Brain, Behavior, and Immunity 58 (2016) 272–279

Contents lists available at ScienceDirect

Brain, Behavior, and Immunity

journal homepage: www.elsevier.com/locate/ybrbi

Full-length Article

Social role conflict predicts stimulated cytokine production among men, not women

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ARTICLE INFO

Article history:
Received 30 March 2016
Received in revised form 25 July 2016
Accepted 26 July 2016
Available online 27 July 2016

Keywords:
Role conflict
Sex differences
Inflammation
Glucocorticoids

ABSTRACT

Objective: To assess whether perceived role conflict is associated with stimulated pro-inflammatory cytokine production and glucocorticoid sensitivity, and whether these associations are moderated by sex.
Methods: 153 healthy adults (aged 45.8 ± 5.5 years, 78% female) listed their 3 main social roles and indicated the amount of role conflict they perceived between each pair of social roles. Subsequently, participants underwent blood draws and leukocyte response to microbial challenge and glucocorticoid sensitivity were assessed by incubating whole blood with lipopolysaccharide (LPS) in the presence or absence of hydrocortisone. Stimulated levels of Interleukin (IL)-1β, IL-6, IL-8, and tumor necrosis factor alpha (TNFα) were measured.
Results: Multiple regression analyses controlling for sociodemographics revealed significant sex × role conflict interactions for LPS-stimulated production of IL-1β, IL-6, and TNFα (all interaction *ps* < 0.05), and a marginal interaction on LPS-stimulated IL-8 production (interaction $p < 0.10$). Greater perceived role conflict was associated with greater pro-inflammatory cytokine production in response to microbial stimulation only among men, not women. There also were significant sex × role conflict interactions with respect to glucocorticoid sensitivity for IL-1β, IL-6, and TNFα production (all interaction *ps* < 0.05) and a marginal interaction for IL-8 (interaction $p < 0.10$). Greater perceived role conflict was unrelated to glucocorticoid sensitivity among women, but associated with less sensitivity to glucocorticoid signaling among men.
Conclusions: Perceived social role conflict, indicating greater perceived demand across multiple social roles, may take a greater toll on the regulation of inflammatory processes among men compared to women.

1. Introduction

Inhabiting multiple social roles is an integral part of people's lives and finding a successful balance of meaningfully engaging in while simultaneously meeting the demands of different social roles represents an important contributor to a person's well-being. Many studies have focused on the importance of social roles, although definitions, measures, and underlying theories vary greatly across studies. Most notably, the existing literature supports both the idea of role strain (Goode, 1960), which suggests that inhabiting more roles increases demands on the individual and comes at a cost with respect to overall well-being, as well as the idea of role enhancement (Sieber, 1974), which suggests that inhabiting more roles provides a more enriching and gratifying life experience.

The influence of social roles on outcomes related to physical health is understudied and existing findings differ depending on whether quantitative aspects (e.g., the number of social roles) or qualitative aspects (e.g., role conflict) are being considered. With respect to quantity, having more social roles is typically associated with health benefits, including reduced mortality risk over a 15-year period (Tamakoshi et al., 2013) and lower risk of chronic illness and need for prolonged medication use due to chronic illness (Nordenmark, 2004). Perhaps this indicates that people with more social roles are better integrated socially or have a greater sense of purpose in life (Uchino, 2006; Berkman et al., 2000). Several studies that focused on women have also found that a greater number of social roles is associated with better overall self-reported health (Collijn et al., 1996), lower prevalence of

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http://dx.doi.org/10.1016/j.bbi.2016.07.156
0889-1591/

common health symptoms and chronic diseases (Lee and Powers, 2002), and lower risk of long-term sickness absence at work (Staland Nyman et al., 2012). Moreover, at least one study finds that the association between social roles and self-reported health is not explained by selection effects of those who are in better health being able to take on multiple roles (McMunn et al., 2006). However, it is important to note that studies focusing on the effects of an individual's number of social roles are often limited by focusing on a select number of specific roles – that is, being a spouse, parent, and employee.

Other studies have linked qualitative aspects of social roles to health – for example, perceptions of role conflict – that is, the extent to which the responsibilities and demands associated with particular roles interfere with individuals' abilities to fulfill the (at times competing) demands of other roles. Two studies focused on women linked greater levels of role conflict to poorer mental health and general health symptoms (Hecht, 2001; Oster and Scannell, 1999). In addition, one study focusing on physicians found that greater role conflict was associated with greater somatic complaints (Pomaki et al., 2007). These associations may be due to conflicting demands across roles resulting in higher levels of ongoing chronic stress for the individual experiencing role conflict (Terrill et al., 2012).

Shortcomings in most of these studies include the fact that participants are not provided with the opportunity to list their most important roles themselves, that previous studies have mostly focused on women, and that they have relied on self-reported health measures. With respect to the first, the frequently used coding of participants as spouse, parent, and employee is overly simplistic and problematic in that it focuses only on a small number of prescribed roles and assumes that these indeed are the most relevant to all participants in the study. Although this may be true for many, it is possible that participants would have chosen to include other social roles as being among the most meaningful to them, e.g., 'friend' or 'athlete'. Similarly, this approach is overly simplistic in that it does not take into account the perceived quality of a role, i.e. how much individuals enjoy acting in a particular role, nor does it take into account how the demands of individual roles relate to each other. These are all aspects of social roles that have been shown to have effects on outcomes related to mental and physical health (Perrone and Civiletto, 2004; Plach, 2007; Plaisier et al., 2008; Reid and Hardy, 1999). Hence, letting participants spontaneously identify the most important roles they inhabit themselves and asking them to indicate perceived role conflict across these roles may result in a more valid assessment of roles and role conflict.

