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Older Adults' Self-Reported Prospective Memory Lapses in Everyday Life: Connections to Inflammation and Gender

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Abstract

Objective: Limited research has focused on the association between inflammatory markers and features of subjective cognitive functioning among older adults. The present work examined links between inflammation and a specific subjective cognitive report: prospective memory (PM), or our memory for future intentions, such as attending an appointment or taking medication.

Method: We assessed self-reported PM lapses using a two-week ecological momentary assessment (EMA) diary protocol via smartphone as well as levels of blood-based inflammation

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among 231 dementia-free older adults (70–90 years, 66% women) enrolled in the Einstein Aging Study.

Results: Overall, PM lapses were largely unrelated to inflammatory markers. However, a significant gender difference was observed in the link between basal levels of interleukin (IL)-8 and PM lapses: higher levels of basal IL-8 were associated with more PM lapses among men (*estimate* = 0.98, *95%CI*: [0.43, 1.53], $p < .001$) but not women (*estimate* = −0.03, *95%CI*: [−0.45, 0.39], $p = .826$). No other significant relationships between PM lapses and basal or stimulated (*ex vivo*) cytokine levels (IL-1β, IL-4, IL-6, IL-8, IL-10, tumor necrosis factor-alpha [TNF-α]) or C-reactive protein (CRP) emerged.

Conclusion: Elevated levels of IL-8 in older men may possibly be an early indicator of neurodegeneration that relates to PM performance. Future studies should continue to examine PM and inflammation across genders to identify possible mechanisms through which these constructs may indicate neurodegeneration and dementia risk.

Keywords

Prospective memory; Cytokine; Biomarker; Aging; Subjective Cognition

Introduction

Extensive research efforts have been dedicated to improving early identification of symptomology and risk for cognitive decline and Alzheimer's disease and related dementias (ADRD). Inflammatory responses appear to play an important role in Alzheimer's disease (AD)-specific pathology and blood-based inflammatory markers may offer opportunities for early identification of risk without requiring more time-consuming or invasive procedures (e.g., brain imaging, cerebral spinal fluid analysis). Blood-based inflammatory markers implicated in risk for cognitive decline and ADRD include pro-inflammatory cytokines (e.g., interleukin [IL]-1β, IL-6, IL-8, tumor necrosis factor [TNF]-α), anti-inflammatory cytokines (e.g., IL-4, IL-10), and C-reactive protein (CRP)[1–7]. Much of the work connecting inflammation to risk for cognitive decline has examined diagnostic or laboratory-based cognitive performance; less is therefore known about how inflammation relates to individuals' everyday cognitive functioning. An emerging body of work has partially addressed this knowledge gap by focusing on links between inflammation and subjective cognitive reports[8–10].

Subjective cognitive reports related to more frequent forgetting may be one of the earliest symptoms of AD[11] and should serve as a red flag for clinicians. Although ADRD risk appears to be even stronger when subjective reports of forgetting are linked with biological risk factors[12], limited research has examined the links between inflammation and subjective cognition. Findings in this area have been mixed, with some pro-inflammatory cytokines (i.e., monocyte chemotactic protein-1) correlating with greater subjective cognitive complaints, and others (i.e., TNF-α) correlating with fewer complaints[10]. Other work that examined differences in gene expression involved in certain inflammatory responses between individuals with and without subjective memory complaints found no significant differences between groups[9]; however, this study and

others like it use brief single-time point assessments that broadly address subjective cognition, which may not be sensitive enough to capture daily experiences. Rather than general subjective assessments, examining specific types of forgetting in daily life may improve our ability to speak to unique links between inflammation and cognitive risk factors for future decline and pathology. Accordingly, the present study focuses on the links between inflammatory markers and subjective reports of prospective memory lapses in daily life.

Prospective memory (PM) refers to our memory for future actions or events[13], such as remembering to turn off the stove after cooking or attending a scheduled appointment. Although there are some mixed findings[14], individuals are more likely to experience PM lapses in daily life compared to other memory lapses, such as retrospective memory failures[15,16]. Much of the existing PM research documents task-specific[17] or psychosocial factors[18] related to older adults' PM performance. Yet, person-specific predictors, including biological factors like inflammation, may play a critical role in PM performance and decline and require further attention. PM forgetting can be consequential for maintaining independence into older adulthood[19,20] and may help distinguish healthy older adults from those in the early stages of ADRD earlier than deficits in other cognitive abilities like executive function, retrospective memory, and working memory[21,22]. Despite arguments that PM decline may be an early indicator of pathological memory aging, limited work has addressed PM in relation to biological correlates of cognitive decline and ADRD risk[22–25].

To our knowledge, only one study has directly assessed the link between inflammation and laboratory-based PM[26]. In this study, researchers examined circulating inflammatory cytokines (i.e., IL-1β, IL-1 receptor antagonist, soluble IL-1 receptor type-II, soluble IL-2 receptor, and IL-6) within a sample of women (aged 45–90 years) who were asked to remind the experimenter at the end of the testing session to sign a paper. Higher levels of IL-6 related to poorer PM performance only among older women (aged 60+). However, the generalizability of this finding is unclear given that older adults' PM performance often differs between laboratory and naturalistic settings[27] and single-item assessments of PM often lack reliability[28,29]; moreover, this study only included women.

There is reason to believe that the link between PM and inflammation would differ by gender/sex[1]. Women are more likely than men to experience other conditions associated with inflammation (e.g., pregnancy complications, depression, chronic stress) which are also linked with cognitive impairment, including poor PM[32,33], and increased risk for ADRD later in life[34–36]. Conversely, men are at greater risk for vascular cognitive impairment across the lifespan compared to women[34], with heightened inflammation involved in the underlying pathology for this greater risk. Researchers have noted a dearth of studies that focus on gender differences in ADRD risk as well as the importance of identifying sexual dimorphisms to improve early detection, prevention, and care for those

[1]We used the term "gender/sex" in keeping with recommendations[30,31] and acknowledge that both biological and sociocultural factors likely relate to differences observed between those who identify as men and women. No participants in the present work reported non-binary or transgender identities and the differentiation between biological and sociocultural factors related to gender/sex was not possible in the present work.

with cognitive decline and ADRD[36,37]. To the extent that PM forgetting is an early ADRD indicator[21,22], identifying gender differences in the link between inflammation and subjective PM reports may be critical in determining *who* is at greater risk of daily memory failures and potential future pathology.

