, respecting the guidelines of Resolution No. 466/12 of the National Health Council. All participants signed the Informed Consent Form (ICF) before participating. The project was approved by the Research Ethics Committee of the responsible institution, according to opinion no. 7.724.641 - CAAE: 87454824.7.0000.5371

Statistical analysis

Descriptive analyses were performed using means, standard deviations, absolute and relative frequencies. The reliability of the BAFRIC was assessed using the Intraclass Correlation Coefficient (ICC). Inter-rater reliability was estimated using the ICC(2,1) model, based on a two-factor model with random effects and absolute agreement. Intra-rater reliability was estimated using the ICC(3,1) model, based on a two-factor model with mixed effects.

ICC values were interpreted according to criteria established in the literature: below 0.50 as low reliability; between 0.50 and 0.75 as moderate reliability; between 0.75 and 0.90 as good reliability; and above 0.90 as excellent reliability [14]. Uncalculated values (NC) were assigned to items without sufficient variability between responses, a condition that makes statistical calculation of the coefficient unfeasible.

RESULTS

Reliability analysis demonstrated favorable performance of BAFRIC in the evaluated dimensions. Considering the dimensional scores, the ICC coefficients ranged from 0.975 to 1.000 in the intra-rater analysis and from 0.996 to 1.000 in the inter-rater analysis, indicating excellent stability and reproducibility of the instrument.

In the item analysis, the ICC values for intra-rater reliability ranged from 0.805778 to 1.000, while inter-rater reliability ranged from 0.800781 to 1.000. Most questions showed good to excellent reliability. Some items showed an absence of variability in responses, preventing the calculation of the ICC; these cases were indicated as NC and should be interpreted with caution, as they may reflect high sample homogeneity or low discriminative sensitivity of the item. The dimensional results are presented in Tables 1, 2, 3, and 4.

Table 1
Intraclass Correlation Coefficient (ICC) for Intra-rater Reliability (Examiner 1, Week 1 vs. Week 2)

Dimension/Risk Factor	Application 1 (M ± DP)	Application 2 (M ± SD)	Application 2 (M ± SD)	ICC	ICC Classification*
Food	1.83 ± 1.42	1.83 ± 1.40	1.83 ± 1.42	0,984	Excellent
Epigenetics	1.72 ± 1,60	1.73 ± 1,60	1.72 ± 1,60	0,997	Excellent
Physical Exercise	2.22 ± 1.50	2.28 ± 1.48	2.22 ± 1.50	0,975	Excellent
Environment	2.31 ± 1.53	2.31 ± 1.54	2.31 ± 1.53	0,995	Excellent
Mental health	2.21 ± 1.62	2.21 ± 1.62	2.21 ± 1.62	1	Excellent

ICC Classification < 0.50 = Poor; 0.50–0.74 = Moderate; 0.75–0.89 = Good; ≥0.90 = Excellent. Source: Author's own work (2025)

Table 2
Intraclass Correlation Coefficient (ICC) for Inter-rater Reliability (Examiner 1, Week 1 vs. Examiner 2, Week 3)

Dimension/Risk Factor	Application 1 (M ± DP)	Application 3 (M ± SD)	ICC	ICC Classification*
Food	1.83 ± 1.42	1.83 ± 1.42	0,996	Excellent
Epigenetics	1.72 ± 1,60	1.73 ± 1,60	0,997	Excellent
Physical Exercise	2.22 ± 1.50	2.25 ± 1.49	0,996	Excellent
Environment	2.31 ± 1.53	2.30 ± 1.53	1	Excellent
Mental health	2.21 ± 1.62	2.21 ± 1.62	1	Excellent

ICC Classification < 0.50 = Poor; 0.50–0.74 = Moderate; 0.75–0.89 = Good; ≥0.90 = Excellent. Source: Author's own work: 2025

Table 3
Intraclass Correlation Coefficients (ICC) for Intra-Rater Reliability (Ratee 1: Week 1 vs. Week 2)