In addition, many of the studies investigating the influence of social roles on health outcomes have focused exclusively on women e.g., (Lee and Powers, 2002; McMunn et al., 2006; Staland Nyman et al., 2012). Two exceptions include the large-scale studies discussed above that reported an association between social roles and mortality and risk of chronic illnesses in a sample that included both men and women (Tamakoshi et al., 2013; Nordenmark, 2004). Another study found that multiple social roles were beneficial with respect to self-reported health among women but unrelated to self-reported health among men (Janzen and Muhajarine, 2003). Hence more research comparing the association between social roles and health across both men and women is needed to investigate whether patterns are similar across gender, especially in light of other research suggesting differing associations between psychosocial variables, such as social network support, and health among men and women (Shumaker and Hill, 1991; Shye et al., 1995).

Lastly, although some studies have addressed the links between social roles and health, most have focused on self-reported prevalence of symptoms, chronic illness, and general health. To our knowledge, no studies have examined the links between social roles and underlying physiological mechanisms that may help explain how and why social roles are associated with clinical health outcomes. Consequently, the present study focused on inflammation mechanisms by assessing the relations between perceived role conflict and *in vitro* production of pro-inflammatory cytokines following bacterial stimulation of immune cells, as well as on *in vitro* measures of glucocorticoid sensitivity. Greater pro-inflammatory responses to microbial challenge, and/or reduced glucocorticoid sensitivity, are indicative of poorer regulation of inflammatory processes, and if maintained over the long-term may increase risk for diseases involving inflammation. Taking advantage of *ex vivo* microbial challenge allows for the evaluation of the functional properties of monocytes under controlled conditions that could not ethically be performed *in vivo*, and as such provides important insights into important aspects of immune functioning. Previous studies have shown increased stimulated pro-inflammatory responses to bacterial challenge as well as reduced glucocorticoid sensitivity in response to other types of stressful life situations (Glaser and Kiecolt-Glaser, 2005; Miller et al., 2009, 2014).

In sum, the focus of the present study was to investigate the links between perceived role conflict (based on participant self-report of their most important social roles) and inflammatory outcomes including stimulated pro-inflammatory cytokine production in response to bacterial stimuli, as well as sensitivity of immune cells to glucocorticoid inhibition. We also tested moderating effects of sex to expand on the existing literature which has largely focused on evaluating the effects of social role conflict among women only and, when comparing men and women, has found contradictory effects. We hypothesized that greater perceived role conflict would be associated with heightened pro-inflammatory cytokine responses to bacterial stimuli and less sensitivity to the anti-inflammatory properties of cortisol. Given that existing studies have linked social roles in general as well as role conflict specifically to health-related outcomes among women (rather than men), we furthermore hypothesized that role conflict would more strongly predict pro-inflammatory cytokine responses and glucocorticoid sensitivity among women compared to men.

2. Methods

2.1. Participants

Participants were 153 healthy adults (aged 45.8 ± 5.5 years, 78% female) recruited as part of a larger study focused on adolescents and their families. The present analyses focused on participating parents. For this community-based sample, participating families were invited to participate with one adolescent child and either parent. In most cases mothers chose to participate. All participants were recruited through advertisements in the local media in the larger Vancouver, BC area between January 2010 and March 2012. To be eligible for participation, individuals had to be healthy, fluent in English, and the parent of an adolescent child between the ages of 13–16. Eligible individuals interested in participating in the study came to the laboratory for a late afternoon visit. Participants reporting an acute illness prior to their scheduled visit were rescheduled for four weeks after the end of symptoms. Participants came from a range of socioeconomic and racial/ethnic backgrounds (see Table 1 for participant characteristics), representative of the region.

2.2. Procedure

Participants arrived at the laboratory for late afternoon visits, were briefed on study procedures, and provided written consent.

Table 1
Participant characteristics.

	n (%)	M (SD)
N = 153		
Male	33 (21.6)	
Female	120 (78.4)	
Age (years)		46.0 (5.33)
Ethnicity		
Caucasian	98 (64.1)	
Asian	42 (27.5)	
'Other'	13 (8.5)	
Marital status		
Married/living together	108 (70.6)	
Single	18 (11.8)	
Divorced/Widowed	27 (17.7)	
Family income		
<$5000	2 (1.3)	
$5000–$19,999	7 (4.6)	
$20,000–$34,999	13 (8.5)	
$35,000–$49,999	17 (11.1)	
$50,000–$74,999	35 (22.9)	
$75,000–$99,999	17 (11.1)	
$100,000–$149,999	30 (19.6)	
$150,000–$199,999	20 (13.1)	
>$200,000	11 (7.2)	
BMI		25.20 (4.52)
Average perceived role conflict		3.80 (1.55)
Inflammatory markers (pg/ml; log)		
LPS only		
IL-1β		3.74 (0.36)
IL-6		4.48 (0.18)
IL-8		4.15 (0.29)
TNFα		4.13 (0.24)
LPS and hydrocortisone		
IL-1β		3.55 (0.38)
IL-6		4.42 (0.20)
IL-8		4.12 (0.27)
TNFα		4.02 (0.25)

Note: Independent samples t-tests and Pearson chi-square tests showed that men were significantly older [$t(151) = -2.011$, $p = 0.046$] and had greater BMIs [$t(150) = -2.219$, $p = 0.028$] than women. Men also had significantly higher levels of hydrocortisone-stimulated IL-1β than women [$t(151) = 3.244$, $p = 0.001$]. Men and women did not differ with respect to any other variable listed in the table.
BMI = body mass index; IL = interleukin; TNF = tumor necrosis factor.