Current Study

Building upon the literature, the current study investigated links between self-reported PM lapses in daily life in association with inflammatory markers. We assess PM lapses using a two-week electronic diary protocol. Daily diaries can capture perceptions of cognitive functioning and document reported forgetting across an extended measurement period[14]. This enabled us to examine instances of PM lapses for self-generated PM tasks *in everyday life*, an approach that is in line with recommendations from PM researchers to address self-generated PM task performance (i.e., true naturalistic PM tasks that participants set for themselves[15,16,38]).

We further extend past work by investigating three distinct measures of blood-based inflammatory markers (i.e., CRP, basal [circulating] cytokines, and stimulated [*ex vivo*] cytokines). In addition to the previously examined IL-6 and IL-1β[26], we quantified CRP and several other cytokines (i.e., IL-4, IL-8, IL-10, TNF-α) linked with cognitive decline[39,40] that have not been examined in association with PM. We also examined stimulated inflammatory responses for these same cytokines. Basal and stimulated levels of cytokines are separate measures (not strongly correlated) that relate to distinct characteristics of inflammation[41,42]; basal cytokines are an index of systemic inflammation, whereas stimulated cytokines represent immune activation in response to an immunogenic challenge. This quantification of different aspects of inflammation, using multiple biomarkers, further strengthens our ability to comprehensively examine linkages between PM lapses and markers of inflammation.

A final important a priori goal of the current research was to test our expectation that gender/sex differences in the relationship between PM and inflammation exist. Based on the extant literature, we explored competing hypotheses as to whether higher levels of inflammation will be uniquely linked with greater PM lapses among women or among men.

Method

Participants & Procedure

The study's sample was drawn from the ongoing Einstein Aging Study (EAS), using deidentified data from the first wave of collection between May 2017 and February 2020. EAS data collection was reviewed and approved by the Albert Einstein College of Medicine institutional review board. Participants were recruited via systematic random sampling from New York City Registered Voter lists for Bronx County. Potential participants were mailed introductory letters and follow-up phone screens were conducted to determine eligibility (i.e., English-speaking, community-residing, ambulatory individuals, aged 70-years or older).

After a phone screening, eligible participants attended an in-person clinic visit and provided written consent. During the clinic visit, participants completed questionnaires to assess demographic and psychosocial characteristics, a neuropsychological battery to assess cognitive function, and the first of two blood draws from which inflammatory markers were obtained. At this time, participants received training on how to use study smartphones for the ecological momentary assessment (EMA) protocol. The EMA protocol included two practice days followed by 14 consecutive days of EMAs during which participants completed self-initiated end-of-day surveys (via smartphone) that included questions on daily PM lapses. After the EMA protocol, participants returned the study smartphones and the second blood draw was obtained during a clinic visit. Blood samples were drawn at approximately the same time of day (morning) and included one fasting sample (pre-EMA) and one non-fasting sample (post-EMA).

Participants were included in the analytic sample if they completed at least one end-of-day survey and blood draw ($n = 274$); however, 42 participants were excluded due to missing data across several biomarkers. Thus, the final sample included 231 dementia-free older adults (152 women, ages 70 – 90 years, $M_{age} = 76.9$, $SD = 4.7$). Additional demographic details can be found in Table 1. More men ($n = 50$, 63.3%) than women ($n = 59$, 38.8%) identified as non-Hispanic White, whereas more women identified with races/ethnicities other than non-Hispanic White (χ^2 (1) = 12.50, $p < .001$). No other gender differences emerged in terms of age, education, number of health conditions, body mass index (BMI), or depressive symptoms ($ps > .20$).

Measures

Prospective Memory Lapses—PM lapses were assessed using a two-week diary protocol during the EMA period. At the end of each day, participants completed the memory lapse checklist[14,43] which asked them to indicate (*Yes/No*) whether they forgot to complete any of the seven following tasks that day: (a) complete an errand or chore, (b) take medication on time, (c) attend a meeting/appointment, (d) make a phone call, (e) complete an action they had started (i.e., forgot why they had entered a room), (f) bring something with them, or (g) do something else. No follow-up questions regarding PM lapses were asked. Across the two-week measurement period, 3,234 evening surveys were distributed (14 days by 231 participants). Participants completed a total of 2,709 surveys, leading to an average compliance rate of 83.8%. To capitalize on the improved reliability of repeated assessments, PM lapses were summed across the two-week measurement period.

Inflammatory Biomarkers—Inflammatory markers were assessed from blood[2]. Samples were centrifuged at 1500g for 15 minutes. The supernatant was aliquoted and stored at −80°C. Prior to centrifugation, a 1 mL subsample of whole blood was combined with 3 mL 0.9% NaCl sterile saline and lipopolysaccharide (LPS; E. coli 055:B5, Sigma Aldrich) at a final LPS concentration of 1 μg/mL; this was then incubated on a rotational shaker

[2]Due to a protocol change early in the study, 50 samples were collected in heparin-coated tubes, with the remainder of samples collected in EDTA (ethylenediamine tetraacetic acid)-coated tubes. Heparin-coated tubes can influence detectable levels of stimulated cytokines[44]; the present findings in stimulated cytokines did not change when participants with heparin-coated tubes were removed from analysis. Thus, all participant data were retained within the current report.

at 37°C with 5% CO2 for 2 hours. These samples were then centrifuged at 1500g for 15 minutes. Basal and LPS-stimulated cytokines (IL-1β, IL-4, IL-6, IL-8, IL-10, TNF-α) and high-sensitivity CRP were quantified using a multiplex (V-plex) assay (Meso Diagnostics, Rockville MD) that performs better than other common multiplex platforms[45]. The minimum detection limit for all cytokines ranged between 0.02 and 0.07 pg/mL and was 1.33 ng/mL for CRP. All samples were run in duplicate. Sample pairs with coefficients of variation >15% were rerun. Confirmed values below the minimum detection limit of the assay were replaced with zeros. Pre- and post-EMA blood draw data were averaged to capture inflammation across the full two-week EMA protocol.

Covariates—Gender/sex was included as a covariate in models in which gender/sex differences were not directly being tested (0 = Men, 1 = Women). Consistent with relevant work[1,26], models also controlled for important markers of health and socioeconomic status related to inflammation, including age, education (number of years), race/ethnicity, number of chronic health conditions, BMI, and depressive symptoms. Participant race/ethnicity was dummy coded for use as a covariate (0 = Non-Hispanic White, 1 = Other). Number of health conditions was coded from a list of 16 possible conditions (e.g., hypertension, stroke, cancer, diabetes, high blood pressure). Sum scores of depressive symptoms (PROMIS Depression Short Form 8a[46]) were calculated such that higher scores indicated greater depressive symptoms ($\alpha = 0.77$).

