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RESEARCH

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A bayesian analysis of healthcare information needs among family caregivers to promote cancer adaptation in female patients

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Abstract

Introduction Family caregivers (FCGs) of cancer patients usually utilize healthcare information to assist them in daily cancer care at home. However, there is another significant utilization in cancer care: promoting cancer adaptation. There are limited insights on how the utilization of healthcare information among FCGs may assist their role in promoting cancer adaptation, especially among female patients. In this study, we aimed to examine how types of demanded healthcare information affect the FCG's role in promoting cancer adaptation.

Methods This secondary analysis employed the Bayesian Mindsponge Framework and its analytics in the statistical analysis of a dataset on 60 FCGs of female cancer patients ($n = 60$), in five community settings in Surabaya, Indonesia.

Results Findings showed that among the six types of demanded healthcare information, FCGs with a higher tendency to demand cancer-specific information are more likely to need support in catalyzing the adaptation of female cancer patients ($\beta = 0.28$, SD = 0.24). Meanwhile, FCGs with a higher demand for information on alternative therapies are less likely to need support in catalyzing cancer adaptation ($\beta = -0.38$, SD = 0.20). Other types of healthcare information have ambiguous effects on the need for support in promoting cancer adaptation.

Conclusion This study reveals that the demanded cancer-specific information, e.g., cancer's prognosis or likely outcome, must be prioritized during information disclosure to FCGs to promote cancer adaptation among female patients. By setting proper priority in health information disclosure among cancer stakeholders, especially FCGs, the facilitation of the cancer adaptation process can be optimized.

Keywords Adaptation, Female cancer, Family caregiver, Healthcare information, Bayesian Mindsponge Framework

> *[…] under good care and continuing using the panacea, Kingfisher's appetite for fish had returned. The birds brought tasty fat carp, and so he recovered quickly.*

In: "Kingfisher's No-Fish Dietary"; *Wild Wise Weird* [1].

1 Introduction

There are striking disparities in the global cancer burden in women, with about 60% of the cancer burden being on women worldwide, based on the data of the International Agency for Research on Cancer [2]. Cancer death rates are generally higher among women in low- and middle-income countries, with the top mortality rates in Zimbabwe (147 deaths per100,000) and Malawi (138 deaths per 100,000), largely due to inadequate access to early detection and treatment [2]. In Indonesia, breast cancer is the most common cancer among women, accounting for 19.2% of the population. Unfortunately, around 73% of Indonesian women with breast cancer are diagnosed in the late stages of the disease [3]. Following improved breast cancer early detection rates and improvements in its treatment, approximately 90% of patients now survive at least five years after diagnosis, and 80% of them even survive for 10 years [4].

Cancer can deeply impact women who are diagnosed with it, affecting not only their physical health but also their emotional well-being and social relationships [5]. Cancer can be a traumatic and life-changing experience, causing feelings of fear and uncertainty [6]. Being diagnosed with cancer and undergoing treatment can trigger psychological problems, such as stress, anxiety, and depression [7]. Approximately 48.2% and 80.8% of women diagnosed with breast cancer and cervical cancer, respectively, experience severe stress [8]. Stress and adaptation are two main concepts useful for better understanding the phases of illness and health-related human behavior. The two faces of adaptation, adaptation as a process and adaptation as a product, have raised a big question about how long the adaptation process will take in cancer trajectories. A prior study in Indonesia among female cancer patients showed that the adaptation process was proven to be limitless in female cancer survivors; therefore, it cannot be seen as a product [8]. Given the increased life expectancy in female cancer patients in the 15–69 years age group [9], patients are expected to improve their stress tolerance because they will experience longer exposure to cancer-related stressors [8]. Thus, they need to adapt to various changes due to cancer.

According to the Chronic Care Model, one of the most influential chronic disease management models, a collaborative partnership between patients and care providers can be enhanced by several factors; among these, self-management support is essential [10]. Family caregivers (FCGs) are in a strategic position to be care providers in community settings. They can provide their loved ones with home-based cancer care and psychological support. They play a pivotal role in helping patients adapt to their diagnosis, treatment, and evolving health needs. To support this cancer adaptation effectively, FCGs need access to a wide range of health information across several domains, such as information on caregivers (to prevent burnout) [11]; cancer-specific information (type and stage details, including prognosis and progression), information on therapy side effects (including chemotherapy, radiation, and surgery), alternative therapies (other treatment options), support services (including clinical appointment, referrals, insurance, finansial aid, legal rights, respite care, support group, hospice service, family counseling, etc.), and physical needs (pain and symptom control, nutrition and dietary needs, physical activity/exercise, personal hygiene, toileting, etc.) [12].

Uncertainty and psychological pain induced by cancer would significantly reduce the psychosocial adaptation among patients. According to the society-to-cells model framework, the influencing factors of cancer adaptation are divided into five levels: society, community, family, individual, and physiology [13]. It is clear now that family plays a significant role in supporting cancer adaptation. In addition, systematic review and meta-analysis indicate that cancer adaptation among patients is also influenced by age, education level, disease uncertainty, hope level, psychological pain, self-efficacy, social support, and coping styles (facing, avoidance, submission, and emotion-oriented) [13]. Another study found that family function and information satisfaction are significant predictors of positive adaptation of FCGs for cancer patients [14]. Informational needs are one of the main cancer FCG's concerns, together with needs for healthcare service, followed by emotional and psychological needs [15]. Thus, the unmet needs of healthcare information among FCGs may affect their roles in facilitating cancer adaptation. Scholars recommend quality health information provision to FCGs and encourage active participation in cancer care, including psychosocial care [14]. However, the specific type of healthcare information most significant for promoting cancer adaptation remains unclear, and the priority in disclosing information to FCGs to catalyze the cancer adaptation process is undetermined.

Due to limitations in health knowledge and care competencies, FCGs face various challenges in home-based cancer care. Healthcare professionals have a duty to provide supportive care to FCGs of cancer patients to facilitate their caregiving roles. The Centre for Health Research and Psycho-oncology (CHeRP) in the Cancer Council New South Wales, Australia, divided the supportive care needs of partners and caregivers of cancer patients into four domains, namely: (1) emotional and relational needs, (2) practical needs, (3) work and social needs, and (4) healthcare and illness-related needs [16]. Healthcare information needs fall within the domain of healthcare and illness-related needs, while FCGs' role in catalyzing adaptation among female cancer patients pertains to the domain of emotional and relational needs. Cancer patients often rely on and trust the health information provided by FCGs [17], making the information-processing mechanism among FCGs crucial for patients to receive proper health information beneficial for cancer adaptation.

