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Women's leadership in academic medicine: A systematic review of extent, condition, and interventions.

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Abstract

Objective

Because culture reflects leadership, the making of diverse and inclusive medical schools begins with diversity amongst leaders. Particularly, the inclusion of women leaders remains elusive, warranting a systematic exploration of scholarship in this area. We specifically ask: 1) What is the extent of women's leadership in academic medicine? 2) What factors influence women's leadership? 3)What is the impact of leadership development programs on women's individual careers and on medical schools' environments?

Method

Searches were conducted through Ovid MEDLINE, EMBASE, CINAHL, PsycINFO, the Cochrane Library, and ERIC databases from the earliest date to April 2018. All English quantitative studies exploring women's attainment of leadership positions, investigating perceptions of women's leadership amongst faculty members, and documenting leadership development programs were identified.

Results

The search resulted in 4024 citations. Review of the abstracts led to the retrieval of 93 full-text articles. Thirty-four studies reported in 36 articles were included in the review. Twenty were cross-sectional studies including 1 case report, 9 cohort, 5 pre/post interventions; 25 (74%) were conducted in more than 3 institutes, and 9 (26%) were conducted at only 1 institute. Of the included studies, 18 (53%) utilized questionnaires with response rates ranging from 34% to 100%, with many not validated properly. Fewer than 50% of women took on leadership positions. Women's leadership was hindered by a mingle of implicit barriers. Leadership

development programs were reported to have an important influence on women's individual professional success and on medical schools' environments.

Conclusion

Scholarship on women's leadership inadvertently produced institute-centric rather than women-centric research. More robust contextualized scholarship is needed to provide practical-recommendations; drawing on existing conceptual frameworks and utilizing more rigorous research methods.

Strengths and limitations of this study

- Unlike other reviews addressing women's careers in academic medicine, this review focuses solely on studies exploring the leadership of women, a central component of gender equity initiatives.
- The systematic approach provided a rigorous framework by which study objectives were set and studies were identified and appraised.
- Exclusion of qualitative literature may limit the conceptual argument of this study.
- Reviewed studies are Western, therefore, findings of this review are not generalizable to non-Western contexts.

Introduction

Inclusivity and diversity are goals every medical school hopes to achieve for its learners and faculty members.[1-3] An impediment to realizing these goals is the culture of academic medicine, commonly criticized for reinforcing gender and ethnic inequalities.[4-8] By bringing a transformative perspective, women leaders are often thought of as catalysts of organizational culture change, capable of creating better career experiences for the diverse workforce that has come to makeup medical education and practice.[9-11] Despite the recognition, it has been challenging for scholars to study and develop women's leadership. The difficulty, in part, stems from the remaining barriers' cultural nature: traditional models of work,[11] implicit gender bias,[12] limited access to support systems both mentors[9] and sponsors[13], gender stereotyping,[14] gendered views of leadership,[15] and culture-abiding self-imposed constraints.[16 17]

Such barriers are, of course, not unique to women leaders or to the context of academic medicine. The wealth of literature exploring women's careers, much of it reviewed in 2 systematic reviews,[12 18] 1 narrative review,[19] and 2 overviews[6 20] conclude that broadly, women faculty face the very same hurdles as they join[12] and progress in academic medicine in their roles as physicians [20], teachers,[18] and researchers.[19] Often, these barriers become reason enough for women to leave academia.[21] Although these reviews, and the studies within them, broaden our understanding of women's experiences, they have treated women's leadership as ancillary to a bigger discourse on career progression, often coming to leadership as one solution to gender inequity. By doing so, these reviews ignore the centrality of leadership in shaping culture and the change needed to realize gender equity. The current systematic review, therefore, aims to address this gap in the research by exclusively reviewing literature on women's leadership in academic medicine.

Background

In the quest to provide patient-centered care, safe learning environments for trainees, and engaging work environments for faculty, the culture of medical education and practice became an area of much scrutiny.[5 21-24] Hostility, disrespect, abuse, and discrimination are widely documented (e.g. US[21 25-28], Canada,[29-31], UK[32-34]) as normalized behaviors. The National Initiative on Gender, Culture, and Leadership in Medicine: C-Change has benchmarked the culture of academic medicine from the perspective of faculty and with special regard to gender equity, both in the US and internationally.[35] As the fulcrum of several studies,[4 5 21 23 24 36-41] C-Change links unhealthy behaviors to culture, and summates that for culture to change, underpinning values need to change first.

But how do values change? According to the organizational literature, cultural values are the values of founding leaders, are adopted by subsequent leaders and members of the culture, and are kept firmly in place by policies and procedures that were developed and implemented over time.[42 43] Although the dynamic interplay between these forces is important, we draw attention to the locus, cultural values are ultimately the values of leaders. In his 2007 speech "Culture and the courage to change"[44], the American Association of Medical Colleges president Kirch spoke to this very point "…This new culture also requires a different kind of leader…search committees will need to look far beyond the weight of a candidate's curriculum vitae, considering factors such as their ability to build alignments, foster trust, and make adaptive changes".

Against the backdrop of need for culture change and a leadership to see it through, we take up women's leadership in academic medicine, often viewed as both savior and victim of culture.[8 22] Such a portrayal illustrates the inevitable role women must play as leaders, especially given their

increased numbers,[10] but it also indicates conceptual immaturity. From the emerging conceptual discourse,[10 17 45-47] we know that scholarship on women's leadership lacks depth, where leadership emergence is commonly restricted to the pipeline metaphor, while enactment of it remains grounded in the generic leadership literature.

Leadership emergence

How women emerge as leaders is often conceptualized using the pipeline metaphor. The metaphor suggests that increasing the number of women in male-dominated fields will eventually lead to an increase in the number of women leaders. According to Magrane and Morahan[10] the metaphor misses pertinent organizational nuances, namely the implicit gender bias women face. For example, while men have many role models and a robust support system, women do not. The metaphor falsely assumes the presence of role models at the end of the pipeline willing to help women transition to leadership. Given the conceptual limitation, the authors propose frameworks that recognize the complex organizational systems women must navigate to emerge as leaders: the leadership continuum[47], and systems of career influences.[45]

Leadership enactment

Much of women's leadership studies remain grounded in the broader leadership literature.[17] As a result, our conceptualizations of leadership enactment draw on theories developed upon the study of male leaders, making such scholarship inherently male. For example, the older 'great man' theory exclude women entirely, associating leadership with agentic qualities e.g. authoritative and assertive, qualities that women supposedly do not possess. Newer collaborative theories e.g. participatory, distributed, and transformational leadership seem accommodating for women leaders because of their emphasis on social accountability and collaborative work, however, they

risk trapping women in gender stereotypes, e.g. nurturing, that nominate women for less prestigious leadership positions e.g. course coordinator.