Statistical Analyses

Analyses were conducted using IBM/SPSS Statistics 27.0 and R statistical software. The statistical significance threshold was set at $\alpha = .05$. Consistent with past work[47,48], natural logarithmic (log) transformations were applied using a log formula of (x+1) for all cytokines and natural log transformations for CRP to correct for skewness. Additionally, 32 cytokine values (1.07% of the inflammation data) were winsorized to retain the maximum number of participants while minimizing the influence of outliers (see Supplemental Materials for information on raw and transformed inflammatory markers). All analyses utilized transformed cytokine values.

Zero-order correlations examined relationships between PM lapses, gender/sex, and inflammatory markers. Next, analyses stratified by gender/sex examined associations between reported PM lapses and each inflammatory marker. To adjust for multiple comparisons, we adopted Benjamini and Hochberg's[49] false discovery rate (FDR) procedure and set the *q*-value (the FDR) to .05. FDR *p*-value adjustments were made based on all examined links (i.e., encompassing full sample and gender/sex stratified analyses). Only correlations that remained significant after FDR adjustments were further examined using zero-inflated negative binomial (ZINB) regression. ZINB regression analyses were deemed appropriate as many participants did not report any PM lapses across the two weeks[14,43] and because of superior Akaike Information Criterion (AIC) fit indices compared to other potential models (e.g., Poisson, negative binomial). We were interested in the expected number of PM lapses as an outcome (i.e., count model), but model statistics for zero-inflated models (i.e., logit of reporting zero PM lapses) are presented within the corresponding tables.

Results

Participants reported experiencing 0 to 35 PM lapses across the two-week measurement period (M = 5.48, SD = 6.74). Approximately 24% of our sample reported zero PM lapses across the two-week measurement period. When examining the relationships between PM lapses and the inflammatory markers within the sample as a whole (Table 2), the only significant link to emerge was in relation to basal IL-8, such that a greater number of reported PM lapses was correlated with higher basal levels of IL-8 (r = .15, p = .024). However, this relationship was not robust to FDR adjustments (adjusted p = .468); thus, no follow-up ZINB regression analyses were conducted. When analyses were stratified by gender/sex, men's basal IL-8 correlated with PM lapses, such that higher levels of basal IL-8 were associated with more PM lapses (r = .40, p < .001). This relationship remained significant after FDR adjustments (adjusted p = .039). Women's reported PM lapses did not relate to basal IL-8 (r = .02, p = .775). No other significant relationships between inflammatory markers and PM lapses emerged among men or women.

Following-up the observed gender difference in the relationship between basal IL-8 and PM lapses, we conducted gender stratified ZINB analyses[3] (Table 3). Among men, analyses revealed a significant effect of basal IL-8, such that higher levels of basal IL-8 were associated with reporting more PM lapses (b = 0.98, p < .001), thereby supporting of our initial correlational findings. Again, ZINB analyses indicated this relationship was not significant among women (b = 0.03, p = .826).

On an exploratory basis, we examined gender/sex differences in the *types* of reported PM lapses (see Supplemental Materials)[4]. In brief, more men (34.2%) than women (18.4%) reported forgetting to complete an errand or chore (p = .008), whereas more women (42.1%) than men (21.5%) reported forgetting to complete an action they had previously started at least once across the two-weeks (p = .002). Among men, higher basal IL-8 related to greater instances of forgetting to complete an errand/chore, take medication, make a phone call, and bring something (ps < .05). Alternatively, men's higher basal IL-1β and IL-6 related to fewer instances of forgetting to complete a previously started action (ps < .05). Among women, basal IL-8, again, did not relate to PM lapses. However, higher levels of basal IL-1β and IL-4 in women related to a greater instance of forgetting to attend a meeting/appointment (ps < .05). Additionally, higher levels of CRP and several stimulated cytokines (i.e., IL-6, IL-8, IL-10, TNF-α) correlated with a lower likelihood of certain types PM lapses among women (ps < .05), mostly with forgetting to attend a meeting. As these analyses are exploratory, findings should be interpreted with caution.

Discussion

The current study examined relationships between subjective reports of PM lapses in everyday life and inflammatory markers within a diverse sample of older men and women.

[3]Gender stratified analyses were conducted to better account for potential interactions between gender and covariates. It should be noted that the observed effects held when gender was included as a moderator in a single ZINB analysis. See Supplemental Materials for additional details.

[4]We thank the reviewers for their suggestions to present additional findings on the types of PM lapses in everyday life in relation to inflammation.

Contrary to hypotheses, self-reported PM lapses did not relate to most inflammatory markers within our sample as a whole. Although higher levels of basal IL-8 related to greater reported PM lapses within our sample as whole, this link was not robust to FDR adjustments. These null findings are, in part, supported by work from Lekander and colleagues[26] who did not observe a relationship between PM and IL-1β, and from Baune and colleagues[1] who found a significant association between memory performance and basal IL-8, but not with IL-1β, IL-4, IL-6, or IL-10. As only one known study has examined inflammatory cytokines in association with PM[26], we decided to include all available inflammatory indicators to better discern the relationship between self-reported PM lapses and inflammation. It is possible that older adults' self-reported PM is not strongly associated with inflammation, at least not at cross-section. Continued investigation into the longitudinal trajectory of inflammatory markers and PM lapses may reveal additional associations that the current cross-sectional study was unable to identify.

A second key goal of the present work was to examine our hypothesis that associations between inflammatory markers and PM lapses would differ by gender. We found that higher levels of basal IL-8 were linked with reporting more PM lapses only in men, an association that was robust to FDR adjustments and covariates. This finding is novel, as the only known study to have examined a connection between inflammation and PM lapses did not measure IL-8 and included only women[26]. In related work (albeit not specific to PM lapses), higher levels of IL-8 related to poor memory performance among older adults[1,50], but gender/sex differences were not examined. Another study that examined the relationship between IL-8 and memory performance[51] did not observe gender/sex differences; however, this study utilized neurocognitive assessments that did not include a measure of PM and furthermore did not capture cognition in everyday settings. More related to cognitive reports, Iulita and colleagues[52] found that individual with subjective cognitive impairment had slightly higher levels of IL-8 compared to healthy controls and that higher levels of IL-8 correlated with cognitive decline; unfortunately, this past study was underpowered to address gender differences in the observed links. The present work builds upon these past studies and suggests that self-reported PM forgetting in daily life relate to IL-8 only among older men.