The current study aims to examine how types of demanded healthcare information affect the FCG's role in catalyzing the adaptation of female cancer patients (i.e., cancer-specific information, caregiver-specific information, therapy-specific information, information on cancer physical needs, information on alternative therapies, and information on support services). Utilizing the Bayesian Mindsponge Framework (BMF), this study sought to understand the health information-processing mechanism among FCGs to assist in promoting cancer adaptation. This framework integrates the Granular Interaction Thinking Theory (GITT) with a strong information-processing basis, based on the mindsponge mechanism of its original form (the Mindsponge Theory), with the BMF analytics, the Bayesian analysis aided with the Markov Chain Monte Carlo (MCMC) algorithm, highly suitable for application in this study context. This study's urgency aligns with the improved roles and involvement of families in cancer care and management in community settings, as cancer patients rely on health information and emotional support from their FCGs, especially in low- and middle-income countries with minimal health literacy and limited healthcare professionals' input [18], such as Indonesia. In addition, the advancement of health information technology has provided more innovative venues for healthcare professionals in cancer information exchange and health knowledge sharing to cancer patients and their FCGs [19], especially to address the limitations in care competencies among FCGs and improve processes and outcomes in cancer.

2 Method

2.1 Theoretical foundation

The theoretical foundation of this study was based on the updated version of the Mindsponge Theory (MT) [20], the Granular Interaction Thinking Theory (GITT) [21, 22]. GITT was used in the study conception and interpretation of results. Initially, MT uses the human mind's information-processing approach to explain various mental products [20], such as adaptation in cancer. Currently, GITT integrates complex worldviews and principles drawn from quantum mechanics and Shannon's information theory to propose an entropy-based notion of values for better explaining complex human behavior [23, 24]. As an extension of MT, GITT preserves MT's foundational capabilities to conceptualize the mind as a mechanism for obtaining and analyzing information, aiming to pursue the system's fundamental goals, while adhering to its primary interests [20]. Thus, the key factor of the whole information-processing mechanism is the mindsponge mechanism, which involves subjective cost-benefit evaluations designed to maximize perceived advantages while effectively mitigating perceived constraints [25, 26], as illustrated in Fig. 1.

MT views the human mind as an information collection-cum-processor that helps explain how humans think, perceive, believe, behave, and establish social constructs. It recognizes the temporal dimension of the natural renewal of human psychology and society associated with information-processing activities in the human mind [27]. In the context of a digitalized world, like nowadays, information may be gathered from both physical and digital environments, or infospheres. FCG can access healthcare information physically by interacting with healthcare professionals, such as through

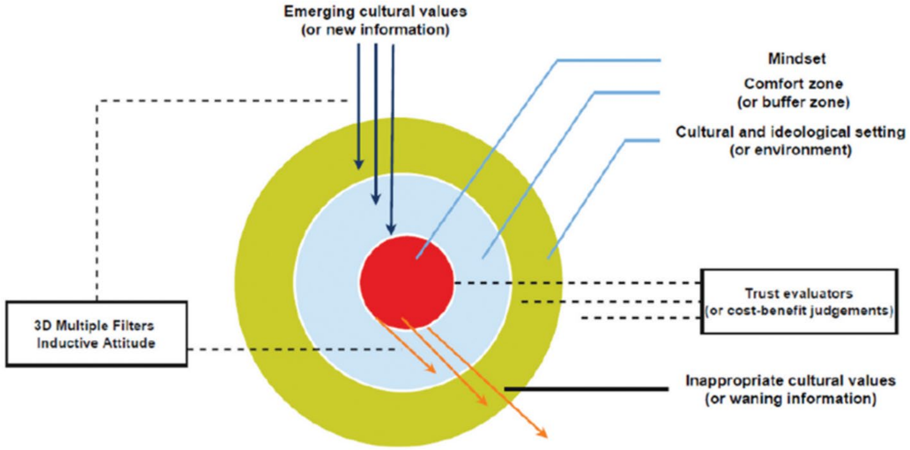

Fig. 1 Mindsponge mechanism [25]

consultations, health education provision, health promotion media (leaflet, pamphlet, booklet, brochure, etc.), etc., and digitally by accessing online health platforms, health applications, social media, or an electronic patient record system. Specifically, health information systems and integrated electronic medical records must be empowered as a means of communication and providing information to patients and their caregivers [28]. However, in the Indonesian context, we need to be cautious about the risk of data invalidation in hospital information systems, which poses a threat and loss for patients, healthcare professionals, and hospital management [29].

Both physical and digital information-seeking behaviors have different requirements in capabilities, and technologically enabled information sources, especially the internet, play an important role in caregiver information seeking [30]. Digital information-seeking behavior requires sufficient digital health literacy as a fundamental skill [31], as stressed by the World Health Organization (WHO), to address misinformation and disinformation of online healthcare information, especially that spread on social media platforms [32]. From the GITT perspective, FCG uses his subjective cost-benefit judgments to weigh the beneficiality of the information using the existing mindset or core values as benchmarking tools, or high-fidelity filters, to determine the absorption or ejection of the collected healthcare information, both physically and digitally.

Human behavior may be influenced and meaningful only if considering the sociocultural context of the individuals [33]. Therefore, subjective cost-benefit judgments are mainly driven by the value system according to the mindset and the observed information available in the infosphere or environment at the time in need. MT views mindset as a set of highly trusted information (or core values) stored in the human mind [20]. New information/value may become a new mindset if the result of cost-benefit judgments is positive or conclusively beneficial in the end. Old information that existed in the mindset may be ejected from the human mind if the result of cost-benefit judgments on new information/value is more positive or better, so that the new information/value forms a new mindset because it replaces the existing one. In case the result of cost-benefit judgments of new information/value is negative or perceived as costly by the individual, it will be more likely to be rejected from the start by the human mind, making the old mindset stay still in its existing position, proving that it is highly reliable information/value.

Adaptation and stress are two important concepts for better understanding the illness phases and individual behavior. Adaptation has two faces. We may see it as a product and as a process as well. Adaptation as a product means it cannot remain entirely faithful to its original form; as a process, it becomes an act of appropriating and salvaging while trying to give a new meaning [34]. The existing adaptation model, Roy's adaptation model, views humans as adaptive systems [35], as illustrated in Fig. 2.

