Revista Contexto & Saúde
Editora Unijuí
*Programa de Pós-Graduação em Atenção Integral à Saúde*
ISSN 2176-7114 – v. 22, n. 46, 2022

http://dx.doi.org/10.21527/2176-7114.2022.46.13335

**COMO CITAR:**
Pereira DR, Guerra N, Matos P. Prospective memory impairment related to cancer: a systematic review. Rev Contexto & Saúde, 2022;22(46): e13335

# Prospective Memory Impairment Related to Cancer:
## A Systematic Review

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**ABSTRACT**

Cognitive complaints and alterations related to cancer may reduce well-being, quality of life, and daily functioning. More recently, prospective memory (PM), i.e., the ability to plan a future intention, to maintain it during a variable delay time in which people are typically engaged in other tasks, and to retrieve it when the expected circumstances arise, has fostered increased attention in cancer research. Examples are to remember to ask for a certain information during a medical appointment (event-based PM – EBPM) or to take medication at certain hours (time-based PM – TBPM). This work aimed to provide an overview of the main findings related to PM functioning in people with history of cancer. A qualitative systematic review of the literature was conducted following the PRISMA guidelines and 20 articles published between 2000 and 2020 were included. People with cancer history (*vs.* healthy controls) tended to report more PM complaints and worst objective PM performance, especially when considering EBPM tasks. Some treatments such as chemotherapy, androgen deprivation therapy, and radiotherapy negatively impacted PM. Importantly, changes in PM were associated with lower quality of life. Also, fatigue and depression appeared to contribute to PM impairment. A puzzling finding was the lack of association between objective and subjective measures of PM, which implies that different facets might underly cancer-related PM changes. Taken together, the inclusion of PM measures when probing cancer-related cognitive impairment is relevant not only to better assess and characterize the cancer experience across time, but also to inform interventions and cognitive rehabilitation approaches.

**Keywords**: Cancer; cancer-related cognitive impairment; prospective memory; systematic review.

**ALTERAÇÕES DE MEMÓRIA PROSPECTIVA RELACIONADAS COM O CANCRO: UMA REVISÃO SISTEMÁTICA**

**RESUMO**

Alterações e queixas cognitivas relacionadas com o cancro podem reduzir o bem-estar, a qualidade de vida e o funcionamento diário. Recentemente, a memória prospectiva (MP), isto é, a capacidade de planear uma intenção, retendo-a durante um período variável de tempo enquanto a pessoa está tipicamente envolvida em outras tarefas, recuperando-a em circunstâncias apropriadas, tem recebido atenção crescente no âmbito da investigação no cancro. Exemplos de MP são lembrar de perguntar sobre uma determinada informação durante uma visita médica (MP baseada em eventos – MPBE) ou de tomar medicação num determinado horário (MP baseada em tempo – MPBT). Este trabalho objetivou rever os principais achados sobre o funcionamento da MP no cancro. Foi realizada uma revisão sistemática qualitativa da literatura seguindo as orientações Prisma, posto que 20 artigos publicados entre 2000 e 2020 foram incluídos. Pessoas com historial de cancro (*vs.* controles saudáveis) reportaram mais queixas e pior performance de MP, especialmente no caso de MPBE. Alguns tratamentos, como a quimioterapia, terapia de privação androgênica e radioterapia influenciaram negativamente a MP. Alterações de MP foram associadas à pior qualidade de vida. Adicionalmente, a fadiga e a depressão contribuem para alterações na MP. Foi verificada uma ausência de associação entre medidas objetivas e subjetivas de MP, o que parece sugerir que diferentes facetas podem explicar as alterações de MP. A inclusão de medidas de MP quando da avaliação de alterações cognitivas, portanto, é relevante não só para melhor caracterizar a experiência de cancro ao longo do tempo, mas também para informar planos interventivos e de reabilitação cognitiva.