It is with the wider need for culture change in academic medicine and the more focused need for conceptual understanding of women's leadership studies in mind that we systematically reviewed studies on women's leadership in academic medicine. It is our aim to first synthesize work done in this area. We ask: 1) What is the extent of women's leadership? 2) What factors influence women's leadership? 3) What is the impact of leadership development programs on women's individual careers and on medical schools' environments? Second, we aim to present an analysis of such works, we concern ourselves, not only with what was done thus far, but how produced knowledge helps or hinders women's leadership.

Methods

Search strategy

In April 2018, the first author conducted a search using the following databases: (1) Ovid MEDLINE; (2) EMBASE; (3) CINAHL; (4) Ovid PsycINFO; (5) all EBM Reviews on Ovid-ACP Journal Club, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, and Cochrane Central Register of Controlled Trials (1st quarter); and (6) ERIC. Searches were restricted to English, using a combination of key terms including "women", "leadership", and "academic medicine" (supplementary material 1). Following the PRISMA protocol,[48] she then screened the compiled results, excluding irrelevant articles, and inductively developing a preliminary thematic framework (Figure 1). The second list of article titles/abstracts and thematic framework were independently reviewed by both authors. The two authors discussed their findings and differences were reconciled. The full texts of nominated

articles were then retrieved for further assessment. At this stage, the bibliographies of nominated articles were reviewed for potential relevant studies. Experts in the field were identified from those works and contacted for published studies not revealed through the database search. We wanted to gain an idea of this area's historical trend, therefore we did not restrict our search to particular dates. Supplementary material 2 is a checklist used to ensure PRISMA guidelines were followed.

Study selection and data extraction

We identified all studies evaluating the extent of women's leadership in academic medicine at a departmental, college, and medical graduate program level. Although we recognize the interconnection, we excluded studies that explored women's leadership in professional societies, journal editorial boards, and journal editorships, focusing our examination solely on leadership within medical schools and graduate residency programs. Moreover, we identified studies evaluating the hindering and facilitating factors to women's leadership as perceived by women and men faculty members and leaders. Finally, we identified studies that document leadership interventions and their efficacy as reported by women participants of such programs and their home medical schools.

We included quantitative study designs and excluded qualitative designs, aiming to report on the latter elsewhere. We included a case study because it presented quantitative descriptive information on women in leadership across non-Western multinational settings. Studies were heterogeneous in their objectives, approaches, and target populations, it was therefore not possible to pool data and come to a meaningful statistical finding. An excel spreadsheet (included the following details: author, title, year, publication, study purpose, population,

response rate, strengths, and weaknesses) was used to collate extracted data. We draw on a strategy suggested by the Best Evidence Medical Education Collaboration,[49 50] to provide a narrative of the results. Moreover, using the Medical Education Research Quality Study Instrument (MERSQI),[51] we give a score and comment on the strength of individual studies, assessing their quality in terms of study design, sampling strategy, type of data, instrument validation, data analysis and outcome measures. The 10 item MERSQI tool was designed to evaluate quantitative medical education studies, giving a total possible score of 5 to 18. Furthermore, we point out specific methodological issues not covered by the MERSQI assessment.

Patient and public involvement

Patients were not directly involved in this systematic review.

Results

Overview

The initial database search revealed 4024 citations. Review of the titles and abstracts led to the retrieval of 93 full-text articles for further assessment. Thirty six articles met the inclusion criteria and were included in this review (Figure 1), 3 of which were identified through the bibliography search.[52-54] No studies beyond those identified were revealed by the 17 contacted scholars. Original data were available for 34 studies, described in 36 articles.[5 15 52-85] The agreement between raters was very good ($\kappa = 0.93$), where there was disagreement, the authors resolved their differences by discussion. See supplementary material 3 for an overview of included studies.

The majority of studies (n=30) were conducted in the United States, 3 included Canadian respondents[60 73] or information on Canadian schools' leadership,[55] 1 study was conducted across 3 countries (UAE, Qatar, and Singapore),[81] 1 study was conducted across 4 European countries (Germany, Sweden, Austria, and the UK),[68] 1 study in Norway,[69] and 1 study in Croatia.[75] The earliest study was conducted in 1999,[69] and more than 50% of the studies were published in the past 5 years alone. The design of 9 (26%) studies was retrospective cohort,[15 55 56 67 73 75-77 82] 1 (3%) prospective cohort,[58] and 5 (15%) were pre/post interventions.[61 64 70 72 80] Ten studies were cross-sectional self-reported questionnaires.[5 60 62 63 66 78 79 81 83 85] Where questionnaires were used, the response rates ranged from 34 to 100%. Nine studies were cross-sectional surveys of publicly available or archives of data,[54 57 59 65 67 69 71 74 84] and 1 study was a case report.[68]

Seventeen articles were published by medical education journals, 10 were published by medical specialty journals (Internal Medicine = 3, Hospital Medicine =1, Ophthalmology =1, Obstetrics/Gynecology = 2, Urology = 2, Surgery = 1), 5 articles were published by The Women's Health Journal, 2 by general medicine journals (British Medical Journal = 1, and the Human Resource for Health Journal = 1).

Many of the studies have methodological limitations. Eleven studies used websites and publicly available data which may be outdated or inaccurate.[15 54-56 59 62 65 67 74 81 84] Six studies did not reveal how their questionnaires were developed or if they were tested,[62 64 78 79 83 85] compromising the validity of the findings. Many of the questionnaires were self-reported with modest response rates. The pre/post intervention studies had small number of participants due to the small number

of participants of leadership development programs. Moreover, nearly all pre/post studies did not present longitudinal findings on the effectiveness of their interventions.

Only 6 studies provided contextual demographic (ethnicity or age) and career (career-stage, other leadership appointments, or leadership training) data on the studied populations.[5 55 59 61 64 80] The MERSQI scores of all studies ranged from 7 to 12.5 (supplementary material 3 and 4). In what follows, we present our findings grouped according to our 3 themes: the extent of women's leadership, the factors influencing women's leadership, and the impact of leadership programs on women's individual careers and on medical schools' environments.