There are several possible explanations as to why PM lapses were uniquely linked with levels of IL-8 in the present research. Researchers who observed similar relationships between higher IL-8 and poor cognitive functioning argued that this link may be indicative of the role of IL-8 in neurodegeneration[1]. IL-8 is a pro-inflammatory chemokine that is involved with early signaling in relation to damage[53], and is thought to mediate glial interactions with neurons and contribute to neuronal damage[54]. Higher levels of IL-8 have been associated with white matter hyperintensity volume (WMHV); WMHV has been associated with reduced cognitive performance in men[55], though this effect is not confined to men[56]. Taken together with recent research that documents poorer PM performance among individuals with more severe WMHs[57], PM lapses may occur more frequently in men with elevated IL-8 due to white matter damage. Furthermore, elevated levels of IL-8 have been found within circulating blood[58,59], cerebral spinal fluid[58], and postmortem brains of patients with AD[60]. Importantly, an upregulation of IL-8 has been suggested to occur early in the progression of AD[60] and can be considered an early risk factor for ADRD[61]. As researchers have argued that PM decline may be an early

indicator of dementia[21,22], the observed elevated basal IL-8 levels in older men may be an early indicator of neurodegeneration that impacts everyday PM. Replication of the current findings and additional work is needed to discern whether this association is relevant to underlying neuropathology and/or ADRD risk in men.

Although we hypothesized that the link between inflammation and PM would differ by gender/sex on an a priori basis, the specific pattern observed in the present research was not predicted. Additional research is needed to determine the generalizability of this finding and potential related mechanisms. From a biological perspective, differences in sex hormones may partially explain the gender/sex-specific relationship between basal IL-8 and PM. Women's higher levels of estrogen may protect aspects of cognition from the detrimental effects of inflammation[62], but research has yet to examine gender/sex differences in PM in relation to sex hormones. It is also important to recognize that there may be societal determinants, such as the division of mnemonic responsibilities, that influence the gendered effects of inflammation on PM. Women are often expected to help their male partners[63,64] and children remember their PM intentions[65]. In doing so, women may develop better mechanisms (e.g., strategy use) to manage the cognitive demands related to retaining familial PM intentions[65,66] which, in turn, might buffer PM from the effects of inflammation. If men rely on women to assume responsibility for or assist with their PM tasks, they may not develop the necessary tools to support their memory, making them more susceptible to lapses, especially in the presence of elevated IL-8.

Regarding links among women, we did not replicate Lekander and colleagues' finding of an association between older women's PM and IL-6 levels[26]. The discrepancy between findings may stem from differences in PM measurement (i.e., laboratory-based vs self-report). PM researchers have long observed differences between older adults' performance on laboratory and naturalistic PM tasks[27,67]. Furthermore, self-generated PM tasks, like those assessed in this study, can be more susceptible to interference from daily life and are arguably more representative of a person's PM abilities than experimenter-generated tasks[38,67]. Hence, associations between PM and inflammation might differ across testing settings or across task types (e.g., experimenter- or self-generated). Rather than focusing on women's number of lapses, the present exploratory analyses suggest that examining types of PM lapses in relation to inflammation may be more informative for understand women' everyday PM; yet, additional research is required to replicate these exploratory findings. Longitudinal examinations may also reveal links between women's PM lapses and inflammation that we were unable to identify. Past work suggests that elevated levels of CRP predict poor memory performance among women during a 12-year follow-up[68]; importantly, the composite memory performance score in this study included PM. It is thus possible that PM itself may relate to inflammation across time, but this notion is currently untested. Given women's higher ADRD risk, it is particularly important to identify risk factors or early indicators of pathology among this group[37]. Continued research into inflammatory markers and cognition, including PM, across a variety of tasks and settings will help elucidate underlying causes of gender/sex differences in cognitive decline and dementia risk.

Limitations and Future Directions

Analyses were cross-sectional as longitudinal data with the present cohort were not yet available (data collection ongoing through 2027). It would be valuable for future research to examine the relationship between PM and inflammation longitudinally to address possible intra-individual changes that could more accurately capture cognitive decline and ADRD risk. Additionally, it is possible that individuals more susceptible to the effects of inflammation (e.g., with inflammatory conditions) died earlier in life and were therefore not represented in the current sample of older adults. Attempts to replicate the current findings across a wider range of lifespan would strengthen our understanding of the link between PM and inflammation. Finally, our measure of PM relied on self-reported PM lapses. Our diary-type protocol is a validated measure of subjective cognition[14,43] and is similar to other PM diary studies[69], but does not provide an objective measure of PM. Relatedly, study methodology prevented us from assessing other features of daily PM (e.g., total number of daily intentions, whether "no" response indicated successful execution versus never intending to complete a given task, descriptives of "other" PM lapses) and our measure may not have captured *all* PM lapses across the two-week measurement period. To improve upon the current methods, future studies could incorporate objective measures of PM in addition to implementing more frequent EMA sampling throughout the day to shorten the interval between PM forgetting and assessment[70].

Conclusion

The current study is one of the first to address the relationship between PM lapses in daily life and inflammation among older individuals, and meaningfully adds to the limited research on biological correlates of PM. Given the paucity of research directly connecting PM and inflammation, the present work was largely exploratory and cast a wide net via numerous blood-based inflammatory markers to inform future research. The majority of inflammatory markers tested did not relate to PM lapses. However, we found that PM lapses in men (but not in women) related to higher levels of basal IL-8. Given past findings with other subjective cognition measures as well as emerging evidence that elevated levels of IL-8 in men may be an early indicator of neurodegeneration, it is possible that IL-8 can impact men's everyday PM performance. Building from the present work, future research is needed to understand the biological underpinnings of PM and how PM forgetting and inflammation may relate to pathology over the lifespan. Current findings also suggest that continued examination of gender/sex differences in this domain is warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

[1]. Baune BT et al. , "Association between IL-8 cytokine and cognitive performance in an elderly general population—The MEMO-Study," Neurobiol. Aging, vol. 29, no. 6, pp. 937–944, Jun. 2008, doi: 10.1016/j.neurobiolaging.2006.12.003. [PubMed: 17207897]

[2]. Bradburn S, Sarginson J, and Murgatroyd CA, "Association of Peripheral Interleukin-6 with Global Cognitive Decline in Non-demented Adults: A Meta-Analysis of Prospective Studies," Front. Aging Neurosci, vol. 9, 2018, Accessed: Apr. 19, 2023. [Online]. Available: https://www.frontiersin.org/articles/10.3389/fnagi.2017.00438

[3]. Engelhart MJ et al. , "Inflammatory Proteins in Plasma and the Risk of Dementia: The Rotterdam Study," Arch. Neurol, vol. 61, no. 5, p. 668, May 2004, doi: 10.1001/archneur.61.5.668. [PubMed: 15148142]

[4]. Kinney JW, Bemiller SM, Murtishaw AS, Leisgang AM, Salazar AM, and Lamb BT, "Inflammation as a central mechanism in Alzheimer's disease," Alzheimers Dement. Transl. Res. Clin. Interv, vol. 4, no. 1, pp. 575–590, Jan. 2018, doi: 10.1016/j.trci.2018.06.014.