Roy's adaptation model views humans as bio-psycho-social beings constantly interacting with a changing environment. Figure 2 illustrates how a person's environment (including focal, contextual, and residual stimuli) influences their internal and external adaptations, mediated by internal and external "regulators" to achieve a state of adaptation. A person or group that conducts adaptation uses conscious awareness, self-reflection, and choice to create human and environmental integration [37]. For healthcare professionals and FCGs who expect this product of adaptation among cancer patients,

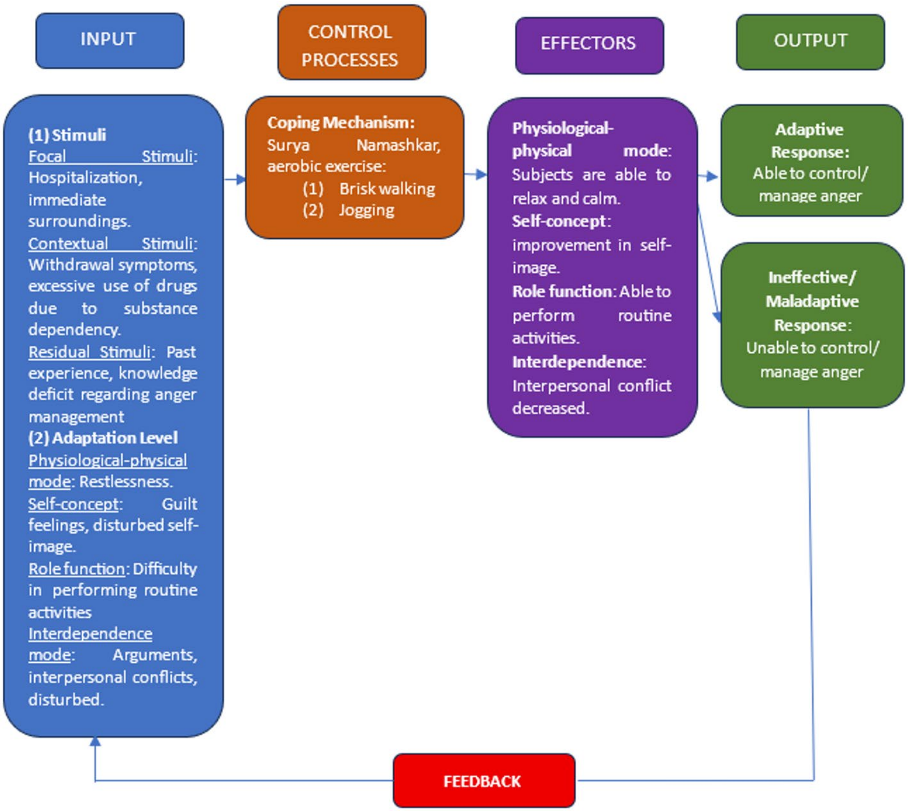

Fig. 2 Roy's adaptation model [36]

consider the need for support in catalyzing cancer adaptation. The faster the patient overcomes the changes and life consequences after cancer, the faster they can achieve this adaptation state.

The use of GITT in this study may complement the existing Roy's adaptation model. From the mindsponge perspective, GITT views the environment, one of its main spectrums, as an infosphere, a collection of information or resources [20]. When an individual attempts to adapt (viewed as a process), it means this person filters the new information or value and tries to adjust, i.e., appropriating and salvaging the existing core values with the renewal or updates of information/value from the infosphere. Finally, when an individual completes an adaptation (viewed as a product), they have renewed or updated the related core values previously existing in their mind with the new information/value, making them possess a new mindset. This new mindset will be used for subsequent information-processing activities in the human mind, which will help the person cope with the new bio-psycho-social state.

A prior study on female cancer patients in Indonesia showed that adaptation remains a process in the long run of cancer trajectories [8]. A longer duration of cancer illness or being a long-term cancer survivor does not guarantee adaptation achievement (viewed as a product). This prior study reveals that cancer adaptation is a continuous process or limitless in women living with cancer because it was found that there was no significant difference in cancer stress and fear between survivorship stages, especially in breast and cervical cancer cases. How long the adaptation process takes in female cancer patients remains a big question. By knowing this, female cancer patients are in a static condition of adjusting, appropriating, and salvaging the existing core values with the renewal or updates on the new information/value from the infosphere in the long run of cancer survivorship.

During health information disclosure towards FCGs, they filter health information by using subjective cost-benefit judgments. After final absorption or rejection of health information, decision-making will be made based on the results of the benchmarking process between the newly exposed information and their existing mindset. In risky decision-making, such as cancer diagnosis or prognosis information disclosure to patients, the results of this benchmarking process are highly essential. The benefit weight of each type of information (i.e., cancer-specific information, caregiver-specific information, therapy-specific information, information on cancer physical needs, information on alternative therapies, and information on support services) may be perceived differently by FCGs, resulting in different levels of supportive care needs in catalyzing cancer adaptation. FCGs who perceived a certain type of information as beneficial for promoting cancer adaptation among patients will be more likely to disclose this information. Conversely, those who perceived a certain type of information as a loss or costly for the patients will be more likely to stay silent, underdisclosing the 'harmful' information. Therefore, the updates on healthcare information provided by FCGs, and the encouragement to disclose health information to patients properly, may assist their caregiving roles in providing psychosocial support for the patients, useful for promoting the adaptation process in female cancer patients.

By attempting to catalyze cancer adaptation, this study emphasizes the critical role of FCG in providing proper healthcare information to patients. Due to limited health-related knowledge, FCGs will be more likely to demand cancer-specific information from healthcareprofessionals to assist their role in catalyzing adaptation among female cancer patients. This study also underscores the critical role of healthcare professionals in providing healthcare information to FCG of cancer patients and the bridging role of FCG in healthcare professionals' and patients' communication.

2.2 Dataset

This secondary analysis utilized a dataset generated from the primary study of Sari et al. [38]. There was no data modification made in this study. We conducted a new analysis for this study by analyzing several data points from the original dataset, as explained in Table 1. There was no missing data found during our analysis.