Extent of women's leadership

Twenty studies reported the extent of women's leadership in academic medicine by comparing the number of women attaining leadership positions to the number of men.[54-59 62 65 67 69 71 74-79 81 84 85] The studies however, differed in their approach and which organizational positions they chose to highlight (Table 1). Three studies merely described the representation of women in specialty leadership positions,[57 65] or within a medical school.[75] One study determined if the proportion of leadership positions in Obstetrics and Gynecology held by women is consistent with the proportion of women entering residency.[55] Six studies compared the composition of chairs and/or program directors' gender to faculty members of medical schools,[59 74 77-79 84] 5 studies compared composition of residency program directors to medical residents composition,[67 71 78 79 84] while 2 studies compared the proportion of residents to department chairs.[78 79] Two studies compared the number of women in leadership positions in one medical specialty to other specialties.[56 67]

At the Department of Medicine at Johns Hopkins, Monroe et al.,[74] examined the number of women leaders and their academic ranks. The authors found that women assistant professors were more likely to hold leadership positions than male assistant professors ($p = 0.03$), while women and men at the associate professor and professor level were equally as likely to take on leadership positions. In contrast, Reed et al.,[76] reported in their longitudinal cohort study that fewer women than men took on leadership positions at Mayo Clinic, arguing that leadership appointments are based on scholarly production at mid-career, and that women had higher research production only later in their careers. A national longitudinal study of US faculty, reported after adjusting for scholarly production that women were less likely to become leaders (OR = 0.49; 95% CI, 0.35 - 0.69).[58]

As part of a larger study on gender inequity in a Pediatrics department, Rotbart et al.,[77] reported the number of women in leadership positions and the time they served in those positions. The authors found women faculty to be less likely to reach leadership positions, and this lag was due to the lag in academic promotion.

Factors influencing women's leadership

Fifteen articles examined factors associated with leadership gender disparities,[5 15 58 60 62 64 66 69 70 72 73 76 77 80 82] revealing that hostile organizational culture, explicit and implicit gender biases, stereotyping, research productivity, lack of mentorship, timing of academic appointments, and educational backgrounds negatively influenced women's attainment of leadership positions (Table 2).

In the United States, 3 studies explored women's leadership through the perceptions of medical schools deans,[60] faculty within Psychiatry departments,[62] and faculty at 1 private medical college.[5] Organizational culture was viewed as hindering to women's leadership. For example, Pololi and colleagues [5] reported that women faculty, in comparison to men, were less likely to perceive their institutions as family-friendly ($T = -4.06$, $p < 0.001$), making efforts towards addressing gender diversity ($T = -9.70$, $p < 0.001$), and that their personal values were less congruent with institutional values ($T = -2.06$, $p < 0.05$).

Two studies, investigated research productivity and its impact on women's leadership.[58 76] Women were almost half as likely as men (OR, 0.49; 95% CI, 0.35–0.69) to hold leadership positions despite the number of research publications.[58] Four studies addressed stereotyping and its effects on women's leadership.[15 62 64 69] Sexism was reported as a significant barrier to women faculty as they progressed in their careers in Psychiatry departments ($p = 0.0001$).[62]

In a pre/post intervention, Girod et al.[64] investigated the association between implicit gender biases and leadership positions. The authors found that gender and age were significantly in favor of men (β male = 0.18, $p = 0.001$; β age = 0.04, $p = 0.004$), suggesting that being an older male faculty is inherently associated with leadership than with other age and gender combinations. Gender bias was also documented in the language of tenure policies of medical schools.[15] Medical schools with the word "leader" in their tenure criteria were 6 times more likely to have a lower percentage of women tenured faculty than schools without the word "leader" (OR, 6.0; 95% CI, 1.02, 35.37; $p = 0.04$). Little or lack of mentorship was documented as a hindering factor to women seeking leadership.[62]

White et al.[82] observed notable differences among women and men medical school deans in the type of advanced degrees (Doctorate in male deans vs. business-related degrees in female deans) and the rank of the deans' medical school education and training (more men graduating from the top 50 NIH-ranked schools than women), presenting what seems like a probable association. An important facilitating factor to women leaders was leadership programs.[60 61 64 66 70 72 73 80] which we discuss in more depth in the next section.

The impact of women's leadership programs

Six studies document the impact of women's leadership interventions on individual career satisfaction [61 66 70 72 80] and on medical schools' environments.[60] A positive effect of leadership development programs was observed on a myriad of leadership skills for women academicians (Table 3). Programs improved women's negotiation skills[66 70 72] and provided networking opportunities.[66 70 72 80] Alumnae of leadership programs were more likely to attain leadership positions,[61 80] they were more likely to have knowledge and confidence in leadership skills, and were more likely to have knowledge of organizational structures and processes.[61] Most studies employed a pre/post design to evaluate leadership programs, while one study evaluated leadership programs through the perceptions of medical school deans. In their survey of US and Canadian medical school leadership, Dannels et al.[60] investigated the influence of the Executive Leadership in Academic Medicine (ELAM) program on organizational climate. The authors report that deans had positive perceptions (M = 5.62, SD = 0.961) of the ELAM program and the influence brought to medical schools by its alumnae.[60] The authors also found a significant difference between men and women deans in how they developed leadership in faculty, with women deans reporting more frequent use of practices than did men (p = 0.032). These practices

included publicly supporting the person when she/he makes a difficult decision, appointing a faculty member to high-level committees or task forces, and nominating faculty to leadership training outside the institution.

Discussion

To our knowledge, this systematic review is the first that synthesizes evidence on women's leadership in academic medicine. The 34 studies address 3 themes: the extent of women's leadership, factors influencing their leadership, and the impact of leadership development programs on women's individual professional success and medical schools' environments. Deeper analysis revealed that included studies are levered by imperceptible underpinnings. Oriented by a positivist paradigm, it seems much of the reviewed literature inadvertently embraced a narrow understanding of leadership, creating institute-centric rather than women-centric scholarship. In what follows, we unsettle the conceptual foundation of the reviewed studies. We argue that women's leadership studies provide a mere diversity/inclusion performance indicator for institutes that does not necessarily serve women. We then argue the need to shift to a more nuanced women-centric understanding of leadership.