**Palavras-chave**: Cancro; défice cognitivo relacionado com cancro; memória prospectiva; revisão sistemática.

SUBMETIDO EM: 17/11/2021
ACEITO EM: 19/3/2022

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## INTRODUCTION

Cancer is considered the second leading cause of death worldwide and, in 2018, there were 17 million new cases and 9.6 million deaths estimated to be related to cancer[1,2]. Even though 27.5 million new cases are estimated to emerge worldwide each year by 2040[1], cancer diagnosis, management and survival has been improving, highlighting the need to better understand disease and recovery trajectories to promote well-being, quality of life, and daily functioning in people with cancer experience.

In fact, one of the aspects that has been reported to interfere with quality of life in cancer patients from diagnosis to the point beyond disease remission is the presence of cognitive complaints and dysfunction[3,4]. This experience has been investigated under different terms, such as "chemobrain", "chemofog", "chemotherapy-induced cognitive impairment", and "cancer-related cognitive impairment" (CRCI)[5]. The prevalence of CRCI is quite variable across studies, even so it is estimated to be up to 30% before treatment engagement, up to 75% during treatment, and up to 35% after treatment completion[6]. Different factors might help to explain the variability of incidence as well as the risk of cognitive impairment, including age, cognitive reserve, genetic factors (e.g., apolipoprotein E – APOE; catechol-o-methyltransferase – COMT; brain-derived neurotrophic factor – BDNF Val66Met polymorphism), immune function, distress, fatigue, chemotherapy dosage, among others[4,6-9]. Nonetheless, possible trajectories, predictors, moderators, and mechanisms underlying CRCI are still under debate.

More specifically, CRCI is characterized by alterations in different cognitive domains: attention, memory, executive functioning, information processing speed, language, and visuo-spatial skills[4,7,10-11]. These changes may be detected immediately after treatment[12-13] or even later on after treatment completion[14]. Moreover, memory-related problems appear to be the most consistent in the context of CRCI, also affecting patients' quality of life[15-16]. Nevertheless, it is not clear whether retrospective and prospective memory components are affected in a similar way in patients with cancer history. As such, the study of prospective memory (PM) has been drawing increased attention in the context of CRCI research.

While retrospective memory (RM) refers to the ability to retrieve past information, PM refers to the ability to plan a future intention, maintaining it during a variable period of time while engaging in other tasks, and recovering it when the appropriate circumstances arise[17]. Different PM tasks have been proposed[18-19] such as activity-based tasks (e.g., do the laundry after lunch), habitual tasks (e.g., walk the dog every morning before going to work), but the most studied have been the event-based PM (EBPM; e.g., stop by the pharmacy to buy some medication on the way home) and the time-based PM (TBPM) tasks (e.g., reply to an e-mail in 30 minutes).

Different methodological approaches and measures have been developed to assess PM, which can generally be categorized into objective and subjective approaches[19-20]. The first approach includes behavioral tasks that allow to collect performance indicators, such as accuracy, omission errors, and response time.

For example, in a typical laboratorial PM task[17], participants are usually instructed to complete a PM task (e.g., press the "space key" when you see the word "whale") while performing an ongoing task (e.g., decide if a given letter sequence is a word or a non-word). The second approach corresponds to self-reported measures that require people and/or an informant to judge personal memory abilities, complaints or perceived incidence of memory lapses. For example, people can be asked to rate in a Likert-type scale how often they forget something they planned to do.

PM failures can have important implications in daily activities (e.g., forget an appointment; forget to turn off the stove after making a tea). It is not by chance that PM has been associated with work-related outcomes, community living skills, and independence in daily living activities[21-22]. Hence, the study of PM in cancer patients and survivors is of uttermost importance not only to better characterize CRCI and memory functioning, but also to achieve a clearer picture regarding factors contributing to changes in occupational, daily functioning, and quality of life indices in cancer experience. In this context, the current work aimed to offer a brief and up-to-date overview of the main PM findings in the field of cancer research.