Parent demographic information was assessed in an interview by a trained research assistant. Subsequently, participants were asked about their most important social roles and extent of role conflict between these roles. Lastly, participants underwent a peripheral blood draw through antecubital venipuncture by a trained phlebotomist. All participants were reimbursed for their time and effort and the study was approved by the research ethics board of the University of British Columbia.

2.3. Measures

2.3.1. Role conflict

Participants were asked to list the three most important social roles they felt they were occupying in any order (e.g., parent; spouse; friend). Next, participants were asked to indicate the extent to which they felt their social roles conflicted with each other, i.e. the extent to which they felt pulled in different directions by the demands associated with particular roles or the extent to which responsibilities associated with one role interfered with their ability to meet responsibilities associated with another role, on a diagram depicting sets of incrementally overlapping circles (see Fig. 1). Participants indicated role conflict for each of the three pairs of previously mentioned roles, each on a separate diagram (i.e., each participant was presented with three copies of the diagram). Selections were scored from 1 (selecting completely non-overlapping circles, indicating no role conflict) to 9 (selecting completely overlapping circles, indicating the greatest role conflict) and overall role conflict was computed as the average score based on all three selections. All participants easily identified three social roles. To examine the validity of this approach we assessed the link between chronic work-related stress (assessed through a semi-structured life stress interview (Hammen, 1991) and role conflict (considering only role conflict ratings that involved a work role). These analyses suggest that greater chronic work-related stress was associated with marginally greater role conflict ($B = 0.501$, $SE = 0.261$, $p = 0.060$).

2.3.2. Inflammatory parameters

Participants' peripheral whole blood was drawn into sodium-heparin Vacutainer tubes (Becton-Dickinson) and diluted in a 10:1 ratio with saline. Two aspects of inflammation were subsequently assessed by culturing cells as described in the subsequent two sections. Following cell culture and incubation, supernatants were collected and frozen at −30 °C until further analysis. Interleukin-1beta (IL-1β), IL-6, IL-8, and tumor necrosis factor alpha (TNFα) were measured in duplicate using MSD Meso Scale Discovery Human ProInflammatory 7-Plex Base Kits (MSD, Rockville, MD) with a minimum detection threshold of 0.15 pg/ml. Inter- and intra-assay CVs were below 10%.

2.3.2.1. Pro-inflammatory response to microbial stimulation. To measure participants' white blood cells' responses to microbial challenge, diluted blood was incubated with lipopolysaccharide (LPS; 50 ng/ml; Sigma, St Louis, MO), a bacterial stimulus that causes cells to secrete cytokines, for 6 h at 37 °C in 5% carbon dioxide. Although an acute inflammatory response to a stimulus such as LPS can represent an appropriate reaction to threats such as infections or injuries, heightened responses may be indicative of a pro-inflammatory phenotype that can increase the risk of future chronic diseases. By culturing cells with a fixed dose of LPS we are able to measure the magnitude of the inflammatory response mounted by our participants' white blood cells. Greater LPS-stimulated pro-inflammatory cytokine production, as indicated by higher cytokine values, suggests a more aggressive response to microbial challenge.

2.3.2.2. Glucocorticoid sensitivity. To assess glucocorticoid sensitivity in our participants, diluted whole blood was cultured with LPS and hydrocortisone (final concentration: 2.76×10^{-7} mol/L) for 6 h at 37 °C in 5% carbon dioxide. Cortisol represents a key mechanism in the regulation of inflammatory responses. Stimulating cells with LPS in the presence of hydrocortisone provides an indication of how sensitive white blood cells are to the anti-inflammatory messages of cortisol and thus is considered a measure of glucocorticoid sensitivity. Greater cytokine production when cells are incubated with both LPS and cortisol indicates that cells are less sensitive to glucocorticoid signaling.

2.3.3. Covariates

Participants self-reported their age, sex, race/ethnicity, marital status, and family income. Family income was indicated on a 9-point scale ranging from 'less than $5000' to '$200,000 and higher'. Dummy variables were created to compare participants of European origin to participants of Asian or 'Other' origin and to compare married individuals to single and divorced/separated individuals. Participants' height and weight was measured using a medical-grade scale without outerwear and shoes and body mass index (BMI) was computed as weight in kilograms divided by height in meters squared.