Leadership as organizational position

Our review revealed that in medical schools, women had less access to leadership positions, the evidence showed fewer than 50% of leadership positions –chairs, program directors, or unit heads- were occupied by women faculty members (Table 1). Rooted in understanding leadership as occupancy of an organizational position, in what Northouse[43] calls *assigned leadership*, nearly 60% of the studies' main objective was to document the gender distribution of leadership positions. This conceptualization is based upon a positivist understanding of leadership, which

ultimately sees leadership as a quantifiable variable. The rationale for this approach may be that determining gender ratio in leadership will establish a performance indicator for the institute in terms of inclusion and diversity i.e. the number of women in leadership reflects gender equity/inequity. We question the benefit of this reduction to the women leaders. Although, we do not think the two are in conflict, we believe institute-centric thinking neglects the value women leaders bring to leadership and the organizational complexities they must navigate to become leaders. Leadership is not merely an organizational position for women faculty to occupy. Moreover, the number of women occupying leadership positions at a given point in time, an idea perpetuated by the pipeline metaphor,[10] does not by itself reflect equity in leadership. Indeed, the goal is not a critical mass of women who are assigned leaders but "a critical mass of women with sustained success as leaders"[47]

Leadership as process of influence

Recognizing the limitation of a positivist paradigm, we suggest a women-centric approach. This understanding aligns with organizational traditions, where leadership is conceptualized as a process of influence between leader and followers;[43 86 87] that is a series of actions and exchanges take place at the interpersonal level for leadership to occur. Here scholars recognize the importance of a leader's capacity for influence and how such influence shapes culture.[42 43 88]

First, to explore capacity for influence, we put women at the heart of inquiry: What are women's leadership capacities, that is their motivations, knowledge, skills, and experiences? Many studies did not mention whether women leaders self-nominated or were assigned to their leadership positions, how long they held those positions, if they had dual leadership appointments, or

whether women had formal leadership training. Many studies assumed prior leadership knowledge amongst their respondents and none examined the role of mentors or sponsors.

Addressing these gaps is vital to our understanding of leadership emergence and how gender bias manifests. Drawing on more mature conceptual work, systems of career influence,[45] we suggest more robust correlational and causal study designs. For example, beyond documenting lack of mentorship,[62] a correlational study can investigate the relationship between mentorship/sponsorship and how long women hold leadership positions. A causal study can investigate the effect of hands on leadership experience e.g. dual-leadership appointments on women's decision-making abilities. Hands-on experience may afford women a wider perspective of organizational processes, as a result, better decision-making abilities.

Second, social interactions are the essence of leadership and in time produce culture; the *values* and *beliefs* that govern our behaviors in organizations.[42] From our review, the current culture, underpinned by biased values and stereotypical beliefs, is identified as a hindering factor to women's leadership. This culture may sometimes feel static and unchanging, but it is actually recreated and reinforced in the daily interactions. In the proposed conceptualization, we come to recognize that culture and leadership are two sides of the same coin,[4 41] understanding one requires exploring the other.

Once more we put women at the heart of inquiry: How do women leaders shape culture? From our review, many studies neglected women's *enactment* of leadership. Many studies did not mention whether women had informal leadership roles, in what Northouse[43] calls *emergent*

leadership, referring to leadership that develops organically and is based on building alignments and fostering trust. Many studies did not mention what values informed women's decisions, what behaviors they modelled, or what actions they took to improve the quality of medical education and practice whether formally or informally. No studies explored the leadership styles women embraced. Addressing these gaps situates women leaders as critical actors in culture change.[22 45 47] and begins to conceptually ground women's enactment of leadership in their lived experiences, rather than the broader generic leadership literature.[17]

The catalyst effect of leadership development programs on women's careers is encouraging. Such programs may be an ideal place to explore women's enactment of leadership. For example, women who join such programs are likely motivated by a desire to transition from informal leadership to formal leadership positions. A comparative case study design can explore the contextual transition for alumnae. A mixed-method design can interview women alumnae on the values that inform their actions as leaders. Based on qualitative findings, a wide-scale survey can be developed and used to map out women's leadership approaches and styles.

Study limitations

Our study has some limitations. First, we restricted the review to quantitative literature and argued for studying contextual organizational nuances, which might have been explored in qualitative studies. Second, we defined leadership as a process of influence between leaders and followers but have limited our discussion to the leader's perspective. Third, we found that all studies except one[81] were conducted in North America and Europe. As a result, the presented evidence may not reflect non-Western contexts, but we have forgone discussion of this finding.

Addressing these limitations requires more space and further research which we hope to embark on and invite others to do so.

Conclusion

After reviewing the quantitative literature on women's leadership, we recognize the need for broader conceptual foundations. We also recognize that in problematizing the current conceptual foundation, we join other scholars [5 17 22 47 53] in arguing for more innovative research questions and rigorous methods. Our argument for broadening the conceptual foundation is two-fold. First, by focusing on women's experiences, we can offer readership of this field, who we assume are largely women faculty, practical knowledge that can help them pursue their own leadership. Second, leadership and culture are inextricability linked.[47] Consequently, the culture change we aspire to in academic medicine cannot happen without a deeper understanding of this relationship.

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Figure legends:

Figure 1: Flowchart of search strategy using PRISMA protocol.

Table 1: The extent of women's leadership in academic medicine.

Table 2: Thematic analysis of the 15 quantitative articles that examined the hindering factors associated with women's leadership.

Table 3: Women's leadership programs in academic medicine.

Table 1

The extent of women's leadership in academic medicine

Source	Population/Setting	% of women faculty or residents	outcome	Results % of women in leadership positions, p value, or odds ratio
Women in leadership positions within one-specialty				
Baecher-Lind 2012[55]	Obstetrics & gynecology departments associated with the council of University Chairs of Obstetrics & Gynecology.	36.8% of residents in 1980.	The number of women in leadership is increasing, yet not proportionally to the number of women residents entering OB/GYNE.	20% of DCs ($p < 0.001$)
Cheng et al. 2006[59]	US emergency departments.	22.3% of faculty	Gender disparities exist.	7.5% of DCs & 15% of PDs. Departments chaired by women had significantly higher percentage of women faculty ($p = 0.01$). Departments chaired by women were more likely to have women RPDs ($p < .01$)
Cancian et al. 2017[57]	US urology leadership programs.	NA	Disparities exist.	1.6% of DCs, & 11.2% of RPDs
Doyle et al. 2016[62]	US Psychiatry chairs	NA	Gender disparities exist. Women chairs perceived career barriers in their career development.	10% of chairs were women Male chairs were more likely than female chairs to head large departments ($p = 0.02$, CI -17.1-69.1)

Han et al. 2017[65]	US urology residency programs	NA	Disparities exist.	3.3% of DCs, 4.5% of vice chairs, & 7.9% of division directors. For educational leadership roles, women comprised 9.4% of fellowship directors, 8.1% of residency directors, and 27.4% of medical student clerkship directors.
Monroe et al. 2015[74]	Department of Medicine at Johns Hopkins University	NA	Gender disparities exist. Women leaders were proportionate to faculty. Women assistant professors were more likely to hold position than men assistant professors.	50% of PDs, 33% PDs assistant/associate director, 27% fellowship program director, 80% of fellowship program assistant/associate director, & 37% of educational program director. Women assistant professors were more likely to hold leadership positions than were men assistant professors (p = 0.03).
Rotbart et al. 2012[77]	Promotion track faculty the University of Colorado School of Medicine's Department of Pediatrics	54% of assistant professors, 56% of associate professors, & 23% of professors.	Gender disparities exist with respect to section head, vice chair but not medical director positions	25% of section heads & 14% of vice-chairs.
Shah et al. 2007[78]	US radiology residency program directors.	26% of residents, 26% of faculty.	Gender disparities exists.	10.7% of DCs, 42.9% of PDs.