[5]. Park J-C, Han S-H, and Mook-Jung I, "Peripheral inflammatory biomarkers in Alzheimer's disease: a brief review," BMB Rep, vol. 53, no. 1, pp. 10–19, Jan. 2020, doi: 10.5483/BMBRep.2020.53.1.309. [PubMed: 31865964]

[6]. Teunissen CE et al. , "Inflammation markers in relation to cognition in a healthy aging population," J. Neuroimmunol, vol. 134, no. 1, pp. 142–150, Jan. 2003, doi: 10.1016/S0165-5728(02)00398-3. [PubMed: 12507782]

[7]. Walker KA, Ficek BN, and Westbrook R, "Understanding the Role of Systemic Inflammation in Alzheimer's Disease," ACS Chem. Neurosci, vol. 10, no. 8, pp. 3340–3342, Aug. 2019, doi: 10.1021/acschemneuro.9b00333. [PubMed: 31241312]

[8]. Hooper C et al. , "Chronically raised C-reactive protein is inversely associated with cortical β-amyloid in older adults with subjective memory complaints," Exp. Gerontol, vol. 108, pp. 226–230, Jul. 2018, doi: 10.1016/j.exger.2018.04.014. [PubMed: 29704641]

[9]. Lau S et al. , "Functional effects of genetic polymorphism in inflammatory genes in subjective memory complainers," Neurobiol. Aging, vol. 33, no. 6, pp. 1054–1056, Jun. 2012, doi: 10.1016/j.neurobiolaging.2010.09.003. [PubMed: 20961668]

[10]. Stenfors CUD, Jonsdottir IH, Magnusson Hanson LL, and Theorell T, "Associations between systemic pro-inflammatory markers, cognitive function and cognitive complaints in a population-based sample of working adults," J. Psychosom. Res, vol. 96, pp. 49–59, May 2017, doi: 10.1016/j.jpsychores.2017.03.010. [PubMed: 28545793]

[11]. Studart Neto A and Nitrini R, "Subjective cognitive decline: The first clinical manifestation of Alzheimer's disease?," Dement. Neuropsychol, vol. 10, pp. 170–177, Sep. 2016, doi: 10.1590/S1980-5764-2016DN1003002. [PubMed: 29213452]

[12]. Ebenau JL et al. , "Association of CSF, Plasma, and Imaging Markers of Neurodegeneration With Clinical Progression in People With Subjective Cognitive Decline," Neurology, vol. 98, no. 13, pp. e1315–e1326, Mar. 2022, doi: 10.1212/WNL.0000000000200035. [PubMed: 35110378]

[13]. Einstein GO and McDaniel MA, "Normal aging and prospective memory," J. Exp. Psychol. Learn. Mem. Cogn, vol. 16, pp. 717–726, 1990, doi: 10.1037/0278-7393.16.4.717. [PubMed: 2142956]

[14]. Mogle J, Turner JR, Rabin LA, Sliwinski MJ, Zhaoyang R, and Hill NL, "Measuring Memory Lapses and Their Impact on Daily Life: Results From Two Daily Diary Studies," Assessment, p. 107319112210779, Feb. 2022, doi: 10.1177/10731911221077962.

[15]. Haas M, Zuber S, Kliegel M, and Ballhausen N, "Prospective memory errors in everyday life: does instruction matter?," Memory, vol. 28, no. 2, pp. 196–203, Feb. 2020, doi: 10.1080/09658211.2019.1707227. [PubMed: 31893967]

[16]. Niedźwieńska A, Sołga J, Zagaja P, and Żołnierz M, "Everyday memory failures across adulthood: Implications for the age prospective memory paradox," PLOS ONE, vol. 15, no. 9, p. e0239581, Sep. 2020, doi: 10.1371/journal.pone.0239581. [PubMed: 32976533]

[17]. Rummel J and Kvavilashvili L, “Current theories of prospective memory and new directions for theory development,” Nat. Rev. Psychol, vol. 2, pp. 40–54, 2023, doi: 10.1038/s44159-022-00121-4.

[18]. Zuber S and Kliegel M, “Prospective Memory Development Across the Lifespan: An Integrative Framework,” Eur. Psychol, vol. 25, no. 3, pp. 162–173, Jul. 2020, doi: 10.1027/1016-9040/a000380.

[19]. Hering A, Kliegel M, Rendell PG, Craik FIM, and Rose NS, “Prospective Memory Is a Key Predictor of Functional Independence in Older Adults,” J. Int. Neuropsychol. Soc, vol. 24, no. 6, pp. 640–645, Jul. 2018, doi: 10.1017/S1355617718000152. [PubMed: 29606153]

[20]. Woods SP, Weinborn M, Velnoweth A, Rooney A, and Bucks RS, “Memory for Intentions is Uniquely Associated with Instrumental Activities of Daily Living in Healthy Older Adults,” J. Int. Neuropsychol. Soc, vol. 18, no. 1, pp. 134–138, Jan. 2012, doi: 10.1017/S1355617711001263. [PubMed: 22032776]

[21]. Browning CA, Thompson CL, Kochan NA, Brodaty H, Sachdev PS, and Henry JD, “Prospective Memory Function Predicts Future Cognitive Decline and Incident Dementia,” J. Gerontol. Ser. B, p. gbad027, Feb. 2023, doi: 10.1093/geronb/gbad027.

[22]. Duchek JM, Balota DA, and Cortese M, “Prospective memory and apolipoprotein e in healthy aging and early stage Alzheimer’s disease,” Neuropsychology, vol. 20, pp. 633–644, 2006, doi: 10.1037/0894-4105.20.6.633. [PubMed: 17100508]

[23]. Driscoll I, McDaniel MA, and Guynn MJ, “Apolipoprotein E and Prospective Memory in Normally Aging Adults,” Neuropsychology, vol. 19, pp. 28–34, 2005, doi: 10.1037/0894-4105.19.1.28. [PubMed: 15656760]

[24]. Lancaster C, McDaniel MA, Tabet N, and Rusted J, “Prospective Memory: Age related change is influenced by APOE genotype,” Aging Neuropsychol. Cogn, vol. 27, no. 5, pp. 710–728, Sep. 2020, doi: 10.1080/13825585.2019.1671305.