The original cross-sectional survey was conducted in five communities in Surabaya, Indonesia, enrolled by means of cluster random sampling, using a door-to-door approach. Enumerators were student nurses in their last year of education, enrolled in a palliative nursing course, conducting clinical internships in several public health centres. Data were collected from February to March 2020. Samples were constituted of 60 FCGs of female cancer patients, consisting of 48 spouses (husbands) and 12 other family members, enrolled by means of simple random sampling. Samples were eligible if the cancer patients confirmed their roles as primary caregivers at home. Exclusion criteria were rejection on filling out the consent form. Most respondents were middle-aged (41–50 years old: 36.67%), male (80%), married (78.33%), high school graduates (63.33%), private employees (60%), living with a spouse (cancer patients) and children (80%), with maximum GDP of IDR (Indonesian Rupiah) 5 million per month (68.34%) [38].

Table 1 Variable description

Variable's name	Description	Data type	Value
Adaptation	The need for support in catalyzing patients' adaptation to changes in working life or usual activities after cancer	Numerical	1 = not applicable 2 = satisfied 3 = low need 4 = moderate need 5 = high need
Information_Caregiver	The need to access information relevant to your needs as a carer/partner	Numerical	
Information_Cancer	The need for accessing information about the person with cancer's prognosis, or the likely outcome	Numerical	
Information_SupportServices	The need for accessing information about support services for carers/partners of people with cancer	Numerical	
Information_AlternativeThe	The need to access information about alternative therapies	Numerical	
Information_PhysicalNeed	The need for accessing information on what the person with cancer's physical needs are likely to be	Numerical	
Information_SideEffects	The need to access information about the benefits and side effects of treatments	Numerical	

The dataset is about the unmet supportive care needs among informal care providers of cancer, measured by the SCNS-P&C45 (Supportive Care Needs Survey—Partners and Caregivers 45) with high reliability (Cronbach's Alpha = 0.965) [38]. SCNS-P&C45 comprises four domains in 45 items: (1) health care and illness-related needs (11 items), (2) emotional and relational needs (16 items), (3) work and social needs (11 items), and (4) practical needs (7 items) [16]. In this study, the data of healthcare information types are sourced from the first domain: healthcare and illness-related needs. In this domain, there are seven specific items dedicated to assessing healthcare information needs. We excluded the data on the information needs of infertility conditions only, and examined six types of healthcare information needs (see Table 1). Meanwhile, the data of FCG's role in catalyzing the patient's adaptation to changes in working life or usual activities after cancer is sourced from the second domain: emotional and relational needs. For each item of SCNS-P&C45, respondents were asked to indicate their level of supportive care needs over the last month as a result of caring for people with cancer. Results from the survey revealed that almost all respondents experienced unmet supportive care needs at various levels (98.33%) [38]. These unmet needs have a high potential to influence their roles as care providers at home, especially in promoting cancer adaptation.

2.2.1 Ethical considerations

The primary study was conducted in accordance with ethical principles, following the Declaration of Helsinki. The study protocol was reviewed by the Ethical Committee of the Faculty of Medicine, Widya Mandala Surabaya Catholic University, East Java, Indonesia. Ethical approval was obtained from this committee before data collection was conducted, with an ethical clearance registered certificate of 082/WM12/KEPK/DOSEN/T/2020 [38]. Before data collection, all respondents had signed an informed consent form to strengthen their willingness to participate.

2.3 Model construction and analysis

2.3.1 Variable selection and rationale

In the current study, seven variables were employed for statistical analysis as described in detail in Table 1 below, such as *Adaptation*, *Information_Caregiver*, *Information_Cancer*, *Information_SupportServices*, *Information_AlternativeThe*, *Information_PhysicalNeed*, and *Information_SideEffects.* To measure the FCG's supportive care needs in catalyzing adaptation of female cancer patients, we employed the *Adaptation* variable, which reflects the FCG's unmet needs of emotional and relational needs in catalyzing adaptation in the person with cancer's life. The six types of demanded healthcare information that may affect the FCG's role in catalyzing adaptation of female cancer patients (i.e., cancer-specific information, caregiver-specific information, therapy-specific information, information on cancer physical needs, information on alternative therapies, and information on support services) were represented by variables of *Information_Caregiver*, *Information_Cancer*, *Information_SupportServices*, *Information_AlternativeThe*, *Information_PhysicalNeed*, and *Information_SideEffects.*

2.3.2 Statistical model

In this study, we positioned the types of demanded healthcare information as predictors of the FCG's needs in catalyzing the adaptation of female cancer patients, as illustrated in Fig. 3 below. We constructed the analytical model based on the theoretical foundation of MT with the following formula of model equations:

$$Adaptation \sim normal(\mu, \sigma) \tag{1}$$

$$\begin{aligned} \mu_i = \beta_0 &+ \beta_{Information\_Caregiver\_Adaptation} * Information\_Caregiver_i + \\ &\beta_{Information\_Cancer\_Adaptation} * Information\_Cancer_i + \\ &\beta_{Information\_SupportServices\_Adaptation} * Information\_SupportServices_i + \\ &\beta_{Information\_AlternativeThe\_Adaptation} * Information\_AlternativeThe_i + \\ &\beta_{Information\_PhysicalNeed\_Adaptation} * Information\_PhysicalNeed_i + \\ &\beta_{Information\_SideEffects\_Adaptation} * Information\_SideEffects_i \end{aligned} \tag{2}$$

$$\beta \sim normal(M, S) \tag{3}$$

The probability around μ and β are determined by the form of normal distribution, with the standard deviation σ. The degree of unmet needs in catalyzing the adaptation of female cancer patients of FCG i is indicated by μ_i. *Information_Caregiver*$_i$,