				Gender composition of radiology faculty & residents does not differ significantly according to gender of leaders.
Shah et al. 2010[79]	US ophthalmology residency programs directors.	Residents (45%), & faculty (28%)	Gender disparities exists.	2% of DCs, & 34% of PDs. Gender composition of ophthalmology faculty & residents does not differ significantly according to gender of leaders.
Woodward et al. 2017[84]	US gastroenterology fellowship programs.	NA	Gender disparities exist, & are more pronounced for division chiefs.	18% of PDs, 28% of associate program directors, 7% of division chiefs. Gender of fellowship program director & gender of division chief (p= 0.0327), no association with faculty or resident composition.
Women in leadership positions across several-specialties				
Burden et al. 2015[56]	US academic adult hospital medicine (HM) & general internal medicine (GIM) programs	49% of HM faculty, & 51% of GIM faculty in a 15% sample.	Gender disparities exist with respect to division or section leadership.	16% of division or section heads of HM were women 35% of division or section heads of GIM were women (p = .008)
Hofler et al. 2016[67]	US academic departments of anesthesiology, diagnostic radiology, general surgery,	Resident numbers are less than 50% in all studied	Gender disparities exists.	women comprised 13.9% of department chairs,

	internal medicine, neurology, obstetrics & gynecology, pathology, pediatrics, & psychiatry.	specialties except pediatrics.		22.6% of vice chairs, 21.6% of division directors, & 39% of PDs. Women significantly underrepresented in the combined leadership positions for all specialties (Ratios 0.61 or less; all $p < .001$) except anesthesiology & radiology
Long et al. 2011[71]	US residency program identified as the largest in JAMA (Brotherton SE, Etzel SI. Graduate medical education, 2009–2010. JAMA 2010;304:1255–1270)	47.8% overall. 79.7% residents Obstetrics 73.2% Pediatrics, family medicine 55.1%, Psychiatry 54.9% Internal Medicine 44.8%, Emergency medicine 40.3%, Anesthesiology 37.5% Surgery, 35% Radiology 28% Orthopedics 13.3%	Gender disparities exist	25.8% of program directors overall were women. program directors 35.2% Obstetrics, 49% Pediatrics, 23.6% Family Medicine, 34.6% Psychiatry, 24.3% Internal Medicine, 18.8% Emergency Medicine, 29% Anesthesiology, 10.8% Surgery, 27.7% Radiology, 6.5% Orthopedics.
Puljak et al. 2008[75]	University of Split School of Medicine in Croatia.	43% of faculty	Gender disparities exist.	18-21% of DCs in 1997-2006.

Reed et al. 2011[76]	women scholarly clinicians employed at Mayo Clinic with 20 or more years of service at Mayo Clinic, who spend more than 25% of their professional effort directly providing patient care.	NA	Gender disparities exist.	56% of women held divisional, departmental, institutional or national positions during their careers. Total leadership position attainment between men and women (p< 0.001)
Weiss et al. 2014[54]	US general surgery, orthopedic surgery, otolaryngology, neurosurgery, plastic surgery, and urology programs.	Medical students 48%, Residents (14-37%), & faculty (assistant professor 19-29%; associate professor 13-21%; professor 7-11%)	Gender disparities exist.	General surgery chairs 3% & PDs 10% (p = .002) Orthopedic Surgery 0% & PDs 6% (p = .002) Otolaryngology 5% of chairs & 13% of PDs (p = .045) Neurosurgery 1% of chairs & 3% of PDs Plastic Surgery 6% of chairs & 9% of PDs Urology 3% of chairs & 6% PDs
Wright et al. 2003[85]	Faculty members of the school of medicine at the University of Arizona	NA	Gender disparities exist, women were less likely be part	55% served as committee chair, 10% as section or division head, & 8% as department chairs.

			of decision making process, or advise chairs.	As compared to men: (p=0.03), (p=0), (p=0.003)
Women leaders across several institutions or countries				
Carr et al. 2018[58]	US Academic medical faculty	NA	Gender disparities exist & are related to scholarly productivity.	10% of women in sample had leadership roles ($p < 0.0001$). After adjusting for scholarly productivity, the OR = 0.49 (95% CI, 0.35-.69)
Kvaerner et al. 1999[69]	Norwegian physicians.	NA	Gender disparity exists.	6.4% of women were leaders. 95% CI (2.6-13.9)
Stadler et al. 2017[81]	Clinician educators & leadership of competency based graduate medical education in Qatar, Singapore, & UAE	NA	Gender disparity exists.	22.1% of program directors & 22.1% of associate program directors.

Abbreviations: NA, not available; PD, program director

Table 2

Thematic analysis of the 15 quantitative articles that examined the hindering factors associated with women's leadership.

Theme	Outcome	Result
Barriers to women's leadership		
Policy development & translation	Dismissal of work-life balance measures.	Out of the 15 family-friendly policies, only 3 were available at more than 68% of medical schools: benefits for part-time faculty, paid maternity & paternity leave.[60]
	Dismissal of diversity & inclusion measures.	Fewer than 14% of schools implemented gender equity specific policies.[60] Women faculty showed more negative perceptions on equity for women ($T=-19.82$, $p<0.001$); institutional change efforts for diversity ($T=-9.70$, $p<0.001$).[5]
	Incongruence between organizational values & individual values.	Women faculty showed more negative perceptions on values alignment ($T= -2.06$, $p<0.05$).[5]
Stereotyping	Existence of gendered language in leadership associated policies.	Being a leader is associated with being male (M= 2.4, SD=2.2 – OR= 6, CI 1.02, 35.37) & traditionally male associated traits: analytical (M=2.5, SD=2.4); independent (M= 3.1, SD= 2.6 – OR=1, CI 0.2, 5.1); & individualistic (M=1.8, SD= 1.5 – OR= 1, CI 0.2, 5.4) in medical school tenure criteria, affecting leader selection decisions.[15]
	Existence of implicit gender bias, favoring men as leaders.	Slight implicit preference for men leaders over women (IAT D score = .16, SD = 0.42).[64]