Variable	ICC	IC 95%	p-value
Q1	0.882039	0.78–0.94	5.91e-13
Q2	1	1. – 1.	2.01e-255
Q3	0.913594	0.84–0.96	3.82e-15
Q4	0.857233	0.74–0.93	1.24e-11
Q5	0.972858	0.95–0.99	1.71e-23
Q6	1	NC	0.00e + 00
Q7	1	1. – 1.	1.000
Q8	1	1. – 1.	2.16e-255
Q9	1	1. – 1.	1.000
Q10	NC	NC	NC
Q11	1	NC	0.00e + 00
Q12	1	1. – 1.	2.35e-253
Q13	1	1. – 1.	1.000
Q14	0.837628	0.7–0.91	9.44e-11
Q15	0.957578	0.92–0.98	3.01e-20
Q16	0.92576	0.86–0.96	3.18e-16
Q17	0.839888	0.71–0.92	7.58e-11
Q18	1	1. – 1.	1.72e-261
Q19	1	1. – 1.	1.000
Q20	1	1. – 1.	4.38e-255
Q21	0.805778	0.65–0.9	1.53e-09
Q22	1	NC	0.00e + 00
Q23	1	1. – 1.	5.52e-258
Q24	1	1. – 1.	7.24e-253
Q25	1	NC	0.00e + 00
Q26	1	1. – 1.	1.43e-261

Variable	ICC	IC 95%	p-value
Q27	1	NC	0.00e + 00
Q28	1	1. − 1.	2.27e-256
Q29	1	NC	0.00e + 00
Q30	1	1. − 1.	1.36e-262
Q31	1	NC	0.00e + 00
Q32	1	NC	0.00e + 00

Legend: NC: Values not calculated due to the absence of variability among those evaluated, making it impossible to calculate the ICC.

Table 4
Intraclass Correlation Coefficients (ICC) for Inter-Rater Reliability (Rater 1 vs. Rater 2)

Questions	ICC	IC 95%	p-value
Q1	0.992329	0.98–1.	9.27e-33
Q2	0.979192	0.96–0.99	1.19e-25
Q3	0.981502	0.96–0.99	4.35e-26
Q4	0.884852	0.79–0.94	4.32e-13
Q5	1	1. – 1.	4.35e-260
Q6	1	NC	0.00e + 00
Q7	1	1. – 1.	1.000
Q8	1	1. – 1.	2.16e-255
Q9	1	1. – 1.	1.000
Q10	NC	NC	NC
Q11	1	NC	0.00e + 00
Q12	1	1. – 1.	2.35e-253
Q13	1	1. – 1.	1.000
Q14	1	1. – 1.	8.05e-254
Q15	1	1. – 1.	1.000
Q16	1	NC	0.00e + 00
Q17	1	1. – 1.	1.000
Q18	0.800781	0.64–0.89	1.56e-09
Q19	1	1. – 1.	1.000
Q20	1	1. – 1.	4.38e-255
Q21	0.984432	0.97–0.99	8.92e-28
Q22	1	NC	0.00e + 00
Q23	1	1. – 1.	5.52e-258
Q24	1	1. – 1.	7.24e-253
Q25	1	NC	0.00e + 00
Q26	1	1. – 1.	1.43e-261

Questions	ICC	IC 95%	p-value
Q27	1	NC	0.00e + 00
Q28	1	1. − 1.	2.27e-256
Q29	1	NC	0.00e + 00
Q30	1	1. − 1.	1.36e-262
Q31	1	NC	0.00e + 00
Q32	1	NC	0.00e + 00

Legend: NC: Values not calculated due to the absence of variability among those evaluated, making it impossible to calculate the ICC.

Standardization among raters and weeks contributed to the methodological robustness of the study. Structured team training, supervision by the principal investigator, and controlled replication of application conditions reduced external sources of variability and strengthened the internal validity of the reproducibility analysis.

Dermatoglyphic analysis was conducted descriptively, considering the distribution of arch, loop, and whorl patterns, as well as the D10 and SQTL indicators. Because it is a complementary and exploratory marker, its results should be presented without direct diagnostic or predictive inference. It is recommended to include a specific figure or table showing the dermatoglyphic distribution of the sample.

Analysis of dermatoglyphic patterns between the Breast Cancer (BC) and Control groups revealed small numerical differences across most patterns. In the BC group, the means of the Whorl (W) and Secondary Whorl (WS) patterns were slightly higher (2.99 and 2.03, respectively) than those observed in the Control group (2.96 and 1.92, respectively), whereas the ulnar (LU) and radial (LR) loops showed slightly lower means (6.90 and 1.37 versus 7.19 and 1.42, respectively). The Arch (A) pattern showed a higher mean in the BC group (1.50 versus 1.34), with this difference reaching statistical significance ($p = 0.043$). The descriptive results are presented in Table 5. These findings are consistent with the general pattern described in the literature, in which ulnar loops predominate, followed by whorls, while variations in dermatoglyphic patterns may be associated with genetic and developmental factors [22].