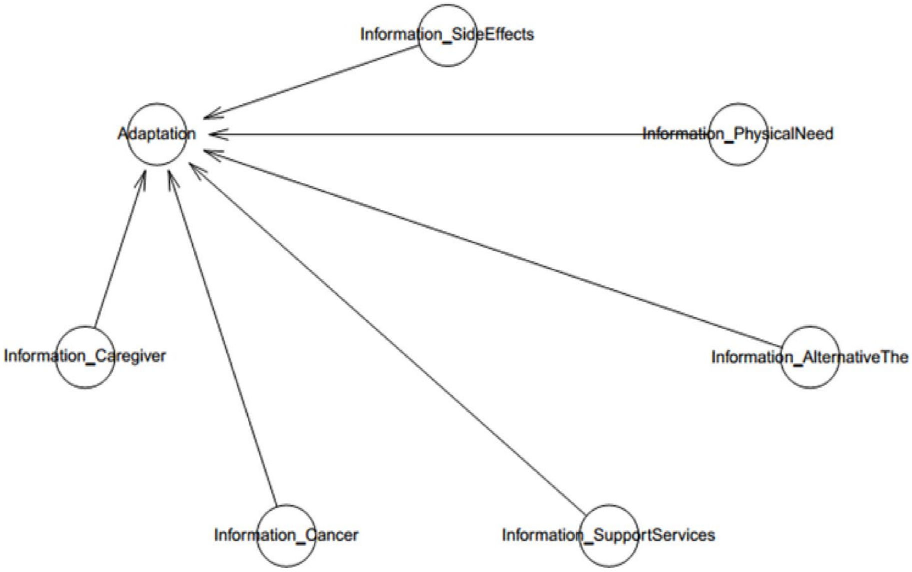

Fig. 3 Model 1's logical network

$Inforamation\_Cancer_i$, $Inforamation\_\_SupportServices_i$, $Information\_AlternativeThe_i$, $Information\_PhysicalNeed_i$ and are the types of demanded healthcare information of FCG i. The model has an intercept β_0 and six coefficients of $\beta_{Information\_Caregiver\_Adaptation}$, $\beta_{Information\_Cancer\_Adaptation}$, $\beta_{Information\_SupportServices\_Adaptation}$, $\beta_{Information\_AlternativeThe\_Adaptation}$, $\beta_{Information\_PhysicalNeed\_Adaptation}$ and $\beta_{Information\_SideEffects\_Adaptation}$.

2.4 Analysis and validation

Bayesian Mindsponge Framework (BMF) analytics was employed in the current study for several reasons [27, 39]. First, the analytical method integrates the logical reasoning capabilities of MT with the inferential advantages of Bayesian analysis, exhibiting a high degree of compatibility [27]. Second, Bayesian inference is a statistical approach that treats all the properties (including the known and unknown ones) probabilistically [40, 41], enabling reliable prediction of parsimonious models. Nevertheless, utilizing the Markov chain Monte Carlo (MCMC) technique still allows Bayesian analysis to deal effectively with various intricate models, such as multilevel and nonlinear regression frameworks [42]. Third, Bayesian inference has various advantages in comparison to the frequentist approach. One notable advantage is the ability to utilize credible intervals for result interpretation instead of relying solely on the dichotomous decision based on *p*-values [43, 44]. The Bayesian analysis was performed on R (R version: 4.4.0) using the bayesvl open-access package (*bvl* version: 1.0), which provides good visualization capabilities [45, 46].

In Bayesian analysis, selecting the appropriate prior is required during the model construction process. Due to the exploratory nature of this study, uninformative priors or a flat prior distribution were used to provide as little prior information as possible for model estimation [47]. The Pareto-smoothed importance sampling leave-one-out (PSIS-LOO) diagnostics were employed to check the models' goodness-of-fit [48, 49]. LOO is computed as follows:

$$LOO = -2LPPD_{loo} = -2\sum {}_{i=1}^{n}\log \int p\left(y_i|\theta\right) p_{post(-i)}\left(\theta\right) d\theta$$

$p_{post(-i)}\left(\theta\right)$ is the posterior distribution calculated through the data minus data point i. The *k*-Pareto values are used in the PSIS method for computing the LOO cross-validation in the R loo package, using package loo version: 2.7.0. Observations with *k*-Pareto values greater than 0.7 are often considered influential and problematic for accurately estimating LOO cross-validation. When a model's *k* values are less than 0.5, it is typically regarded as being fit.

If the model fits well with the data, we will proceed with the convergence diagnoses and result interpretation. In the current study, we validated the convergence of Markov chains using statistical values and visual illustrations. Statistically, the effective sample size (*n_eff*) and the Gelman–Rubin shrink factor (*Rhat*) can be used to assess the convergence. The *n_eff* value represents the number of iterative samples that are not autocorrelated during stochastic simulation, while the *Rhat* value is referred to as the potential scale reduction factor [50]. If *n_eff* is larger than 1000, it is generally considered that the Markov chains are convergent, and the effective samples are sufficient for reliable inference [51]. As for the *Rhat* value, if the value exceeds 1.1, the model does not converge. The model is considered convergent if *Rhat* = 1. Visually, the Markov chains'

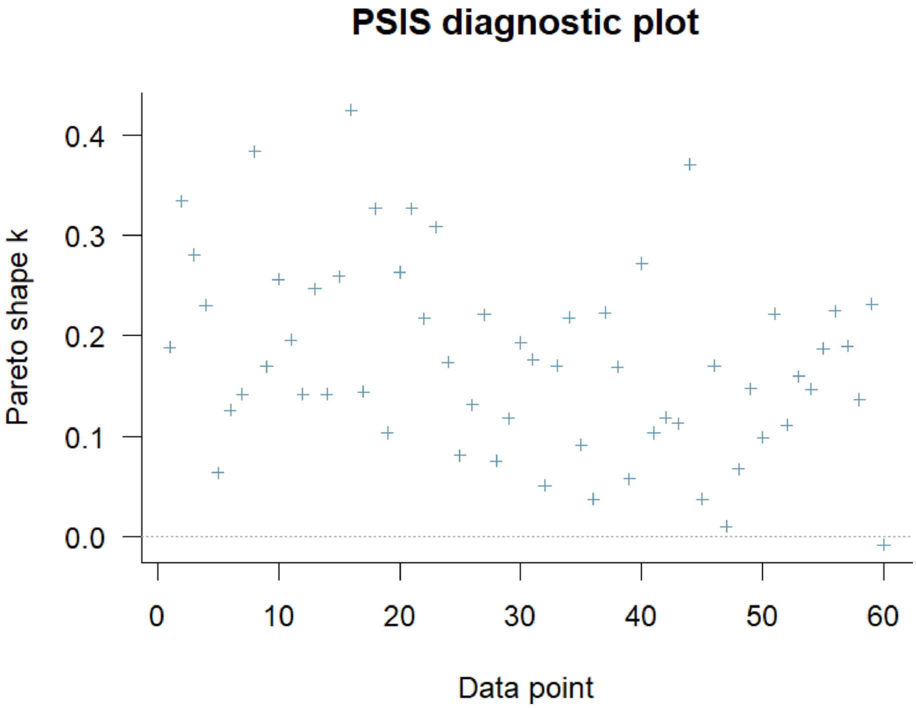

Fig. 4 Model 1's PSIS-LOO diagnosis

Table 2 Estimated results of model 1

Parameters	Mean	SD	95% CI	n_eff	Rhat
a_Adaptation	2.64	0.55	1.57, 3.72	11,414	1
b_Information_Caregiver_Adaptation	0.09	0.23	−0.37, 0.54	9887	1
b_Information_Cancer_Adaptation	0.28	0.24	−0.20, 0.75	10,241	1
b_Information_SupportServices_Adaptation	−0.07	0.21	−0.49, 0.35	11,263	1
b_Information_AlternativeThe_Adaptation	−0.38	0.20	−0.77, 0.02	10,832	1
b_Information_PhysicalNeed_Adaptation	0.08	0.20	−0.31, 0.48	11,213	1
b_Information_SideEffects_Adaptation	0.10	0.18	−0.26, 0.46	11,281	1

convergence was also validated using trace plots, Gelman–Rubin–Brooks plots, and autocorrelation plots.