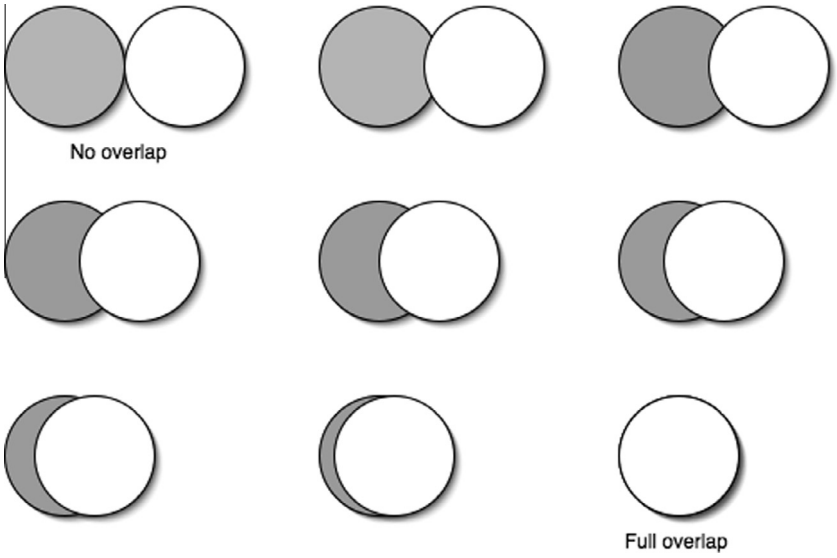

Fig. 1. Diagram used to assess perceived social role conflict between individual pairs of roles, scored from 1 (no overlap, minimal role conflict) to 9 (complete overlap, maximal role conflict).

Table 2
Most commonly reported social roles by participant sex.

	Women (n = 120)		Men (n = 33)	
Information on reported social roles in general				
Types of roles from most to least common	Family	69.7%	Family	66.7%
	Social	14.7%	Professional	15.2%
	Professional	12.2%	Social	11.1%
	Leisure	2.2%	Leisure	5.1%
	Organizational	1.1%	Organizational	2.0%
Most common combinations of role types[a]	Family/Family/Family	29.2%	Family/Family/Professional	27.3%
	Family/Family/Professional	23.3%	Family/Family/Family	21.2%
	Family/Family/Social	23.3%	Family/Family/Social	18.2%
	Family/Social/Professional	11.7%	Family/Social/Professional	12.1%
Information on reported family roles in particular				
Types of *family roles*, from most to least common	Parent	47.8%	Parent	50.0%
	Spouse	27.9%	Spouse	36.4%
	Daughter	16.7%	Son	9.1%
	Sibling	6.4%	Provider	3.0%
	Grandparent	1.2%	Uncle	1.5%
Most common combinations of *3 family roles*[*b]	Parent/spouse/daughter	62.9%	Parent/spouse/son	66.7%
	Parent/spouse/sibling	22.9%	Parent/spouse/uncle	16.7%
	Parent/daughter/sibling	8.6%	Parent/spouse/provider	16.7%
Most common combinations of *2 family roles*[**c]	Parent/spouse	60.7%	Parent/spouse	85.7%
	Parent/daughter	27.9%	Parent/son	9.5%
	Parent/sibling	8.2%		

[*] *Note:* Percentages presented in this section of the table reflect percentages among those participants who reported 3 family roles.
[**] *Note:* Percentages presented in this section of the table reflect percentages among those participants who reported 2 family roles.
[a] Six other combinations of social roles were reported but occurred at frequencies of <7%.
[b] Two other combinations of family roles were reported but made up fewer than <5% of listed family-only combinations (three family roles).
[c] Two other combinations of family roles were reported but made up fewer than <5% of listed family-only combinations (two family roles).

2.4. Analyses

Values of stimulated cytokines were not normally distributed and consequently were log transformed to reduce skewness. All analyses controlled for the covariates listed in the above section. Hierarchical linear regression analyses were used to investigate main effects and two-way interaction effects between role conflict and sex on stimulated cytokine production. Variables were centered at zero and the interaction term between role conflict (centered at 0) and participant sex (0 = female, 1 = male) computed by multiplying the two centered variables, following the guidelines of Aiken and West (Aiken and West, 1996). In the first step of the analyses, covariates were controlled for and role conflict and participant sex entered as main effects. In the second step of the analyses, the role conflict × sex interaction term was entered. All analyses were performed using SPSS version 18.0 (IBM, New York, NY).

3. Results

Of the 459 roles reported across all participants, 317 (69.1%) roles pertained to family life (e.g., 'father', 'daughter', 'spouse');

[1] After additionally controlling for the number of hours worked/week all main effect and interaction effect results remained unchanged with the exception that the perceived role conflict × sex interaction predicting LPS-stimulated IL-6 production became significant (B = 0.054, SE = 0.025, p = 0.034) and the perceived role conflict × sex interaction predicting LPS + hydrocortisone stimulated IL-8 production dropped below significance (B = 0.062, SE = 0.039, p = 0.115).

64 (13.9%) roles pertained to participants' social life (e.g., 'friend'); 59 (12.9%) roles pertained to participants' professional life (e.g., 'employee'); 13 (2.8%) roles pertained to leisure activities (e.g., 'athlete'); 6 (1.3%) roles pertained to involvement with organizations (e.g., 'volunteer'). Men and women did not differ with respect to the types of roles they reported (all *p*s > 0.10) but the most commonly reported roles by sex are listed in Table 2.