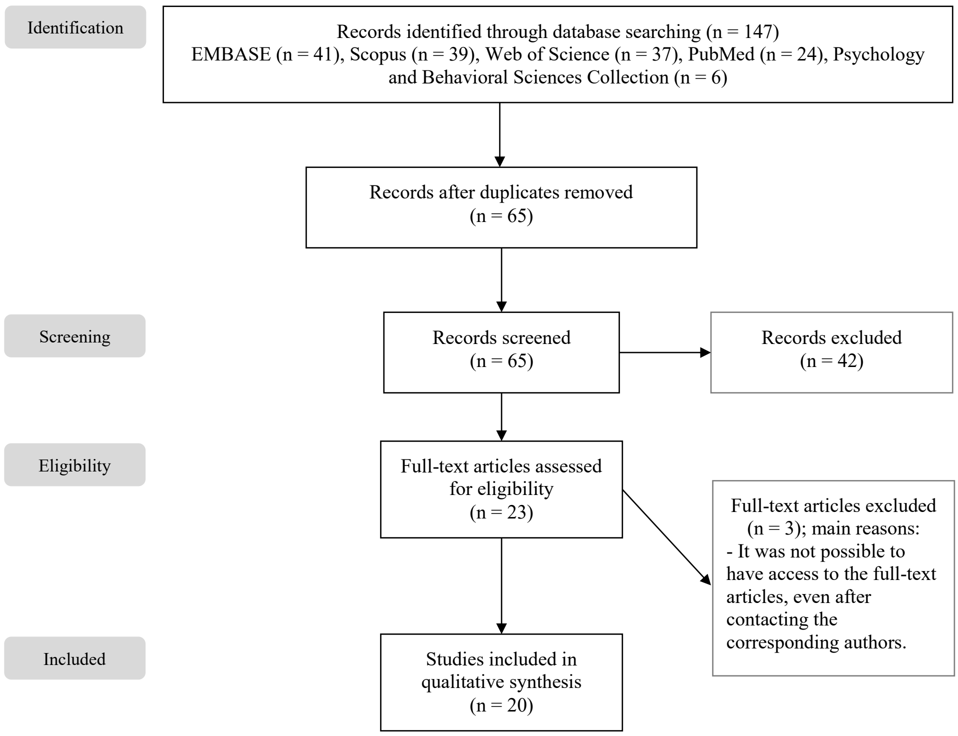
## METHOD

This qualitative systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (Prisma)[23]. The literature search was conducted in different databases – Embase, Scopus, Web of Science, PubMed, Psychology and Behavioral Sciences Collection – pairing the following search terms: "cancer" and "prospective memory" (as it is the most used terminology in the literature). All results obtained until 7th July 2020 were considered. Figure 1 displays the steps adopted in the literature search. Specifically, after removing duplicates, two authors – DRP and NG – completed the abstract screening independently. When inconsistencies were found, the authors discussed until a consensus was reached. Then the full-text reading phase ensued. There was a full agreement among authors at this stage.

In both abstract and full-text phases, the following eligibility criteria were used: (a) empirical studies, leading to the exclusion of other types of publications, such as book chapters, conference abstracts, conference proceedings, editorials, letters to the editor, quantitative and qualitative systematic reviews, and research protocols; (b) articles written in English, Portuguese, Spanish or French (documents written in other languages were not considered); (c) studies with human participants, including at least a group of cancer patients or survivors regardless of cancer type, stage or age; (d) studies incorporating at least one measure of PM that could be objective or subjective.

As a result, 20 studies published between 2000 and 2020 were included in the systematic qualitative review. From each study, the following information was extracted and summarized in Table 1: author(s), year, and country; study design (cross-sectional or longitudinal); participants (total number of participants, number of females, mean age); outcome measures related to PM (objective and/or subjective); main PM-related findings.