3 Results

Before interpreting the results, evaluating how well Model 1's fits the data is necessary. As can be seen in Fig. 4 below, all Pareto k estimates were within the acceptable range ($k < 0.7$), suggesting stable estimates and no highly influential observations. The mean *k*-values are below the 0.5 threshold, indicating a good fit signal between the model and the data.

The posterior distribution statistics of Model 1 are shown in Table 2. All *n_eff* values are greater than 1000, and *Rhat* values are equal to 1, so it can be assumed that Model 1's Markov chains are well-convergent. The convergence of Markov chains is alsoreflected in the trace plots of Fig. 5. In particular, after the 2000th iteration, all chains' values fluctuate around the central equilibrium.

Table 2 shows that FCGs with a higher tendency to demand cancer-specific information are more likely to need support in catalyzing the adaptation of female cancer

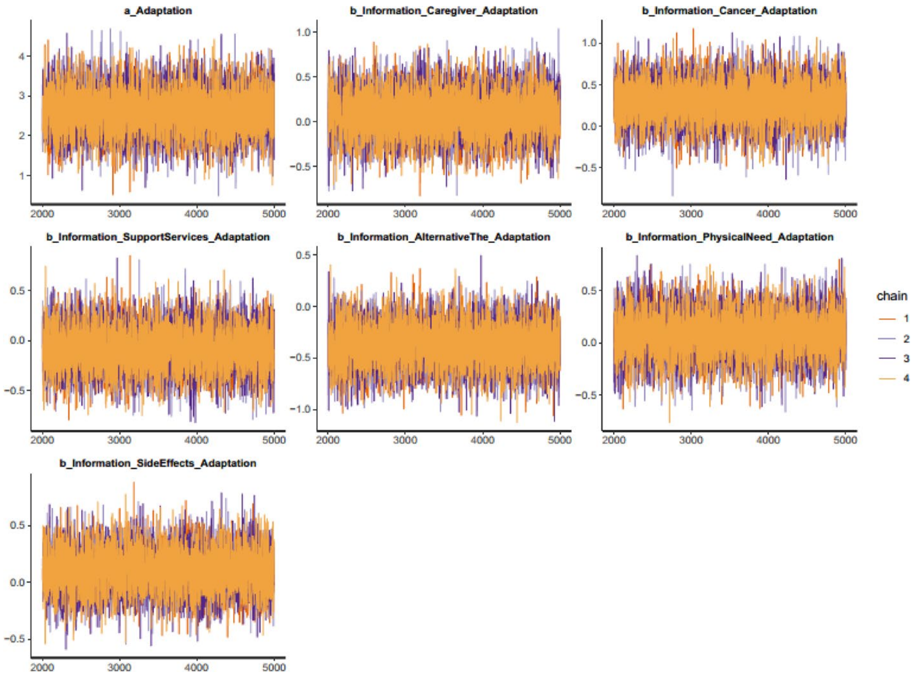

Fig. 5 Model 1's trace plots

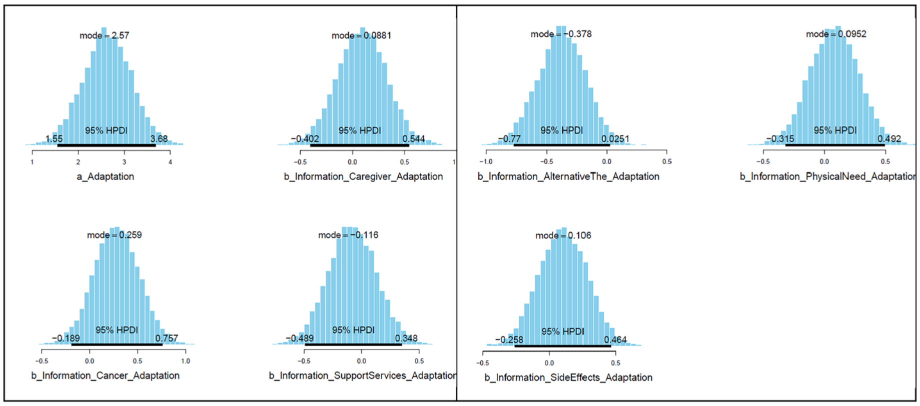

Fig. 6 Coefficients' posterior distributions of Model 1 with HPDI at 95%

patients (β = 0.28, SD = 0.24). Meanwhile, FCGs with a higher demand for information on alternative therapies are less likely to need support in catalyzing cancer adaptation (β = -0.38, SD = 0.20).

To enhance interpretability, Fig. 6 illustrates the posterior distributions of Model 1 along with their 95% Highest Posterior Density Intervals (HPDIs), indicating that there is a 95% probability that the true parameter values lie within these intervals. Among the six types of healthcare information, FCGs with a higher tendency to demand cancer-specific information are more likely to need support in catalyzing the adaptation of female cancer patients. A small proportion of *b_Information_Cancer_Adaptation*'s HPDI is still located on the negative side of the x-axis, and its Mean value is larger than SD (β = 0.28, SD = 0.24), so the positive association between *Information_Cancer* and *Adaptation* can be considered moderately reliable. For the posterior distribution of *Information_AlternativeThe*, the HPDI is located almost entirely on the negative side of the x-axis, suggesting high reliability that FCGs with a higher demand for information on alternative therapies are less likely to need support in catalyzing cancer adaptation. Other types of information have ambiguous effects on the need for support in promoting cancer adaptation, as the proportion of the intercepts (*b_Information_Caregiver_Adaptation*, *b_Information_SupportServices_Adaptation*, *b_InformationPhysicalNeed_Adaptation*, and *b_Information_SideEffects_Adaptation*) is approaching the neutral zone (0.0) with the Highest Posterior Density Interval (HPDI) of 95%.