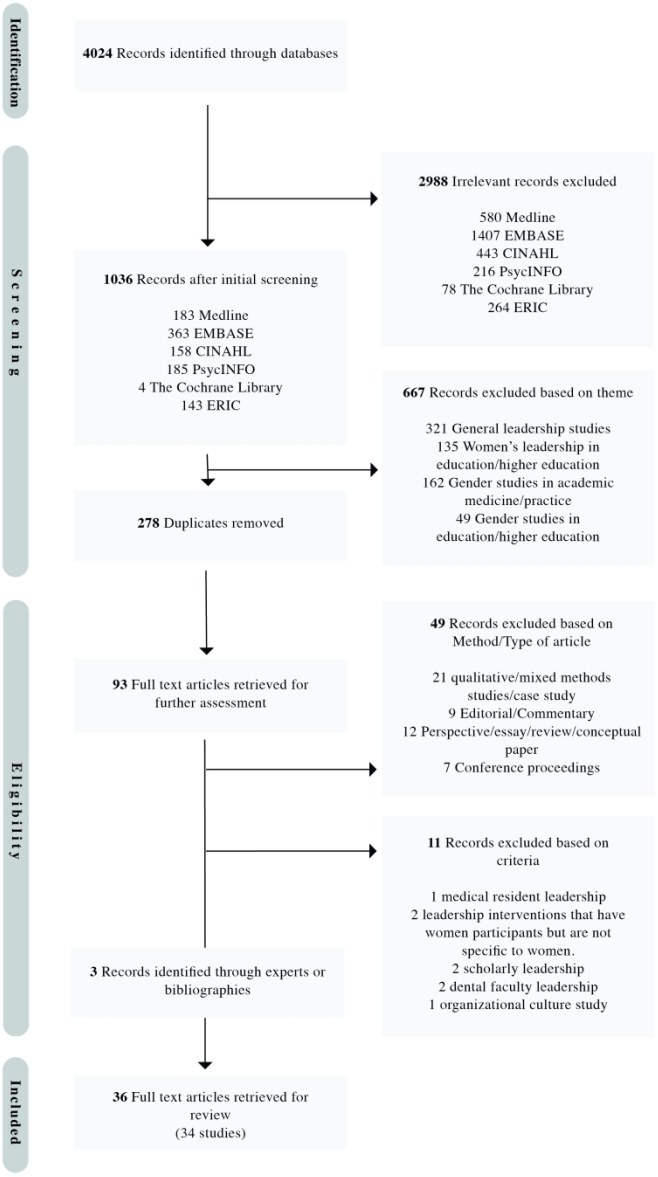
Research Production	Increased production of research is associated with leadership attainment.	Senior leadership positions were more likely held by male faculty despite research publications (OR = 0.49; 95% CI, 0.35–0.69).[58]
	Timing of leadership appointments (mid-career) negatively affected by modest research production.	Women published fewer articles throughout their careers than men (M = 29.5, SD = 28.8 versus M = 75.8, SD = 60.3 – p = .001). However, after 27 years, women produced a mean of 1.57 more publications annually than men (p = .001). Throughout their careers, women held fewer leadership roles than men (p = .001).[76]
Mentorship	Lack of mentorship may hinder women from becoming leaders.	Women chairs were more likely than men chairs to perceive barriers in their career development citing little or no mentorship (p=0.04).[62]
Time of academic appointment	Entering academia belatedly may contribute to leadership disparities.	Women faculty in the UCSOM Department of Pediatrics entered academia at a later career stage, in part, resulted in women trying to advance at a later stage than men in academic position and tenure.[77]
Educational background & advanced degrees	Educational background & types of degrees may influence leadership selection.	A greater percentage of male deans graduated from the top 50 NIH-ranked research-award schools than women deans (p = .005, ω2 = 23.3%, η2 = 25.4%) Doctorate degrees were more prevalent among men deans as opposed to business-related degrees among women (MBA, MHA, MPH, or JD).[82]

Table 3

Women's leadership programs in academic medicine

Citation	Program/initiative	Purpose	Outcome	Result
Dannels et al. 2009[60]	ELAM	Evaluate a leadership program's & its impact from medical school leadership perspective.	Positive impact on its alumnae & their schools.	Medical school deans' (M = 5.62 out of 7), with those having more fellows reporting greater benefit (p = 0.01), positive influence on alumnae (M = 6.27), & increase their eligibility for promotion (M = 5.7)
Dannels et al. 2008[61]	ELAM	Determine the extent to which program participants, compared with women from two comparison groups, aspire to leadership, demonstrate mastery of leadership competencies, and attain leadership positions.	ELAM program has a beneficial impact on fellows in terms of leadership behaviors and career progression.	ELAM participants scored higher than AAMC & NON-groups in 15 of the indicators, and for 1 indicator they scored higher than the AAMC group (aspiration to leadership outside academic health centers). The differences were statistically significant for 12 indicators. Indicators, including 7 of the leadership competencies, 3 of the administrative leadership attainment

				indicators, & 2 of the leadership aspirations & education indicators.
Helitzer et al. 2014[66]	EWIM MidWIM ELAM	Perceptions of CPD program alumnae of CPD.	Participants reported gained & improved career skills from CPDs.	Across all 3 CPDs leadership aspiration was aligned with career stage; full professors reported more interest in leadership than associate professors (p = .043)
Levine et al. 2015[70]	Johns Hopkins University School of Medicine Leadership Program for Women Faculty	Evaluation of 3 cohorts of a longitudinal program.	Women reported improved leadership skills.	Significant improvement across 11 leadership domains except: public speaking & working in teams.
McDade et al. 2004[72]	ELAM	Measures impact of ELAM program.	Increased leadership capabilities across all ten identified constructs.	($p < 0.01$)
Spalluto et al. 2017[80]	LIFT-OFF	Report of design, implementation, & evaluation of leadership intervention to further the training of female faculty.	31% of educational modules were useful.	($p < 0.05$)



Flowchart of search strategy using PRISMA protocol.

Supplementary material 1

Search terms and number of results for review of women's leadership in academic medicine

Database	Date	Search query	Results, n
Ovid Medline	1946 May 2018	(Women OR woman OR female OR females OR girl OR girls) AND (Leadership OR Leader OR leaders OR leading) AND (Medical education OR academic medicine OR health professions education or health profession education OR professional development OR faculty development)	763
EMBASE	1974 to May 2018		1773
CINAHL	1989 to May 2018		601
Ovid PsycINFO	1967 to April 2018		401
The Cochrane Library*	-		82
ERIC	1965 to April 2018		407

*The library includes: Cochrane Database of Systematic Reviews (2005 to May 2018), EBM Reviews - ACP Journal Club (1991 to May 2018), EBM Reviews - Database of Abstracts of Reviews of Effects (1st Quarter 2016), EBM Reviews - Cochrane Clinical Answers.