The majority of participants (n = 125, 82%) were employed at the time of study participation. Men and women were equally likely to be employed ($\chi^2(1) = 0.279$, p > 0.50), although women worked on average fewer hours than men (30.7 vs. 41.3 h/week; t[122] = −4.263, p < 0.01).[1]

3.1. Role conflict and cytokine responses to microbial stimulation

There were no main effects of perceived role conflict on levels of LPS-stimulated production of any cytokine (all *p*s > 0.10). Parent sex was significantly associated with LPS-stimulated production of IL-1β (B = −0.146, SE = 0.074, p = 0.049), such that men's levels were lower, and not associated with LPS-stimulated production of all other pro-inflammatory cytokines (*p*s > 0.40). There was evidence of role conflict × sex interactions with respect to LPS-stimulated pro-inflammatory cytokine production (Table 3). Specifically, there were significant role conflict × sex interactions for LPS-stimulated production of IL-1β (interaction: B = 0.111, SE = 0.050, *p* = 0.027), IL-6 (interaction: B = 0.055, SE = 0.025, *p* = 0.030), and TNFα (interaction: B = 0.089, SE = 0.033, *p* = 0.009), and a marginal interaction for IL-8 (interaction: B = 0.071, SE = 0.042, *p* = 0.090). See Table 3.

In stratified analyses by sex to clarify these interactions, role conflict was unrelated to stimulated pro-inflammatory cytokine production among women (all *p*s > 0.30). Among men, however, role conflict was positively associated with pro-inflammatory cytokine production. Specifically, greater perceived role conflict was significantly associated with greater LPS-stimulated IL-1β (B = 0.103, SE = 0.033, *p* = 0.004) and TNFα production (B = 0.073, SE = 0.022, *p* = 0.003) and marginally associated with greater LPS-stimulated IL-6 (B = 0.037, SE = 0.018, *p* = 0.055) and IL-8 production (B = 0.055, SE = 0.029, *p* = 0.069) among men. See Fig. 2.

3.2. Role conflict and glucocorticoid sensitivity

There were no main effects of perceived role conflict on glucocorticoid sensitivity (all *p*s > 0.10). Parent sex was significantly associated with LPS + hydrocortisone-stimulated IL-1β (B = −0.329, SE = 0.076, *p* < 0.001) and TNFα production (B = −0.1090, SE = 0.052, *p* = 0.038), such that men's levels were lower. Parent sex was not associated with LPS + hydrocortisone-stimulated IL-6 and IL-8 production (*p*s > 0.10). Again there was evidence of role conflict × sex interactions (Table 4). There were significant role conflict × sex interactions for IL-1β (B = 0.129, SE = 0.051, *p* = 0.012), IL-6 (B = 0.075, SE = 0.028, *p* = 0.008), and TNFα (B = 0.090, SE = 0.035, *p* = 0.011) cytokine responses, and a marginal interaction for IL-8 cytokine responses (B = 0.066, SE = 0.039, *p* = 0.092).

Table 3
Hierarchical multiple regression analyses of perceived role conflict and sex interaction on pro-inflammatory cytokine production.

	B	SE	*p*
IL-6			
Intercept	**4.472**	**0.017**	**<0.001**
Age	0.001	0.003	0.776
Sex	0.019	0.037	0.606
White vs. Asian	0.004	0.034	0.902
White vs. 'Other'	**−0.112**	**0.054**	**0.041**
Married vs. Single	−0.032	0.052	0.534
Married vs. Divorced	−0.012	0.041	0.777
BMI	0.006	0.003	0.055
Income	0.000	0.008	0.972
Role Conflict	−0.010	0.011	0.358
Sex × Role Conflict	**0.055**	**0.025**	**0.030**
IL-8			
Intercept	**4.147**	**0.028**	**<0.001**
Age	−0.001	0.005	0.889
Sex	0.034	0.062	0.578
White vs. Asian	0.062	0.056	0.266
White vs. 'Other'	−0.057	0.090	0.527
Married vs. Single	0.029	0.086	0.735
Married vs. Divorced	0.040	0.068	0.556
BMI	**0.012**	**0.005**	**0.025**
Income	−0.011	0.014	0.416
Role Conflict	0.004	0.018	0.835
Sex × Role Conflict	0.071	0.042	0.090
IL-1β			
Intercept	**3.761**	**0.033**	**<0.001**
Age	−0.001	0.006	0.856
Sex	**−0.146**	**0.074**	**0.049**
White vs. Asian	**−0.222**	**0.067**	**0.001**
White vs. 'Other'	−0.179	0.107	0.097
Married vs. Single	−0.138	0.103	0.181
Married vs. Divorced	−0.042	0.081	0.600
BMI	0.011	0.006	0.078
Income	−0.022	0.017	0.193
Role Conflict	0.004	0.021	0.856
Sex × Role Conflict	**0.111**	**0.050**	**0.027**
TNFα			
Intercept	**4.112**	**0.022**	**<0.001**
Age	0.005	0.004	0.213
Sex	0.037	0.050	0.463
White vs. Asian	−0.015	0.045	0.745
White vs. 'Other'	−0.111	0.072	0.128
Married vs. Single	0.008	0.069	0.904
Married vs. Divorced	−0.023	0.054	0.669
BMI	0.006	0.004	0.168
Income	−0.004	0.011	0.696
Role Conflict	−0.009	0.014	0.525
Sex × Role Conflict	**0.089**	**0.033**	**0.009**

BMI = body mass index.
Bold values indicate $p < 0.050$.