Figure 1 – Flow diagram of the search strategy conducted in the present systematic qualitative following the Prisma guidelines[23]




## RESULTS

A brief overview of the main characteristics and findings of the studies included in the systematic analysis are presented in Table 1. Regarding general characteristics, it was observed that 95% of the studies (n = 19) were published in the last decade (≥ 2013), showing that the investigation of PM in cancer is a recent field of inquiry. Most studies were conducted in China (n = 12), followed by Canada (n = 4), Australia (n = 3) and France (n = 1). Also, most studies were conducted in the context of breast cancer (n = 11), but studies with brain (n = 4), prostate (n = 2), nasopharyngeal cancer (n = 1), and merging different cancer types (n = 2) were also found. A total of 11 studies used a cross-sectional approach: six used matched healthy controls as the comparison group; three used another group of cancer patients; two used both matched healthy controls and cancer patients. The remainder nine studies used a longitudinal approach to probe the effects of different treatments (e.g., chemotherapy; radiotherapy; surgery) on PM by comparing PM before and after treatment. The participants were young, middle-age or old adults. No study including children or adolescents was found. Nine studies employed subjective measures to assess PM, other nine used objective measures, and two combined subjective and objective measures.

Table 1 – Systematization of the main characteristics of the studies included in the systematic review (in chronological order)

| Study (country) | Study design (cross-sectional – CS; longitudinal – L) | N participants (sex; $M_{age}$) | PM outcome measure(s) (objective – O; subjective – S) | Main PM-related findings |
|---|---|---|---|---|
| [24] (Canada) | CS (survivors of tumors treated with surgery only *vs*. those treated with surgery, focal radiation, and craniospinal radiation *vs*. age-matched controls) | 20 long-term survivors of childhood cerebellar tumors treated with surgery only (astrocytoma; 9F; $M_{age}$ = 20.3)<br>20 survivors treated with surgery, focal radiation, and craniospinal radiation (medulloblastoma; 8F; $M_{age}$ = 23.7)<br>40 age-matched controls (21F; $M_{age}$ = 23.0) | O: TBPM task (tell the examiner as accurately as possible when participants believed 30 min had elapsed) | ↓ PM interfered with the ability of long-duration prospective estimates (i.e., prospective time perception) in the groups treated for tumors |
| [10] (China) | CS (BC patients who completed post-operative adjuvant chemotherapy *vs*. healthy controls) | 40 BC patients (40F; $M_{age}$ = 43.13)<br>40 healthy controls (40F; $M_{age}$ = 41.53) | O: Semi-naturalistic EBPM (e.g., tap the desk whenever two animal words were found) and TBPM tasks (e.g., tap the desk at 5-min intervals) | ↓ EBPM scores in BC patients *vs*. healthy controls<br>X TBPM scores |
| [25] (Canada) | CS (BC patients vs. aged-matched healthy controls) | 80 BC patients who had completed chemotherapy in the preceding year (80F; $M_{age}$ = 54.1)<br>80 Aged-matched healthy controls (80F; $M_{age}$ = 54.0) | O: MIST | ↓ PM performance in BC patients *vs*. healthy controls<br>23% of patients had PM impairment<br>↑ PM was predicted by being in the control group, younger age and less fatigue symptoms<br>Fatigue (but not depression) mediated the relationship between group membership and PM performance |
| [26] (China) | CS (prostate cancer patients undergoing ADT *vs*. patients who had not undergone ADT *vs*. age and education-matched healthy controls) | 43 prostate cancer patients undergoing ADT ($M_{age}$ = 69.28)<br>35 patients who had not undergone ADT (non-ADT; $M_{age}$ = 68.83)<br>40 age and education-matched healthy controls ($M_{age}$ = 67.80) | O: Semi-naturalistic EBPM (e.g., tap the desk whenever two animal words were found) and TBPM tasks (e.g., tap the desk at 5-min intervals) | ↓ PM performance in the ADT group *vs*. non-ADT and control groups<br>X TBPM performance |