Supplementary material 2

Reporting checklist for systematic review and meta-analysis based on the PRISMA guidelines.

		Reporting Item	Page
Title			
	#1	Identify the report as a systematic review, meta-analysis, or both.	1
Abstract			
Structured summary	#2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number	2
Introduction			
Rationale	#3	Describe the rationale for the review in the context of what is already known.	5-7
Objectives	#4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	8
Methods			
Protocol and registration	#5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address) and, if available, provide registration information including the registration number.	n/a
Eligibility criteria	#6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rational	9
Information sources	#7	Describe all information sources in the search (e.g., databases with dates of coverage, contact with study authors to identify additional studies) and date last searched.	8-9
Search	#8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	8-9

Study selection	#9	State the process for selecting studies (i.e., for screening, for determining eligibility, for inclusion in the systematic review, and, if applicable, for inclusion in the meta-analysis).	8-10
Data collection process	#10	Describe the method of data extraction from reports (e.g., piloted forms, independently by two reviewers) and any processes for obtaining and confirming data from investigators.	8-10
Data items	#11	List and define all variables for which data were sought (e.g., PICOS, funding sources), and any assumptions and simplifications made.	10
Risk of bias in individual studies	#12	Describe methods used for assessing risk of bias in individual studies (including specification of whether this was done at the study or outcome level, or both), and how this information is to be used in any data synthesis.	10
Summary measures	#13	State the principal summary measures (e.g., risk ratio, difference in means).	n/a
Planned methods of analysis	#14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis.	n/a
Risk of bias across studies	#15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	n/a
Additional analyses	#16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	n/a
Results			
Study selection	#17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	10-11
Study characteristics	#18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citation.	11
Risk of bias within studies	#19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).	11-12

Results of individual studies	#20	For all outcomes considered (benefits and harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot.	10-16
Synthesis of results	#21	Present the main results of the review. If meta-analyses are done, include for each, confidence intervals and measures of consistency.	n/a
Risk of bias across studies	#22	Present results of any assessment of risk of bias across studies (see Item 15).	n/a
Additional analysis	#23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
Discussion			
Summary of Evidence	#24	Summarize the main findings, including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers	16-19
Limitations	#25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).	19-20
Conclusions	#26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	20
Funding			
Funding	#27	Describe sources of funding or other support (e.g., supply of data) for the systematic review; role of funders for the systematic review.	21

Supplementary material 3

Characteristics of the 34 articles reviewed from earliest date available – April 2018.

Citation	Country	Study Design	Study Purpose	Time Frame	N +/- RR	Data Source	Methodological limitations	MERSQI Score
Baecher-Lind, 2012[55] ¶	USA	Retrospective cohort	Determine whether the proportion of leadership positions in OBS/GYNE held by women is consistent with the proportion of women entering residency.	July-Aug 2012	155 academic departme nt chairs	Department websites for name & sex of leader & state medical license databases for graduation year.	*Limited population*: no report on other leadership positions: vice-chairs, program directors, or unit heads. *Lack of contextual demographic data:* ethnicity, marital status, or age. *Lack of contextual career data*: career stage, dual leadership appointments, or formal leadership training. Does not differentiate community-based & academic programs.	10.5
Burden et al., 2015[56]	USA	Retrospective cohort	Determine the existence of gender disparities among academic hospitalists in leadership & scholarly productivity & compare the results	Oct, 2012 – Aug, 2014	69 Hospital Medicine (HM) Programs 80 General Internal Medicine	Graduate Medical Education Directory (AAMC listed members fully accredited by the Liaison Committee on Medical Education) for programs & department	No *information on* or *adjustment for* size, age or geographic location of HM or GIM departments. It was unclear whether HM departments were divisions or sections of GIM departments.	10.5

			with academic general internists.		(GIM) Programs	websites for sex of leaders, & number/sex of faculty, & Program contacted through email if necessary		
Cancian et al., 2018[57] ¶	USA	Cross-sectional	Determine the number of women in urological leadership positions.	July 2016	NA	Accreditation Council for Graduate Medical Education.	*Lack of contextual demographic data:* ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments, or formal leadership training. Not clear which departments were academic vs community.	8.5
Carr et al., 2018[58]$	USA	Prospective cohort	Identify predictors of advancement, retention, & leadership for women faculty from a 1995 National Faculty Survey.	1995-2012/13	1995: 1801 faculty, RR = 60% 2012: 1273 faculty, RR = 48%	Mailed national faculty questionnaire conducted in 1995 & a follow-up online self-reported questionnaire in 2012-13	No methodological deficits were identified.	12
Cheng et al., 2006[59]	USA	Cross-sectional	Determine if there is an association between the gender	Dec, 2004	133 EM programs	Society for Academic Emergency	Authors claim retrospective design & although trend of chairperson gender is	9.5

			of the chairperson/program director & the gender of Emergency Medicine (EM) faculty.			Medicine online residency catalog, program websites, & program contacted through email if necessary.	reported, this does not qualify as a retrospective cohort. *Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	
Dannels et al., 2008[60]#	USA	Pre/post intervention & prospective cohort	Determine the extent of leadership aspiration, mastery of leadership competencies, & attainment of leadership positions amongst graduates of the ELAM compared to 2 comparison groups (NON-ELAM & AAMC group).	2002-06	78 ELAM graduates, RR = 73% 63 NON-ELAM group, RR= 44% 468 AAMC group, RR= 38%	Online self-reported questionnaires.	No methodological deficits were identified.	12.5

Dannels et al., 2009[61]#	USA	Cross-sectional	Elicit the perceptions of deans on their medical schools' organizational climate & its effect on faculty, policies affecting faculty, processes deans use for developing faculty leadership, and the impact of the ELAM Program for Women.	May, 2006	142 medical school deans: Overall RR= 58% 72 men RR=57% 11 women RR=69%	AAMC for medical schools & online self-reported questionnaire.	Small sample size of women deans limits detecting relevant statistical effect. *Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	10.5
Doyle et al, 2016[62]	USA	Cross-sectional	Investigate the causative factors contributing to gender disparity in senior leadership positions in academic psychiatry.	April, 2014	118 (final n =109) Overall RR = 39% 97 men chairs RR = 34% 12 women chairs, RR= 83%	Publicly available data: American Association of Chairs of Departments of Psychiatry (AACDP) for psychiatry chair names, department websites for demographic information, & online self-reported questionnaire.	Problematic survey design: Assumption of prior leadership knowledge. Objective does not align with study design: causation cannot be established in cross-sectional study designs.	8