In stratified analyses by sex, role conflict was unrelated to glucocorticoid sensitivity among women (all *p*s > 0.30).[2] Among men, however, role conflict was positively associated with glucocorticoid sensitivity. Specifically, greater perceived role conflict was significantly associated with greater IL-1β (B = 0.122, SE = 0.037, *p* = 0.003), IL-6 (B = 0.053, SE = 0.021, *p* = 0.019), IL-8 (B = 0.050, SE = 0.024, *p* = 0.048), and TNFα (B = 0.068, SE = 0.021, *p* = 0.003) cytokine responses.[3] These patterns indicate that even in the presence of cortisol, the leukocytes of men experiencing greater role conflict were continuing to produce greater pro-inflammatory cytokines, in line with these cells displaying less glucocorticoid sensitivity.

[1] After additionally controlling for the number of hours worked/week all main effect and interaction effect results remained unchanged with the exception that the perceived role conflict × sex interaction predicting LPS-stimulated IL-6 production became significant (B = 0.054, SE = 0.025, p = 0.034) and the perceived role conflict × sex interaction predicting LPS + hydrocortisone stimulated IL-8 production dropped below significance (B = 0.062, SE = 0.039, p = 0.115).

[2] We also ran exploratory analyses to examine whether, among women, results varied depending on which of the most three common combinations of roles women reported. Role conflict continued to be unrelated to both cytokine responses to microbial stimulation and glucocorticoid sensitivity in all models, suggesting that no one combination of roles was associated with our outcomes of interest (all *p*s > 0.05).

[3] After additionally controlling for depressive symptoms all reported associations between perceived role conflict and cytokine responses to microbial stimulation as well as glucocorticoid sensitivity among men remained significant.