[25]. McDaniel MA, Shelton JT, Breneiser JE, Moynan S, and Balota DA, “Focal and nonfocal prospective memory performance in very mild dementia: A signature decline,” Neuropsychology, vol. 25, pp. 387–396, 2011, doi: 10.1037/a0021682. [PubMed: 21443344]

[26]. Lekander M et al. , “Cytokines and memory across the mature life span of women,” Scand. J. Psychol, vol. 52, no. 3, pp. 229–235, 2011, doi: 10.1111/j.1467-9450.2010.00865.x. [PubMed: 21332483]

[27]. Henry JD, MacLeod MS, Phillips LH, and Crawford JR, “A Meta-Analytic Review of Prospective Memory and Aging,” Psychol. Aging, vol. 19, pp. 27–39, 2004, doi: 10.1037/0882-7974.19.1.27. [PubMed: 15065929]

[28]. Babicz MA et al. , “Does the Key Task Measure Prospective Memory? Cautionary Findings from Parallel Studies in HIV Disease and Older Adults,” Arch. Clin. Neuropsychol, vol. 34, no. 8, pp. 1438–1444, Nov. 2019, doi: 10.1093/arclin/acz009. [PubMed: 30844064]

[29]. Henry JD, “Prospective memory impairment in neurological disorders: implications and management,” Nat. Rev. Neurol, vol. 17, no. 5, Art. no. 5, May 2021, doi: 10.1038/s41582-021-00472-1.

[30]. Darnall BD and Suarez EC, “Sex and gender in psychoneuroimmunology research: Past, present and future,” Brain. Behav. Immun, vol. 23, no. 5, pp. 595–604, Jul. 2009, doi: 10.1016/j.bbi.2009.02.019. [PubMed: 19272440]

[31]. Hyde JS, Bigler RS, Joel D, Tate CC, and van Anders SM, “The future of sex and gender in psychology: Five challenges to the gender binary,” Am. Psychol, vol. 74, pp. 171–193, 2019, doi: 10.1037/amp0000307. [PubMed: 30024214]

[32]. Henry JD and Rendell PG, “A review of the impact of pregnancy on memory function,” J. Clin. Exp. Neuropsychol, vol. 29, no. 8, pp. 793–803, Nov. 2007, doi: 10.1080/13803390701612209. [PubMed: 18030631]

[33]. McFarland CP and Vasterling JJ, “Prospective memory in depression: Review of an emerging field,” Arch. Clin. Neuropsychol, vol. 33, no. 7, pp. 912–930, 2018, doi: 10.1093/arclin/acx118. [PubMed: 29228162]

[34]. Gannon OJ, Robison LS, Custozzo AJ, and Zuloaga KL, “Sex differences in risk factors for vascular contributions to cognitive impairment & dementia,” Neurochem. Int, vol. 127, pp. 38–55, Jul. 2019, doi: 10.1016/j.neuint.2018.11.014. [PubMed: 30471324]

[35]. Ullah MF, Ahmad A, Bhat SH, Abu-Duhier FM, Barreto GE, and Ashraf GM, “Impact of sex differences and gender specificity on behavioral characteristics and pathophysiology of neurodegenerative disorders,” Neurosci. Biobehav. Rev, vol. 102, pp. 95–105, Jul. 2019, doi: 10.1016/j.neubiorev.2019.04.003. [PubMed: 30959072]

[36]. Zhu D, Montagne A, and Zhao Z, “Alzheimer’s pathogenic mechanisms and underlying sex difference,” Cell. Mol. Life Sci, vol. 78, no. 11, pp. 4907–4920, Jun. 2021, doi: 10.1007/s00018-021-03830-w. [PubMed: 33844047]

[37]. Nebel RA et al. , “Understanding the impact of sex and gender in Alzheimer’s disease: A call to action,” Alzheimers Dement, vol. 14, no. 9, pp. 1171–1183, 2018, doi: 10.1016/j.jalz.2018.04.008. [PubMed: 29907423]

[38]. Kvavilashvili L and Rummel J, “On the Nature of Everyday Prospection: A Review and Theoretical Integration of Research on Mind-Wandering, Future Thinking, and Prospective Memory,” Rev. Gen. Psychol, vol. 24, no. 3, pp. 210–237, Sep. 2020, doi: 10.1177/1089268020918843.

[39]. Feng L, Wang Y, Zeng D, Wang M, and Duan X, “Predictors of cognitive decline in older individuals without dementia: An updated meta-analysis,” Ann. Clin. Transl. Neurol, vol. 10, no. 4, pp. 497–506, Apr. 2023, doi: 10.1002/acn3.51740. [PubMed: 36705073]

[40]. Shen X-N et al. , “Inflammatory markers in Alzheimer’s disease and mild cognitive impairment: a meta-analysis and systematic review of 170 studies,” J. Neurol. Neurosurg. Psychiatry, vol. 90, no. 5, pp. 590–598, May 2019, doi: 10.1136/jnnp-2018-319148. [PubMed: 30630955]

[41]. Davis KM, Engeland CG, and Murdock KW, “Ex vivo LPS-stimulated cytokine production is associated with cortisol curves in response to acute psychosocial stress,” Psychoneuroendocrinology, vol. 121, p. 104863, Nov. 2020, doi: 10.1016/j.psyneuen.2020.104863. [PubMed: 32950932]

[42]. Prather AA, Carroll JE, Fury JM, McDade KK, Ross D, and Marsland AL, “Gender differences in stimulated cytokine production following acute psychological stress,” Brain. Behav. Immun, vol. 23, no. 5, pp. 622–628, Jul. 2009, doi: 10.1016/j.bbi.2008.11.004. [PubMed: 19070658]

[43]. Mogle J, Muñoz E, Hill NL, Smyth JM, and Sliwinski MJ, “Daily Memory Lapses in Adults: Characterization and Influence on Affect,” J. Gerontol. Ser. B, vol. 74, no. 1, pp. 59–68, Jan. 2019, doi: 10.1093/geronb/gbx012.

[44]. Heinzelmann M and Bosshart H, “Heparin Binds to Lipopolysaccharide (LPS)-Binding Protein, Facilitates the Transfer of LPS to CD14, and Enhances LPS-Induced Activation of Peripheral Blood Monocytes1,” J. Immunol, vol. 174, no. 4, pp. 2280–2287, Feb. 2005, doi: 10.4049/jimmunol.174.4.2280. [PubMed: 15699163]

[45]. Belzeaux R et al. , “How to: Measuring blood cytokines in biological psychiatry using commercially available multiplex immunoassays,” Psychoneuroendocrinology, vol. 75, pp. 72–82, Jan. 2017, doi: 10.1016/j.psyneuen.2016.10.010. [PubMed: 27810706]

[46]. Pilkonis PA, Choi SW, Reise SP, Stover AM, Riley WT, and Cella D, “Item Banks for Measuring Emotional Distress From the Patient-Reported Outcomes Measurement Information System (PROMIS®): Depression, Anxiety, and Anger,” Assessment, vol. 18, no. 3, pp. 263–283, Sep. 2011, doi: 10.1177/1073191111411667. [PubMed: 21697139]

[47]. Graham-Engeland JE et al. , “Negative and positive affect as predictors of inflammation: Timing matters,” Brain. Behav. Immun, vol. 74, pp. 222–230, Nov. 2018, doi: 10.1016/j.bbi.2018.09.011. [PubMed: 30217538]

[48]. Van Bogart K et al. , “The Association Between Loneliness and Inflammation: Findings From an Older Adult Sample,” Front. Behav. Neurosci, vol. 15, 2022, Accessed: Apr. 19, 2023. [Online]. Available: https://www.frontiersin.org/articles/10.3389/fnbeh.2021.801746

[49]. Benjamini Y and Hochberg Y, “Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing,” J. R. Stat. Soc. Ser. B Methodol, vol. 57, no. 1, pp. 289–300, 1995, doi: 10.1111/j.2517-6161.1995.tb02031.x.