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|---|---|---|---|---|
| [27] (Canada) | CS (chemotherapy-exposed BC survivors *vs*. healthy controls) | 80 BC patients, stages I and II exposed to chemotherapy with or without hormonal treatment (80F; $M_{age}$ = 54)<br>80 healthy controls (80F; $M_{age}$ = 54) | O: MIST | ↑ Omission errors in cancer patients<br>X Recognition test |
| [7] (China) | L (BC patients triple negative *vs*. non-triple negative before and 1-month after chemotherapy) | 80 triple negative BC patients with no hormonal therapy (80F; $M_{age}$ = 48.48)<br>165 non-triple negative with no hormonal therapy BC patients (165F; $M_{age}$ = 49.39) | S: PRMQ | After chemotherapy: ↑ PM and RM lapses in BC patients, but these were more pronounced in the triple negative *vs*. non-triple negative group |
| [14] (Australia) | CS (BC survivors *vs*. demographically matched women with no history of cancer) | 26 BC survivors (26F; $M_{age}$ = 53.0)<br>25 control group with no history of cancer (25F; $M_{age}$ = 50.4) | O: Virtual reality PM task (e.g., press a key every time participants heard an auditory announcement about a sale – EBPM task; send messages at the 4$^{th}$, 8$^{th}$, and 12$^{th}$ minutes – TBPM task); Semi-naturalistic activity-based PM (e.g., ask to give a questionnaire at the end of the session)<br>S: BAPM | ↑ PM failures in instrumental activities of daily living in survivors *vs*. control group<br>X Objective PM performance (EBPM, TBPM, and activity-based PM)<br>Negative association between TBPM performance and self-reported cognitive problems |
| [16] (China) | CS (non-metastatic prostate cancer patients undergoing ADT *vs*. patients who had not undergone ADT) | 19 non-metastatic prostate cancer patients undergoing ADT ($M_{age}$ = 70.0)<br>20 non-metastatic prostate cancer patients who had not undergone ADT (non-ADT; $M_{age}$ = 67.5) | S: Semi-structured interview | ↓ Perceived PM in ADT *vs*. non-ADT group<br>ADT group reported more PM problems (74%) *vs*. non-ADT group (50%) |
| [11] (China) | L (BC patients before *vs*. after adjuvant chemotherapy *vs*. cognitively normal group) | 34 BC patients with no hormonal treatment (34F; $M_{age}$ = 52.00)<br>31 cognitively normal (31F; $M_{age}$ = 50.61) | O: Semi-naturalistic EBPM (e.g., tap the desk whenever two animal words were found) and TBPM tasks (e.g., tap the desk at 5-min intervals) | Before chemotherapy: X EBPM and TBPM scores between BC patients and cognitively normal participants<br>After chemotherapy: ↓ EBPM and TBPM scores in BC patients *vs*. cognitively normal participants; left HPC and left FFA connectivity were negatively correlated to EBPM scores; left HPC and right cerebellum connectivity was negatively correlated to both EBPM and TBPM scores |