Meanwhile, a portion of *Information_Cancer*'s HPDI is still located on the negative side of the axis, so the positive effect of *Information_Cancer* on *Adaptation* can only be deemed moderately reliable (see Fig. 6).

4 Discussion

The study employs the BMF analytics to examine how types of demanded healthcare information affect the FCG's role in catalyzing the adaptation of female cancer patients. The results show that among the six types of healthcare information, FCGs with a higher tendency to demand cancer-specific information are more likely to need support in catalyzing the adaptation of female cancer patients. This finding indicates that cancer-specific information, especially related to prognosis, should be prioritized during information disclosure towards FCGs to support their role in promoting cancer adaptation, especially among female patients.

This result suggests that cancer patients demand full disclosure of prognosis information to help them be prepared, plan additional treatment, anticipate complications, and plan for the future and family, while their FCGs tend to underdisclose this cancer-specific information due to worries about patients' stress, depression, loss of hope, and confidence [52]. Regarding cancer-specific information disclosure, there is an inconsistency between what patients desire to know and the type of health information FCGs want to provide. Most respondents were in their middle-agedphase of life, prone to low performance in executive functioning, which is a risk factor for lower information use in risky decision-making [53], such as disclosing cancer prognosis. Our findings encourage FCGs to fully support the disclosure of cancer prognosis information to patients, facilitating better cancer adaptation.

In line with the current findings, a study by Niedzwiedz et al. showed that information on the type and stage of cancer (cancer-specific information) has more profound effects on cancer adaptation compared to other cancer-related information [54]. It is common knowledge that individuals with cancer have greater rates of anxiety and depression, and they frequently do not receive specific therapy or sufficient psychological support [54, 55], challenging the adaptation process. From the healthcare system perspective, the lack of knowledge and recognition of mental health symptoms, the stigma associated with mental health issues, the lack of data supporting successful treatments, and patient preferences are likely some of the contributing causes to such scenarios [54, 56]. In addition, a study in Indonesia found that the long-term survival period for cancer patients is low [8]. This could be attributed to adaptation challenges, in which adaptation is regarded as an infinite process, particularly in terms of psychological stress and fear induced by cancer [8, 57]. Throughout their survival period, Indonesian women with cancer require ongoing psychological care to lessen their stress and fear responses, which requires FCGs to work in concert with their care recipients, nurses, psychologists, and even psychiatrists to some degree [8].

Findings corroborate with Eheman et al., who highlighted that the availability of sufficient knowledge improves communication and coping mechanisms, important aspects to facilitate adaptation, as well as decreases anxiety, enhances satisfaction with treatment options, and fosters higher participation in decision-making [58]. FCGs greatly aid cancer patients' care and support, and the findings on caregiver-specific information align with Chua et al. [59]. Support is crucial, and FCGs provide essential support throughout the journey with the disease and its treatments [60]. Specifically in male caregivers, like most respondents in this study, evidence shows that they could modify caregiving behaviors, social support needs, role strain, and emotional aspects of caring through masculinization, but they still need hands-on education, especially when they are high school graduates (limited educational background) [61]. For FCGs to provide effective transition and adaptation mechanisms to cancer patients, they may assist with financial, emotional, social, physical, and spiritual care [56, 59]. However, it is important to note that long-term caregiving is an emotionally and physically taxing undertaking, particularly when dealing with people who have advanced cancer [59], possibly lowering their quality of life due to excessive exhaustion and burden [62].

GITT also provides several insights into understanding the observed positive association between the demanded cancer-specific information and the need for support in catalyzing cancer adaptation [21]. From the GITT perspective, FCGs absorb vast amounts of information from their environment, particularly in response to significant stressors like a loved one's cancer diagnosis (including type and stage details) and prognosis (including progress). However, this absorption can lead to cognitive and emotional strain, as FCGs become overwhelmed by the sheer volume of cancer-specific information, resulting in heightened anxiety, worry, and a sense of helplessness. Additionally, anticipatory psychological stress complicates matters as FCGs seek cancer-specific information to prepare for future life challenges, potentially worsening their stress levels.

Nowadays, digital information exchange and remote support are increasingly integrated into cancer care. Given the prevalence of cancer and the known needs of these patients and their FCGs, the scalability and overall availability of social support can be accelerated by utilizing digital platforms in innovative ways [63]. The cancer-specific information is increasingly spread in the digital sphere, improving and easing access for FCGs, assisting them in utilizing health information to execute their caregiving tasks. Healthcare professionals may utilize these digital platforms in health knowledge transfer and cancer-specific information exchange to meet the demand among FCGs in promoting cancer adaptation. To ensure cancer wellbeing, especially adapting to various changes due to cancer, healthcare professionals are putting more effort into the quality of the communication they provide in oncology clinics, as well as online communication. Evidence review indicates that health information technology in cancer care is effective for supporting knowledge transfer and shared understanding, increasing care satisfaction and ability to manage emotions, make decisions and progress in their treatment, increase social support, and build a stronger therapeutic alliance with healthcare professionals [64]. Specifically for nurses, results of meta-analyses showed that the telenursing services they provide, including telemonitoring and health education services, are effective for patients, such as for reducing distress [65], readmission rates and emergency department visits [66], and also effective for their FCGs, such as for improving the quality of care at home, especially the psychosocial care related to cancer adaptation [67].

Our findings also show that FCGs with a higher demand for information on alternative therapies are less likely to need support in promoting cancer adaptation among female cancer patients. This could be attributed to the extensive knowledge and use of alternative methods for cancer treatment, with promising efficacy in symptom management [68]. Tangkiatkumjai et al. noted that the primary drivers of the use of alternative medicine in cancer care were perceived safety and benefits of the treatment, control over one's treatment, alignment of needs and sociocultural norms, influence from friends, family, and the media, accessibility, and availability of alternative medicine, and dissatisfaction with traditional medicine [69]. In addition, complementary therapies have shown beneficial effects in cancer patients for symptomatic relief [70], thus also easing the process of cancer adaptation. However, we need to be cautious of potential confounding variables, such as cultural values, belief systems, access to biomedical care, etc., in interpreting this intriguing finding.