[50]. Serre-Miranda C et al. , “Cognition Is Associated With Peripheral Immune Molecules in Healthy Older Adults: A Cross-Sectional Study,” Front. Immunol, vol. 11, 2020, Accessed: Apr. 19, 2023. [Online]. Available: https://www.frontiersin.org/articles/10.3389/fimmu.2020.02045

[51]. Trollor JN et al. , “Systemic Inflammation Is Associated with MCI and Its Subtypes: The Sydney Memory and Aging Study,” Dement. Geriatr. Cogn. Disord, vol. 30, no. 6, pp. 569–578, 2010, doi: 10.1159/000322092. [PubMed: 21252552]

[52]. Iulita MF et al. , “Identification and Preliminary Validation of a Plasma Profile Associated with Cognitive Decline in Dementia and At-Risk Individuals: A Retrospective Cohort Analysis,” J. Alzheimers Dis, vol. 67, no. 1, pp. 327–341, Jan. 2019, doi: 10.3233/JAD-180970. [PubMed: 30636741]

[53]. Engeland CG and Marucha PT, “Wound Healing and Stress,” in Neuroimmunology of the Skin: Basic Science to Clinical Practice, Granstein RD and Luger TA, Eds., Berlin, Heidelberg: Springer, 2009, pp. 233–247. doi: 10.1007/978-3-540-35989-0_21.

[54]. Lee KS, Chung JH, Choi TK, Suh SY, Oh BH, and Hong CH, “Peripheral Cytokines and Chemokines in Alzheimer’s Disease,” Dement. Geriatr. Cogn. Disord, vol. 28, no. 4, pp. 281–287, 2009, doi: 10.1159/000245156. [PubMed: 19828948]

[55]. Sachdev PS, Parslow R, Wen W, Anstey KJ, and Easteal S, “Sex differences in the causes and consequences of white matter hyperintensities,” Neurobiol. Aging, vol. 30, no. 6, pp. 946–956, Jun. 2009, doi: 10.1016/j.neurobiolaging.2007.08.023. [PubMed: 17950492]

[56]. Zhu Y et al. , “Serum IL-8 is a marker of white-matter hyperintensities in patients with Alzheimer’s disease,” Alzheimers Dement. Diagn. Assess. Dis. Monit, vol. 7, no. 1, pp. 41–47, Jan. 2017, doi: 10.1016/j.dadm.2017.01.001.

[57]. Yoon B, Ryu SY, and Yoon SJ, “Prospective Memory Loss and Related White Matter Changes in Patients with Amnestic Mild Cognitive Impairment,” Dement. Neurocognitive Disord, vol. 17, no. 3, p. 120, 2018, doi: 10.12779/dnd.2018.17.3.120.

[58]. Alsadany MA, Shehata HH, Mohamad MI, and Mahfouz RG, “Histone Deacetylases Enzyme, Copper, and IL-8 Levels in Patients With Alzheimer’s Disease,” Am. J. Alzheimers Dis. Dementiasr, vol. 28, no. 1, pp. 54–61, Feb. 2013, doi: 10.1177/1533317512467680.

[59]. Sokolova A, Hill MD, Rahimi F, Warden LA, Halliday GM, and Shepherd CE, “Monocyte Chemoattractant Protein-1 Plays a Dominant Role in the Chronic Inflammation Observed in Alzheimer’s Disease,” Brain Pathol, vol. 19, no. 3, pp. 392–398, 2009, doi: 10.1111/j.1750-3639.2008.00188.x. [PubMed: 18637012]

[60]. Grammas P, Samany PG, and Thirumangalakudi L, “Thrombin and inflammatory proteins are elevated in Alzheimer’s disease microvessels: Implications for disease pathogenesis,” J. Alzheimers Dis, vol. 9, no. 1, pp. 51–58, Jan. 2006, doi: 10.3233/JAD-2006-9105. [PubMed: 16627934]

[61]. Li K, Liu S, Yao S, Wang B, Dai D, and Yao L, “Interaction between Interleukin-8 and Methylenetetrahydrofolate Reductase Genes Modulates Alzheimer’s Disease Risk,” Dement. Geriatr. Cogn. Disord, vol. 27, no. 3, pp. 286–291, 2009, doi: 10.1159/000204766. [PubMed: 19246914]

[62]. Mendelsohn ME and Karas RH, “Molecular and cellular basis of cardiovascular gender differences,” Science, vol. 308, no. 5728, pp. 1583–1587, 2005, doi: 10.1126/science.1112062. [PubMed: 15947175]

[63]. Ahn JN, Haines EL, and Mason MF, “Gender Stereotypes and the Coordination of Mnemonic Work within Heterosexual Couples: Romantic Partners Manage their Daily To-Dos,” Sex Roles, vol. 77, no. 7, pp. 435–452, Oct. 2017, doi: 10.1007/s11199-017-0743-1.

[64]. Moulton-Tetlock EE, Ahn JN, Haines EL, and Mason MF, “Women’s work: Remembering communal goals,” Motiv. Sci, vol. 5, pp. 157–178, 2019, doi: 10.1037/mot0000109.

[65]. Harrington EE and Reese-Melancon C, “Who is Responsible for Remembering? Everyday Prospective Memory Demands in Parenthood,” Sex Roles, vol. 86, no. 3, pp. 189–207, Feb. 2022, doi: 10.1007/s11199-021-01264-z.

[66]. Niedźwieńska A and Zielińska M, “Gender Differences in Remembering about Things to Do Depend on Partnership Status,” Sex Roles, vol. 84, no. 3, pp. 139–151, Feb. 2021, doi: 10.1007/s11199-020-01158-6.