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| [28] (China) | CS (BC ER+/PR+ *vs*. BC ER-/PR- patients) | 120 BC patients who underwent chemotherapy:<br>60 BC patients ER+/PR+ (60F; $M_{age}$ = 49.91)<br>60 BC patients ER-/PR- (60F; $M_{age}$ = 49.45) | O: Semi-naturalistic EBPM (e.g., tap the desk whenever two animal words were found) and TBPM tasks (e.g., tap the desk at 5-min intervals) | ↑ EBPM scores in BC ER+/PR+ *vs*. BC ER-/PR- patients<br>X TBPM scores in BC ER+/PR+ *vs*. BC ER-/PR- patients |
| [13] (China) | L (cancer patients with brain metastases before *vs*. after whole brain radiotherapy) | 81 patients with brain metastases (33F) | O: Semi-naturalistic EBPM (e.g., tap the desk whenever two animal words were found) and TBPM tasks (e.g., tap the desk at 5-min intervals) | After radiotherapy: ↓ EBPM scores<br>X TBPM scores |
| [29] (China) | CS (BC patients triple negative *vs*. non-triple negative *vs.* healthy control group; each group was further divided in young, middle-aged, and older adults) | 120 BC patients receiving chemotherapy (120F; $M_{age}$ = 52.04):<br>60 BC patients triple negative<br>60 BC patients non-triple negative<br>120 healthy control group (120F; $M_{age}$ = 50.44) | S: PRMQ | ↑ PM and RM lapses in BC patients *vs*. control group<br>↑ PM and RM lapses in triple negative *vs*. non-triple negative in young, middle-age, and elderly patients<br>Positive association between PM and RM lapses and age<br>Triple negative status and age were risk factors for the occurrence of CRCI |
| [30] (China) | L (patients with nasopharyngeal carcinoma before *vs*. after intensity-modulated radiotherapy) | 48 patients with nasopharyngeal carcinoma treated with intensity-modulated radiotherapy (13F; $M_{age}$ = 50.94) | S: PRMQ | ↑ PM and RM lapses after *vs*. before radiotherapy<br>Negative association between PM and RM lapses and QoL |
| [31] (Australia) | L (pilot cancer group, pilot non-cancer group, randomized controlled trial cancer group; 4-week web-based intervention *e*ReCog program) | 12 pilot cancer group (100%F; $M_{age}$ = 45.4)<br>16 pilot non-cancer group (75%F; $M_{age}$ = 47.6)<br>32 randomized-control trial cancer group (100%F; $M_{age}$ = 55.1) | S: BAPM (instrumental activities of daily living subscale) | Total engagement in the intervention was correlated with fewer PM problems on instrumental activities of daily living subscale |
| [32] (Australia) | L (two-arm randomized controlled trial: cancer survivors that completed a 4-week web-based cognitive rehabilitation therapy program – *e*ReCog *vs*. waitlist control group) | 32 cancer survivors allocated to the intervention (32F; $M_{age}$ = 55.1)<br>33 cancer survivors allocated to the waitlist (33F; $M_{age}$ = 56.9) | S: BAPM | ↓ PM failures in the intervention *vs*. control group |

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|---|---|---|---|---|
| [33] (Canada) | CS (BC survivors who were within 1 year of having completed chemotherapy/ radiotherapy *vs*. age-and education-matched healthy controls) | 80 BC survivors stage I and II who were within 1 year of having completed chemotherapy/ radiotherapy with or without hormonal treatment (80F; $M_{age}$ = 54.1)<br>80 control participants (80F; $M_{age}$ = 54.0) | O: MIST<br>S: PRMQ | PM > RM failures in both groups<br>↑ PM failures in BC survivors *vs*. control participants (no longer significant after adjusting for fatigue and depression)<br>↓ PM performance in BC survivors *vs*. control participants (even after controlling for fatigue and depression)<br>Lack of association between objective and subjective measures of RM and PM |
| [12] (China) | L (BC ER+/PR+ *vs*. BC ER-/PR-patients before and 1-month after chemotherapy) | 21 BC patients ER+/PR+ (21F; $M_{age}$ = 52.29)<br>19 BC patients ER-/PR- (19F; $M_{age}$ = 48.47) | S: PRMQ | Before chemotherapy: X PM and RM lapses between groups<br>After chemotherapy: ↑ PM and RM lapses in the ER-/PR- *vs*. ER+/PR+ group<br>Positive association between PM score and functional connectivity between left DLPFC and left PC in the ER-/PR- group |
| [34] (China) | L (BC survivors before *vs*. after chemotherapy) | 63 BC survivors who have received chemotherapy | S: PMQ | After chemotherapy: ↓ PM score<br>↓ PM score in patients with *vs*. without depression |
| [35] (China) | L (glioma patients 48h before being hospitalized *vs*. two weeks after surgery) | 71 glioma patients (38F) | S: PRMQ | ↑ PM and RM perceived failures after surgery<br>Depression before surgery did no predict PM failures after surgery<br>PM and RM failures before surgery did not predict depression after surgery |
| [15] (France) | CS (cancer patients with brain metastases 1-month after treatment *vs*. matched controls) | 49 patients with brain metastases who underwent neurosurgery/ radiosurgery (28F; $M_{age}$ = 56.8)<br>111 matched controls (74F; $M_{age}$ = 50) | O: Experimental task 'PROMESSE' (EBPM: press key when specific target word appeared; TBPM: press key every 1 min after starting the task) | ↓ PM performance in patients (regardless of brain metastases location and after adjusting for age and socio-cultural level)<br>Positive association between PM performance with general cognitive ability, health-related QoL<br>Negative associations between PM performance and depressive symptomatology, number of brain metastases, and volumetric of brain metastases<br>Positive association between TBPM performance and QoL |