Based on GITT [71], FCGs who actively seek information on alternative therapies may feel empowered and in control, reducing their need for support. This behavior may indicate adaptive coping strategies, as FCGs view alternative therapies as supplementary methods to overcome cancer sufferings. When FCGs receive adequate information on alternative therapies, they are empowered by the perceived benefits, enabling them to provide more effective psychosocial and emotional support to cancer patients. Moreover, seeking information on alternative therapies may provide a temporary distraction from the psychological challenges associated with conventional medical treatments, offering FCGs a sense of relief. This multifaceted perspective underscores the intricate interaction between information absorption and support needs among FCGs, offering valuable insights for developing more effective interventions to meet their needs comprehensively.

Findings illustrated in Fig. 6 showed that information on caregivers, support services, therapy side effects, and physical needs shows ambiguous effects on the need for support in promoting cancer adaptation. This could be attributed to challenges in cancer decision-making and individual psychological limitations [72]. A study by Zhu et al. highlighted that the experience of caring for patients with terminal cancer is distinct, culturally specific, and fraught with hardship [55]. To improve the experience of FCGs caring for patients with advanced disease, adequate professional support, including early palliative care, should be considered, while to comprehend and create effective ways to assist FCGs, cultural attitudes must be taken into account [55]. In support, Kim & Hong revealed that patients must manage their care and get ongoing medical treatment for successful cancer adaptation [57]. The FCGs'contribution to adaptation should include a bio-psycho-social approach. This may involve creating comprehensive survival programs for patients, which will benefit them by understanding the interplay between biological, psychological, and social components and how they affect health [57].

GITT suggests that these ambiguities may lead to a further need for the benchmarking process [21]. FCGs who demand more information on caregivers, support services, therapy side effects, and physical needs may not have a pre-existing mindset related to these topics. This condition results in the buffering of this type of information in the mind, awaiting further evaluation of its perceived usefulness in catalyzing the cancer adaptation process among care recipients.

Though the study offers valuable insights, it is crucial to recognize certain limitations. The cross-sectional design used in the original study that generated the dataset imposes constraints on establishing causal relationships, while longitudinal studies could offer a more nuanced understanding of the dynamic caregiving process. In addition, further mixed-method studies integrating qualitative caregiver experiences will be useful to describe the whole phenomenon. Researching with secondary data offers efficiency and cost-effectiveness, but it also comes with several important limitations, such as timeliness and obsolescence, bias and source credibility, and incompatibility across sources. However, this study has overcome the issues of lack of relevance or fit, limited control over data quality, and legal and ethical constraints.

The sample size is considered small for an exploratory study, thus raising concerns about posterior credibility and risk of model overfitting. However, a previous study in Vietnam shows that Bayesian analysis is effective for analyzing a dataset with a small sample size, even smaller than in this study ($n = 49$) [73]. In Bayesian analysis, a small sample size can significantly influence the model's goodness-of-fit. Still, the implications depend on how prior information is incorporated and the nature of the model. With limited data, the prior distribution exerts greater influence on the posterior, which can either stabilize or bias estimates depending on the quality of the prior. In this study, Model 1 is exploratory, and prior information is absent because we set uninformative priors or a flat prior distribution to provide as little prior information as possible for model estimation. This setting can reduce subjective bias and provide transparent inference, but it can also destabilize estimates, lead to overdispersion, and cause unstable fit diagnostics (e.g., LOO).

Furthermore, the study's focus on a specific geographical location may limit the generalizability of the findings. Future research endeavors could explore cultural variations in healthcare information needs and the need to catalyze adaptation among FCGs of cancer patients, further enriching our understanding of this complex and evolving phenomenon.

5 Conclusion

Among the six types of demanded healthcare information, FCGs with a higher tendency to demand cancer-specific information, e.g., cancer prognosis, the type and stage of cancer, are more likely to need support in catalyzing the adaptation process among female cancer patients. This type of information should be prioritized during information disclosure, especially to FCGs, to assist their roles and active involvement in the cancer adaptation process among female patients. Specific to cancer prognosis, this information may reflect future outcomes of cancer management; thus, it may be promising for patients. On the other hand, FCGs with a higher demand for information on alternative therapies are less likely to need support in promoting cancer adaptation in this population, as they have found other options. Other types of healthcare information, such as information on caregivers, support services, therapy side effects, and physical needs, have ambiguous effects on the need for support in facilitating cancer adaptation. Further study may explore these specific areas of health information to clarify their roles in assisting FCGs to promote better cancer adaptation.

6 Practical implications

For practical implications, this study underscores that cancer-specific information, such as cancer prognosis and therapeutic outcomes, is a priority in information disclosure to FCGs to assist their role in catalyzing cancer adaptation among female cancer patients. Initially, community nurses, for instance, need to assess the general unmet supportive care needs among FCGs using SCNS-P&C45 for measurement, and later identify specific needs for assistance in cancer adaptation. Once the need for support is identified, nurses can provide healthcare information through health education activities or family counseling. They can apply culturally sensitive communication strategies for FCGs and use the cancer-specific information module as the communication medium. Nurses should prioritize disclosing cancer-specific details before delivering other related cancer information. This approach helps FCGs feel that healthcare professionals acknowledge their concerns about promoting cancer adaptation. In turn, FCGs can share this information with female cancer patients at home, helping them achieve adaptation capability sooner.

Author contributions

NPWPS: Conceptualization, methodology, data curation, investigation, formal analysis, supervision, project administration, writing original draft, review-editing. AM: writing original draft, review-editing, validation, visualization. MMP: Conceptualization, writing original draft, software, review-editing. AGP: Data curation, investigation, review-editing. MHN: Conceptualization, software, methodology, validation. QHV: Methodology, supervision, validation.

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Data availability

Due to ethical concerns, the data is not publicly shared. The anonymized data can be accessed upon reasonable request through private sharing with the corresponding author (Ni Putu Wulan Purnama Sari).

Declarations

Ethical approval and consent to participate

The primary study protocol was reviewed by the Ethical Committee of the Faculty of Medicine, Widya Mandala Surabaya Catholic University, East Java, Indonesia, following the Declaration of Helsinki, with an ethical clearance registered certificate of 082/WM12/KEPK/DOSEN/T/2020 [38]. Before participating in the primary data collection, all respondents had signed an informed consent form to strengthen their willingness to participate.

Consent for publication

All authors have read the final version of this manuscript and have provided specific consent to publish this study in *Discover Public Health*.

Competing interests

The authors declare no competing interests.

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