[67]. Schnitzspahn KM, Kvavilashvili L, and Altgassen M, “Redefining the pattern of age-prospective memory-paradox: new insights on age effects in lab-based, naturalistic, and self-assigned tasks,” Psychol. Res, vol. 84, no. 5, pp. 1370–1386, Jul. 2020, doi: 10.1007/s00426-018-1140-2. [PubMed: 30588544]

[68]. Komulainen P et al. , “Serum high sensitivity C-reactive protein and cognitive function in elderly women,” Age Ageing, vol. 36, no. 4, pp. 443–448, Jul. 2007, doi: 10.1093/ageing/afm051. [PubMed: 17537742]

[69]. Schnitzspahn KM et al. , “Age differences in prospective memory for everyday life intentions: A diary approach,” Memory, vol. 24, no. 4, pp. 444–454, Apr. 2016, doi: 10.1080/09658211.2015.1018276. [PubMed: 25750997]

[70]. Anderson FT and McDaniel MA, “Hey buddy, why don’t we take it outside: An experience sampling study of prospective memory,” Mem. Cognit, vol. 47, no. 1, pp. 47–62, Jan. 2019, doi: 10.3758/s13421-018-0849-x.

Highlights:

- Subjective memory reports coupled with biomarkers can inform future pathology risk
- Self-reported prospective memory did not relate to most inflammatory markers
- Higher basal IL-8 related to more prospective memory lapses among men but not women
- Men’s memory lapses and IL-8 levels may suggest risk for cognitive decline

Table 1.

Sociodemographic Characteristics of Participants

	Full Sample (*n* = 231)	Men (*n* = 79)	Women (*n* = 152)
Age (years)	76.9 (4.7)	76.3 (4.7)	77.1 (4.6)
Race/ Ethnicity			
Non-Hispanic, White	109 (47%)	50 (63%)	59 (39%)
African American/ Black	92 (40%)	20 (25%)	72 (47%)
Hispanic, White	21 (9%)	7 (9%)	14 (9%)
Hispanic, Black	6 (2%)	1 (1%)	5 (3%)
Asian	2 (1%)	1 (1%)	1 (1%)
Other	1 (<1%)	0 (0%)	1 (1%)
Marital Status			
Married	76 (33%)	51 (65%)	25 (16%)
Separated	3 (1%)	0 (0%)	3 (2%)
Widowed	56 (24%)	7 (9%)	49 (32%)
Divorced	53 (23%)	9 (11%)	44 (29%)
Never married	43 (19%)	12 (15%)	31 (20%)
Income			
Less than $15,000	23 (10%)	7 (9%)	16 (11%)
Between $15,001 – $30,000	66 (30%)	19 (24%)	51 (34%)
Greater than $30,000	131 (58%)	52 (66%)	81 (53%)
Refused	2 (1%)	1 (1%)	1 (1%)
Don’t Know	2 (1%)	0 (0%)	2 (1%)
Education (years)	15.2 (3.7)	15.3 (3.9)	15.1 (3.5)
Number of Health Conditions	2.3 (1.4)	2.2 (1.4)	2.4 (1.4)
BMI	29.20 (5.94)	28.78 (6.16)	29.41 (5.36)
Depressive Symptoms	11.51 (5.06)	11.93 (5.36)	11.29 (5.36)
PM Lapses	5.48 (6.74)	4.78 (6.64)	5.84 (6.79)

Note. Values represent *M*(*SD*) or *n*(%). Percentages were rounded to the nearest integer. One participant did not provide income information.

Table 2.

Bivariate Associations between Inflammatory Markers and PM Lapses for the Full Sample and by Gender/Sex.

	PM Lapses		
	Full Sample	**Men**	**Women**
Basal Cytokines			
IL-1β	0.04	0.03	0.03
IL-4	−0.01	0.03	−0.04
IL-6	0.05	−0.00	0.07
IL-8	**0.15** *	**0.40** ***	0.02
IL-10	0.04	0.08	0.03
TNF-α	0.00	−0.01	0.02
Stimulated Cytokines			
Stimulated IL-1β	−0.09	−0.08	−0.09
Stimulated IL-4	−0.04	−0.02	−0.01
Stimulated IL-6	−0.05	−0.04	−0.06
Stimulated IL-8	0.02	−0.11	0.07
Stimulated IL-10	0.04	−0.07	0.12
Stimulated TNF-α	−0.00	−0.04	0.04
CRP (mg/L)	−0.10	−0.00	−0.14

Note.

* $p < .05$.

*** $p < .001$.

Table 3.

Gender Stratified Analyses Examining IL-8 and PM Lapses Adjusting for Covariates

	Men			Women		
	Estimate	***SE***	**95% *CI***	**Estimate**	***SE***	**95% *CI***
Count Model						
Intercept	−1.62	2.32	[−6.17, 2.93]	2.34	1.83	[−1.25, 5.94]
Basal IL-8	0.98***	0.28	[0.43, 1.53]	−0.03	0.22	[−0.45, 0.39]
Age	0.03	0.03	[−0.03, 0.08]	−0.02	0.02	[−0.06, 0.02]
Education	−0.06	0.04	[−0.13, 0.01]	0.05	0.03	[−0.01, 0.11]
BMI	−0.00	0.02	[−0.04, 0.04]	−0.04*	0.02	[−0.08, −0.00]
Health Conditions	−0.22*	0.11	[−0.43, −0.00]	0.12	0.07	[−0.02, 0.26]
Depression	0.06*	0.02	[0.01, 0.11]	0.06**	0.02	[0.02, 0.11]
Race/Ethnicity	−0.01	0.28	[−0.56, 0.54]	0.62**	0.20	[0.23, 1.00]
Zero-Inflated Model						
Intercept	−11.88	12.67	[−36.71, 12.95]	−321.58	260.19	[−779.62, 162.42]
Basal IL-8	0.57	1.25	[−1.88, 3.03]	78.17	66.10	[−53.89, 207.27]
Age	0.18	0.15	[−0.10, 0.47]	0.98	1.20	[−1.07, 2.87]
Education	−0.30	0.15	[−0.60, 0.00]	−5.58	5.06	[−15.87, 4.87]
BMI	−0.01	0.13	[−0.26, 0.25]	6.99	5.75	[−4.49, 18.16]
Health Conditions	−1.27	0.78	[−2.80, 0.26]	−35.79	30.29	[−95.86, 25.55]
Depression	0.12	0.10	[−0.08, 0.32]	−0.31	0.96	[−2.14, 1.54]
Race/Ethnicity	0.46	1.48	[−2.44, 3.37]	−19.00	19.67	[−62.19, 23.78]

Note.

* $p < .05$;

** $p < .01$.

*** $p < .001$.