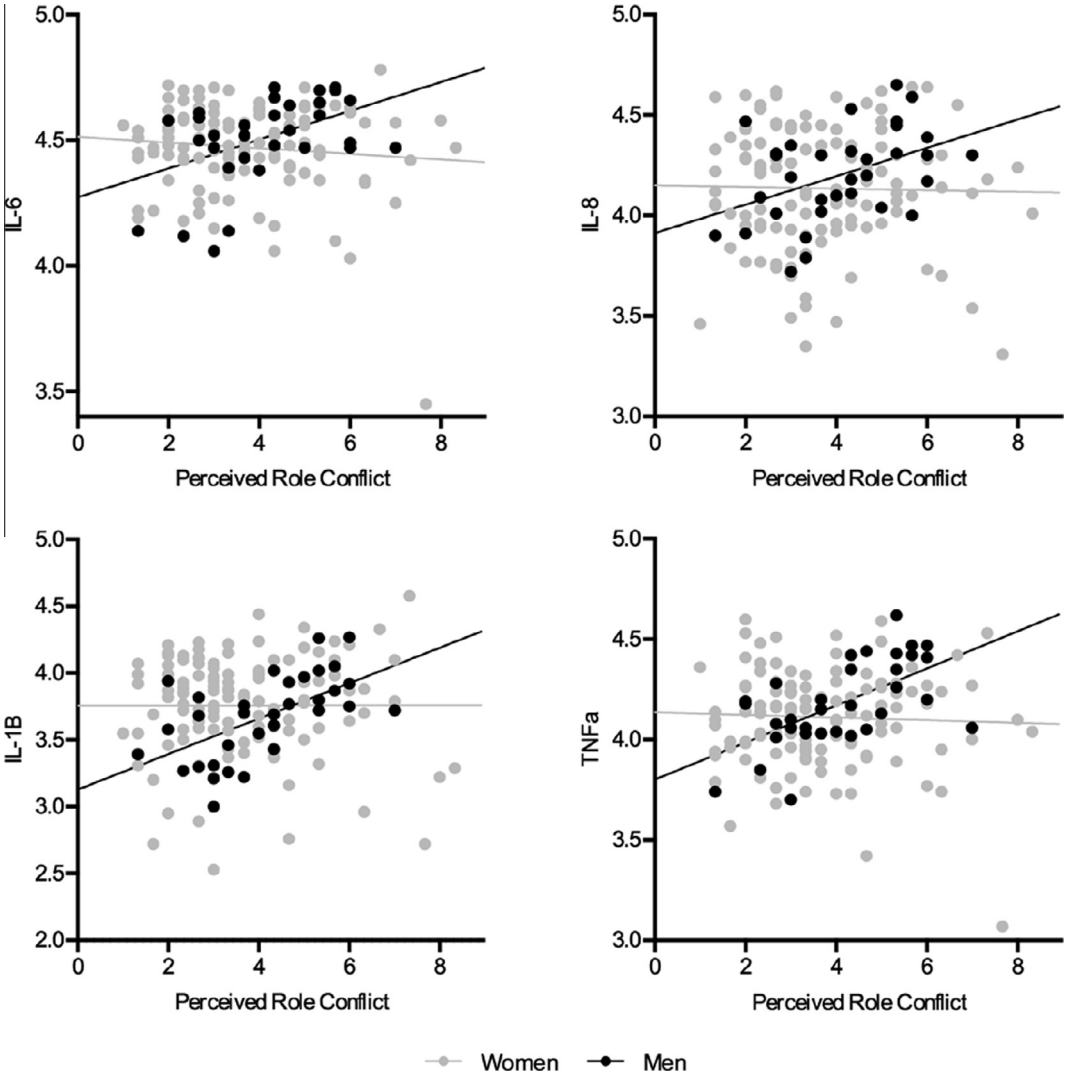

Fig. 2. Association between perceived role conflict and lipopolysaccharide-stimulated pro-inflammatory cytokine production among men and women. *Note:* Among women, role conflict was unrelated to stimulated pro-inflammatory cytokine production (all *p*s > 0.30). Among men, greater perceived role conflict was significantly associated with greater LPS-stimulated IL-1β (B = 0.103, SE = 0.033, $p = 0.004$) and TNFα production (B = 0.073, SE = 0.022, $p = 0.003$) and marginally associated with greater LPS-stimulated IL-6 (B = 0.037, SE = 0.018, $p = 0.055$) and IL-8 production (B = 0.055, SE = 0.029, $p = 0.069$). All graphs depict log-transformed levels of cytokine concentrations in pg/ml. Seven participants reported perceived role conflict scores between 2 and 3 standard deviations above the mean; exclusion of these participants did not change the results and they were kept in the analyses.

4. Discussion

To our knowledge, this is the first study to show an association between perceived role conflict and inflammatory processes including pro-inflammatory cytokine production in response to microbial challenge and glucocorticoid sensitivity. Specifically, we found that, among men, greater role conflict was associated with greater LPS-stimulated pro-inflammatory cytokine production, and as well with lower sensitivity of immune cells to the inhibitory properties of cortisol. These effects persisted after controlling for depressive symptoms. Although several studies have previously reported associations between role conflict and health, such as increased reports of health symptoms, chronic illness, and mortality risk (Tamakoshi et al., 2013; Nordenmark, 2004), the underlying biological mechanisms linking role conflict to these outcomes are not understood. Our findings suggest that one reason why greater social role conflict may be associated with these types of clinical health outcomes is via an enhanced pro-inflammatory cytokine response to bacterial stimuli, coupled with a decreased sensitivity to the anti-inflammatory properties of cortisol in the context of high perceived role conflict.

Intriguingly, we only found significant associations between perceived role conflict and pro-inflammatory cytokine production among men, but not women. This is particularly surprising as it has been theorized that role conflict may create greater chronic stress in women's lives (Terrill et al., 2012), thus ultimately leading to poorer health outcomes. Importantly, previous research on the effects of role conflict in women has not examined effects on underlying physiological processes but reports effects on somatic complaints and psychological well-being (Hecht, 2001; Oster and Scannell, 1999). As there are well-documented effects on the link between psychological well-being and somatic complaints, even in the absence of underlying physiological dysregulation, it is possible that women report greater somatic complaints in response to greater role conflict, but that this does not necessarily translate into heightened inflammatory profiles.

In addition, much literature focuses on the impact of role conflict among individuals juggling both work and family lives

Table 4
Hierarchical multiple regression analyses of perceived role conflict and sex interaction on glucocorticoid sensitivity.

	B	SE	*p*
IL-6			
Intercept	**4.429**	**0.019**	**<0.001**
Age	0.002	0.003	0.446
Sex	−0.068	0.041	0.100
White vs. Asian	0.002	0.037	0.959
White vs. 'Other'	−0.077	0.060	0.205
Married vs. Single	**−0.137**	**0.058**	**0.019**
Married vs. Divorced	−0.017	0.045	0.706
BMI	0.004	0.004	0.241
Income	−0.011	0.009	0.251
Role Conflict	−0.010	0.012	0.399
Sex × Role Conflict	**0.075**	**0.028**	**0.008**
IL-8			
Intercept	**4.137**	**0.026**	**<0.001**
Age	−0.001	0.004	0.903
Sex	−0.076	0.058	0.190
White vs. Asian	0.005	0.052	0.923
White vs. 'Other'	−0.035	0.084	0.675
Married vs. Single	−0.087	0.081	0.284
Married vs. Divorced	0.038	0.063	0.550
BMI	0.010	0.005	0.054
Income	**−0.026**	**0.013**	**0.050**
Role Conflict	−0.002	0.016	0.922
Sex × Role Conflict	0.066	0.039	0.092
IL-1β			
Intercept	**3.618**	**0.034**	**<0.001**
Age	0.001	0.006	0.921
Sex	**−0.329**	**0.076**	**<0.001**
White vs. Asian	**−0.160**	**0.069**	**0.021**
White vs. 'Other'	−0.160	0.111	0.149
Married vs. Single	**−0.234**	**0.106**	**0.029**
Married vs. Divorced	−0.050	0.083	0.546
BMI	0.008	0.007	0.224
Income	**−0.039**	**0.017**	**0.024**
Role Conflict	0.004	0.022	0.859
Sex × Role Conflict	**0.129**	**0.051**	**0.012**
TNFα			
Intercept	**4.035**	**0.023**	**<0.001**
Age	0.005	0.004	0.222
Sex	**−0.109**	**0.052**	**0.038**
White vs. Asian	−0.003	0.047	0.942
White vs. 'Other'	−0.084	0.076	0.270
Married vs. Single	−0.104	0.073	0.156
Married vs. Divorced	−0.003	0.057	0.962
BMI	0.004	0.005	0.370
Income	−0.017	0.012	0.159
Role Conflict	−0.014	0.015	0.361
Sex × Role Conflict	**0.090**	**0.035**	**0.011**

BMI = body mass index.
Bold values indicate $p < 0.050$.