Legend: ADT: Androgen Deprivation Therapy; BAPM: Brief Assessment of Prospective Memory; BC: Breast Cancer; CRCI: Cancer-Related Cognitive Impairment; CS: Cross-Sectional; EBPM: Event-Based Prospective Memory; ER: Estrogen Receptor; F: Female; FFA: Fusiform Area; HPC: Hippocampus; L: Longitudinal; MIST: Memory for Intentions Screening Test; O: Objective; PC: Precuneus; PM: Prospective Memory; PMQ: Prospective Memory Questionnaire; PR: Progesterone Receptor; PRMQ: Prospective and Retrospective Memory Questionnaire; QoL: Quality of Life; RM: Retrospective Memory; S: Subjective; TBPM: Time-Based Prospective Memory; ↑: Increased; ↓: Decreased; X: No statistically significant difference(s).

With respect to PM functioning in the context of cancer, the vast majority of studies showed greater perceived PM-related problems as well as worst PM performance in cancer patients, especially when considering EBPM tasks (see Table 1). Even though alterations in TBPM were observed in one study[11], most studies assessing TBPM indicated a preserved performance[10,13,14,26].

Importantly, the relationship between PM and quality of life was supported by different studies[15,30]. Moreover, the investigation of other psychosocial variables such as depression and fatigue have yielded important findings: a) there was a negative association between PM performance and depressive symptoms[15]; when comparing cancer patients with *vs*. without depression, the first reported more PM complaints[34]; differences in PM lapses were no longer significant after controlling for depression and fatigue, which appears to not be the case for objective measures[33]; fatigue mediated the relationship between being part of the group of cancer patients and PM performance[25]. Thus, the study of these variables is relevant to better explain PM impairment related to cancer.

## DISCUSSION

The main goal of this study was to provide a summary of the literature with respect to PM functioning in cancer. The investigation of PM in this group is of uttermost importance not only to better characterize the CRCI experience, but also to better understand which factors might modulate quality of life, well-being, and daily functioning in cancer. In fact, evidence supporting the association between PM and quality of life was found in this review[15,30].

Moreover, PM difficulties were consistently reported (see Table 1). Specifically, cancer patients reported more PM lapses and complaints after the main treatment[7,12,30,34,35] and as compared to both matched healthy controls with no history of cancer[14,29] and to other patients not submitted to the same treatment[16]. Nonetheless, when assessing objective PM performance, the findings were not always consistent. Whereas some studies documented worst PM performance in cancer patients after treatment when contrasting pre-and post-treatment[15] and as compared to healthy controls[10,11,25,27,33], there was a study by Mihuta et al.[14] showing similar performance between breast cancer survivors and a control group in different PM tasks, including EBPM, TBPM, and activity-based PM.

From the current review, it was possible to verify that different factors may account for these variations, such as cancer type, type of treatment, type of PM task, presence of depressive symptomatology, fatigue, genetic variability, among others. For instance, with respect to the type of treatment, in a study by Yang et al.[26], PM performance was impaired in prostate cancer patients that underwent androgen deprivation therapy when compared to a group of patients who did not receive this type of therapy and to a healthy control group.