Despite these differences, the lack of statistical significance indicates that the dermatoglyphic patterns evaluated do not robustly differentiate between women with and without breast cancer in this sample, suggesting that the instrument, while reliable for identifying general patterns, does not have sufficient sensitivity as an isolated diagnostic marker. This means that, in the context of the study, the instrument remains useful for population characterization and genetic risk analyses, but cannot be considered predictive or discriminative for breast cancer. Previous studies corroborate this interpretation, showing that small variations in patterns can occur between groups with cancer, but often without reaching

statistical significance [16] Therefore, the results reinforce that dermatoglyphics is a valuable tool for descriptive and epidemiological studies, but its impact as a clinical indicator depends on complementary analyses and larger samples [8].

Table 5
Means and standard deviations of dermatoglyphic patterns in the Cancer (CM) and Control groups.

W (Whorl)	**2,99**	**9,99**	**2,96**	**9,85**
WS (Whorl) **Secondary**	2,03	9,94	1,92	9,81
LU (Loop Ulnar)	6,90	9,65	7,19	9,51
LR (Loop Radial)	1,37	9,89	1,42	9,81
A (Arch)	1,50	9,94	1,34	9,86

Source: Author's own work (2025).

The most significant finding among the dermatoglyphic parameters analyzed was the higher prevalence of the Arch (A) pattern among women with breast cancer (1.50) compared to the Control group (1.34), with a statistically significant difference according to Student's t-test ($p = 0.043$). However, this is a one-off, isolated finding observed among multiple parameters evaluated, and does not represent a global or consistent association between the groups.

From a biological standpoint, this result can be discussed in light of hypotheses described in the literature, which relate the formation of papillary ridges occurring between the 13th and 17th weeks of gestation to interactions between genetic and environmental factors during embryonic development [1]. Previous studies suggest that the greater presence of arches may be associated with the simplification of the dermatoglyphic pattern and alterations described as genomic instability, aspects discussed in multifactorial diseases, including cancer [1]. However, such interpretations should be made with caution, considering the methodological heterogeneity and the lack of consensus in the literature.

Thus, although the Arch pattern showed isolated statistical significance, the dermatoglyphic findings of this study, in general, reinforce the complementary and exploratory nature of dermatoglyphics, not supporting predictive, diagnostic, or prognostic extrapolations. Its inclusion in the assessment instrument broadens the proposed integrative approach, allowing the description and exploration of possible associations between phenotypic characteristics and biological, behavioral, and environmental factors related to breast cancer. The detailed results are presented in Table 6, which compares the Cancer and Control groups.

Table 6
:Comparison of dermatoglyphic patterns between the Cancer and Control groups.

Design	Observed difference	Interpretation
IN	2,99 vs. 2,96	No difference
WS	2,03 vs. 1,92	No difference
LU	6,90 vs. 7,19	Slightly greater in control
LR	1,37 vs. 1,42	No difference
A	1,50 vs. 1,34	Most prevalent in the cancer group*

Significant difference according to Student's t-test (p = 0.043; percent delta = 89.33%).

Source: Author's own work (2025).

DISCUSSION

The findings indicate that the BAFRIC showed satisfactory psychometric performance, with high levels of reliability and objectivity. Intraclass correlation coefficients showed good to excellent agreement in intra- and inter-rater analyses, demonstrating temporal stability of the measures and high reproducibility under different application conditions. These results reinforce the methodological consistency of the battery and its potential as a standardized tool for multidimensional investigations in the field of women's health [5].

Intra-rater reliability indicates that the BAFRIC is capable of producing stable measurements when reapplied by the same examiner at different times. Inter-rater reliability, in turn, demonstrates reduced influence of examiner variations on the results obtained. This attribute is especially relevant in instruments whose application may involve different professionals or teams, since their scientific and practical utility depends on the ability to generate equivalent interpretations regardless of who performs the measurement.