(Elliott, 2003; Gordon et al., 2011; Higgins et al., 2010; Morris and Levine, 2004; Scharlach, 2001), and much of this research has focused solely on women and on mental health outcomes, meaning that possible effects among men and on physiological outcomes are understudied. Nonetheless, it is somewhat surprising that we did not find associations between perceived role conflict and inflammatory responses among women. Below we speculate about some possible reasons why.

The observed sex differences in the present study may be a function of several different processes. For example, it is possible that women are more likely to grow up expecting to have to juggle multiple roles during adulthood. In fact several studies show that young women are more likely than young men to have thought of and to anticipate having to one day balance family and work roles (Baber and Monaghan, 1988; Cinamon, 2006; Friedman and Weissbrod, 2005). By being socialized to expect multiple roles, women may be more prepared to effectively deal with, and hence be less physiologically responsive to, role conflict when it arises. Women's need to juggle multiple roles (family and work roles in particular) is an often-discussed issue and the subject of multiple books, suggesting that women may have substantial access to both informational support as well as social support from their networks for role conflict. In comparison, men may find fewer resources and less support available to help them manage such situations effectively.

Another possibility is that the extent to which people enjoy acting in a particular role may moderate the detrimental effects of perceived role conflict. For example, it is possible that women derive greater satisfaction from the roles they reported, and that this enjoyment mitigated relationships between role conflict and inflammatory responses.

This study has several strengths, most notably the fact that our participants themselves nominated the most important social roles in their lives (rather than simply being coded for marital and employment status and parenthood) and our ability to examine the association between perceived role conflict and more in-depth inflammatory processes including stimulated pro-inflammatory cytokine production as well as glucocorticoid sensitivity. In addition, by considering average role conflict across three pairs of roles we were able to capture perceived role conflict more broadly, which is relevant as people act in multiple social roles throughout their everyday lives and the consideration of role conflict between just two roles may be overly simplistic.

Limitations include the fact that this study was cross-sectional and hence does not allow for conclusions about causality or directionality, nor can it address the possible longer-term consequences of greater pro-inflammatory responses and lower glucocorticoid sensitivity among men. In addition, although we were able to assess the influence of perceived role conflict on stimulated pro-inflammatory cytokine production and glucocorticoid sensitivity, these are *in vitro* assays that may differ from *in vivo* inflammatory processes and that are difficult to discern the clinical significance of. We also note that even though we were able to ask participants to report their most important social roles from their own point of view, we did not have information on the extent to which participants enjoyed particular roles and how rewarding their social roles were to them. Finally, some limitations with respect to our sample apply. First, given that roughly three quarters of participating parents in the study were mothers, the sample of men included in this study was small and hence our findings could be tenuous and need to be replicated in a larger sample of men. Nonetheless, our convergent findings across four different pro-inflammatory cytokines increase our confidence in these findings. Second, our sample was restricted to parents of teenage children. Consequently, virtually all participants listed at least one family role and our findings may not generalize to adults without children or with children in different life stages, as parenting teenagers involves a particular set of challenges (Anderson, 2008; Steinberg and Silk, 2002). Similarly, our sample may be biased towards men who value being involved in family life more highly, as indicated by their study participation together with a child of theirs.

Future research should continue to explore links between perceived social roles and health in greater detail, especially the nuances of how people perceive their different roles (e.g., perceived enjoyment and meaning). Mechanisms underlying the sex differences found in the present study should also be explored further. These include probing psychosocial explanations such as sex differences in social support and expectations about roles. In addition, future studies may want to assess experiences of role conflict on a day-to-day basis, rather than asking participants about experiences of role conflict in general. Information regarding daily fluctuations in perceived role conflict and diurnal variations in physiological markers (e.g., salivary cortisol) may provide

additional insights into the mechanisms connecting perceived role conflict and physiological mechanisms. Lastly, participants in the present study had no difficulty identifying the three most important social roles in their life, and hence researchers may want to expand the number of social roles they inquire about in future studies.

4.1. Conclusions

Our findings suggest that perceived role conflict is related to processes involved in the regulation of inflammation, such as pro-inflammatory cytokine production in response to a microbial stimulus and glucocorticoid sensitivity, in men. If sustained over the long-term, this type of pro-inflammatory phenotype may have the potential to increase risk for chronic diseases of aging. Although the reasons for why men may be uniquely vulnerable to the adverse effects of perceived role conflict are not yet understood, these findings nonetheless have important implications. For example, our results may mean that although, or perhaps because, women are more likely to be perceived as struggling with balancing multiple roles in their lives, they may be less sensitive to the negative physiological consequences, perhaps because they also have access to more support and resources. This may indicate a need for greater support aimed specifically at fathers to help them successfully manage conflicting demands across multiple social roles in their lives.

Conflict of interest and source of funding

The authors report no conflict of interest. This study was funded by the Canadian Institutes of Health Research (grant funding reference number: 97872; EC).

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