Regarding the type of PM task, whereas extant evidence suggests a preserved TBPM performance[10,13,14,26], EBPM performance appears to be more consistently impaired[10,13,26].

In the case of psychosocial factors, worst PM performance was observed in patients with depression when compared to those without depression[34]. Higher depressive symptomatology was related to lower PM performance[15]. Also, less fatigue symptoms predicted better PM performance[25].

Concerning genetic variability, some of the studies probed whether different hormone expressions in the context of breast cancer modulated CRCI after chemotherapy. These studies revealed that patients with negative *vs*. positive estrogen and progesterone receptors expression are more prone to report PM and RM lapses[12] and display worst EBPM performance[28]. Other group of studies tested whether having triple negative *vs*. non-triple negative breast cancer modulated PM performance. Triple negative means that estrogen, progesterone and human epidermal growth factor receptors are not expressed. The results showed that triple negative patients exhibited more pronounced PM and RM failures when compared to non-triple negative patients[7,29]. Moreover, the triple negative status together with age emerged as risk factors for the occurrence of CRCI[29].

Despite the evidence presented so far, more studies using longitudinal approaches, proper assessment measures and control conditions are warranted to shed light on the role of the former factors in CRCI and PM[4]. For example, it is not yet possible to identify CRCI trajectories (e.g., spontaneous recovery *vs*. persistent alterations), which cognitive abilities are more likely to be impaired or preserved, and which are the risk or protective factors. In other words, the mechanisms underlying CRCI are poorly understood, even though it is recognized that different individual, biological, genetic factors are indisputable players[5,6].

It is worthy to note that discrepancies between subjective and objective PM measures are expected and that these measures might be uncorrelated. This issue is recognized in both CRCI[5] and PM literature[36]. In this line, the study of Paquet et al.[25] tested the association between objective and subjective PM measures but no association was found. Indeed, whereas subjective measures tend to capture a personal view that can be shaped by other factors, such as mood, self-awareness, and memory self-efficacy, objective measures might provide a more reliable proxy of PM functioning[37]. Nonetheless, this argument does not demerit the value of self-reported measures as it allows to explore other types of information, such as metamemory, reasons driving memory lapses, and perceived impact of memory difficulties on daily functioning[38]. Taken together, it is relevant to use both subjective and objective instruments when assessing PM in the context of CRCI, and to expect that these measures will likely convey distinct facets of PM functioning.

In a similar fashion, this review indicated that the studies in the field of CRCI are not yet tuned to explore which PM-related processes are more or less affected[5]. For example, PM involves different abilities such as planning future intentions, recognition of retrieval cues and contexts, retrieval of an intention, execution of the intention and its deactivation when no longer relevant[39]. Thus, this topic could be addressed in future studies.

This work is not without limitations as restricted databases, keywords, and idioms were used. For instance, specific searches targeting grey literature were not conducted, even though such studies would provide valuable information considering the dearth of evidence in this field of research. Also, this systematic review was intended to be short with a particular focus on PM, so plenty of information from the included studies was not incorporated. This poses some problems in terms of selective reporting and precludes the discussion of PM findings in the broader picture of CRCI.

## CONCLUSION

CRCI affects different cognitive domains, including attention, memory, executive functioning, information processing speed, language, and visuo-spatial skills, which may contribute to worst outcomes in terms of quality of life, well-being, and daily functioning. Nevertheless, PM has received less attention. The evidence reviewed here indicated that PM is also affected in cancer, and it is associated with quality of life, highlighting the need to include PM measures when examining CRCI. This is an important step not only to better characterize CRCI experience, but also to guide the development of interventions that aim to ameliorate or prevent CRCI. An important example is the development of cognitive rehabilitation approaches, which are being tested as a way to mitigate PM and other cognitive difficulties in cancer with promising results[31,32].

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