The main contribution of BAFRIC lies in its integrative design. In contrast to classic breast cancer risk models, which prioritize clinical, familial, hormonal, and genetic variables, BAFRIC articulates dimensions related to diet, epigenetics and dermatoglyphics, physical exercise, environment, mental health, and clinical history in a single evaluative matrix. This conceptual breadth is consistent with the contemporary understanding of breast cancer as a multifactorial phenomenon, resulting from the interaction between biological, behavioral, environmental, and psychosocial determinants [6].

Defining interpretative standards for the battery is also a relevant step for its applicability. By establishing parameters for reading the scores and categorizing the IFRIC, the study expands the operational utility of the instrument, favoring consistent comparisons between individuals and groups.

However, this categorization must be presented transparently, with a description of the score calculation, quartiles, and cut-off points, avoiding clinical interpretations not supported by the data.

Regarding dermatoglyphic analysis, its incorporation enhances the innovative nature of the proposal, although its results require cautious interpretation. The study positions it as a complementary biological marker, of an exploratory and descriptive nature, without isolated diagnostic or prognostic purpose. This delimitation is methodologically appropriate given the heterogeneity of the available evidence regarding the association between digital patterns and breast cancer [12].

Some aspects require critical appraisal. The occurrence of ICC values equal to 1.000 and coefficients not calculated due to lack of variability suggests that certain items may exhibit low dispersion in the analyzed sample. Although this phenomenon may reflect the stability of the measures, it may also indicate excessive homogeneity of responses or limitation of the discriminative sensitivity of some items. It is recommended to review items with low variability and include complementary analyses, such as limits of agreement and evaluation of problematic items [13].

Another limitation relates to convenience sampling and the composition of the evaluated groups. The first stage included women with no history of breast cancer, while the second included women who had been diagnosed, were undergoing treatment, or were survivors. This strategy is consistent with the methodological objectives of each stage, but caution is advised in generalizing the findings to larger and more heterogeneous populations. Future studies should include larger, multicenter samples with different sociodemographic profiles, disease stages, and care settings [19].

In summary, BAFRIC presents promising metric properties and a relevant conceptual difference by integrating multiple vulnerability domains into a single instrument. Its stability and objectivity, associated with the multidimensional approach and the complementary incorporation of dermatoglyphics, reinforce its potential for application in research, characterization of vulnerability profiles, and planning of preventive and educational actions.

CONCLUSION

BAFRIC has proven to be a reliable and reproducible instrument for the integrated and multidimensional assessment of factors associated with breast cancer vulnerability in adult women. The results showed excellent intra- and inter-rater reliability in the dimensional scores, supporting the stability and objectivity of the instrument.

The key difference of BAFRIC lies in the systematic integration of multiple domains into a single assessment matrix, including environmental, dietary, behavioral, psychosocial, epigenetic, and dermatoglyphic factors. This approach broadens the understanding of cancer risk as a multifactorial phenomenon and offers a tool with potential applications in epidemiological research, health education, and the planning of preventive strategies.

BAFRIC should be understood as an auxiliary and complementary tool, not a diagnostic or predictive one, and is not intended for the clinical identification of neoplasms or the individualized definition of medical conduct. Its use is more appropriate as a resource to support scientific research, the characterization of population vulnerability profiles, and the planning of preventive and educational actions, without replacing specialized clinical assessments or established diagnostic tools [27].

Declarations

Ethics approval and consent to participate

The study was approved by the Research Ethics Committee of Tiradentes University (Universidade Tiradentes – UNIT), under approval number 7,724,641 (CAAE: 87454824.7.0000.5371). All participants provided informed consent before participating in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

M.A.S.R., I.P.V. de A., and A.V.F.S. wrote the main manuscript text. M.A.S.R. also contributed to conceptualization, methodology, investigation, data curation, and formal analysis. E.H.M.D. and H.A. dos A. contributed to supervision, conceptualization, and validation. I.P.V. de A., A.V.F.S., E.H.M.D., and H.A. dos A. contributed to reviewing and editing the manuscript. All authors reviewed and approved the final manuscript and agreed to be accountable for all aspects of the work.

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Data Availability

The datasets are available from the corresponding author upon reasonable request and ethics approval. The study was approved by the Research Ethics Committee under approval number 7.724.641 (CAAE 87454824.7.0000.5371). All participants provided written informed consent.

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