Ellinas et al., 2018[63]§	USA	Cross-sectional	Identify factors that promote medical faculty's engagement & gender difference in those factors.	June-Aug, 2013	1456 faculty members RR= 42% 227 women	Online self-reported questionnaire.	No methodological deficits were identified.	9
Girod et al., 2016[64]	USA	Pre/post intervention	Investigate the implicit & explicit biases favoring men as leaders & assess whether these attitudes change following an educational intervention.	March 2012-April 2013	281 faculty members	Questionnaire for general perceptions of bias, measure of explicit attitudes related to gender & leadership, & Implicit Association Test (IAT).	Findings limited by lack of longitudinal data on effectiveness of intervention.	9.5
Han et al., 2017[65]§	USA	Cross-sectional	Determine the gender & subspecialty of those holding academic departmental, administrative & educational leadership roles in urology.	June-Aug, 2016	124 urology programs	Accreditation Council for Graduate Medical Education for programs & Urology department websites for main data. Program contacted if necessary.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	8.5
Helitzer et al., 2014[66]	USA	Cross-sectional	Explore whether skills acquired by women in career development programs implemented by	Feb – April, 2011	2537 women participants, RR = 35%	National online self-reported questionnaire.	*Limited population*: Loss of follow-up on participants who left academic medicine.	9

			AAMC & Drexel University would vary by career stage & program attended.					
Hofler et al., 2016[67]^	USA	Cross-sectional	Compare the representation of women in OB/GYNE department-based leadership to leadership in other clinical specialties while accounting for the proportions of women in the residency cohorts of 1990.	Nov-2012 to Oct, 2013	851 eligible programs 105 OB/GYN programs	Accreditation Council for Graduate Medical Education 2012-13 for programs & program websites for leadership positions.	*Lack of contextual demographic data:* ethnicity, or age. Assumption that women choose academic medicine early in their career in equal proportion to men.	9.5
Kuhlmann et al., 2017[68]	Sweden, Germany, Austria, &UK	Case study	Explore & compare the representation of women in leadership and management in European academic health centers.	May, 2016	4 academic health centers	Unspecified	No methodological deficits were identified.	NA
Kværner et al., 1999[69]	Norway	Cross-sectional	Determine the proportion of women leaders to men leaders.	Oct, 1997	Overall reported 13,844 physicians; 3939 women.	Norwegian Medical Association records.	No methodological deficits were identified.	9.5

					N in academic medicine 334; 94 women			
Levine et al., 2015[70]	USA	Pre/post intervention	Describe & evaluate a longitudinal cohort-based leadership program for women faculty at the Johns Hopkins University School of Medicine.	2010-2013	134 women RR cohort 2: 80%, 58% RR cohort 3: 86%, 76% RR cohort 4: 92%, 69%	Self-reported questionnaire.	No follow up on long term effect of program.	8.5
Long et al, 2011[72]	USA	cross-sectional	Compare the gender distribution of residency program directors with gender distribution of residents & faculty in the 10 largest specialties.	NA	601 female program directors 75,156 Residents	Educational issue of JAMA, 2010 for information on the 10 largest residency specialties. ACGME website for number and program names. AAMC for gender distribution of	No methodological deficits were identified.	9.5

						medical school faculty.		
Marchant et al., 2007[15]	USA	Retrospective cohort	Examine whether the presence of the word "leader" in written tenure criteria may impact the promotion of women in elite medical school differently than men.	2004	24 medical schools	Carnegie Foundation classification system and the National Institutes of Health (NIH) for medical schools. School's website for tenure criteria.	Limited sample size (24/125), does not account for recruitment or departure of tenured female faculty, or the number of faculty who apply for tenure. Wide C.I. (1.02, 35.37) Uncertainty is greater with wider confidence intervals.	11.5
McDade et al., 2004[72]#	USA	Pre/post intervention	Measure the impact of the ELAM program on women academicians' leadership capacities.	1997-2001	79 participants RRs were nearly 100% (pre) & 69% to 76% (post)	Self-reported questionnaire	Only one group, lack of follow-up.	11
McLean et al., 2013[73]	USA	Retrospective cohort	Explore whether geographic mobility is associated with career advancement of women in U.S. medical schools who are entering mid- to executive-level	2009	345 ELAM participants	ELAM database	Unclear whether Canadian participants were accounted for.	10.5

			positions.					
Monroe et al., 2015[74]	USA	Cross-sectional	Delineate leadership positions in the Department of Medicine held by faculty & compare leadership positions held by male & female.	2012	474 faculty, 181 were women.	Division websites &/or Johns Hopkins referral directory, or division heads.	*Lack of contextual demographic data:* ethnicity, or age. *Lack of contextual career data*: career stage, dual leadership appointments or formal leadership training. Lack of definition of leadership. Response bias.	8.5
Pololi et al., 2013[4]	USA	Cross-sectional	Assess & compare the experiences of women & men faculty of institutional culture including leadership.	2007-2009	4578 faculty, RR= 52%	Online self-reported questionnaire.	No methodological deficits were identified.	10.5
Puljak et al., 2008[75]	Croatia	Retrospective cohort	Determine the extent of women advancing to leadership positions.	1979-2006	NA	University of Split School of Medicine's archives.	*Lack of contextual demographic data:* Ethnicity, marital status, or age.	9.5
Reed et al., 2011[76]	USA	Retrospective cohort	Compare the publication records, academic promotions, & leadership appointments of women and men physicians.	2007	25 women 50 men	Mayo clinic faculty database (CVs).	*Lack of contextual demographic data:* Ethnicity, marital status, or age.	9.5

Rotbart et al., 2012[77]	USA	Retrospective cohort	Determine the extent of gender inequity in a pediatrics department including leadership attainment & to demonstrate an assessment methodology other departments can use.	2009	263 faculty members	Department databases: The Faculty Information Database Online (FIDO), department Web-based software contains data on faculty members' careers, & PeopleSoft containing salary records.	No methodological deficits were identified.	9.5
Shah et al., 2007[78]	USA	Cross-sectional	Determine if there is any association between the gender of the chairperson/residency program director & the gender of faculty & residents in radiology.	Dec, 2006	188 programs directors, RR= 45%	Online self-reported questionnaire.	Does not account for women self-selecting for leadership positions.	8
Shah et al., 2010[79]	USA	Cross-sectional	Determine if there is any association between the gender of the chairperson/residency program director & the gender of faculty & residents in ophthalmology.	July, 2007	121 program directors, RR=45.45%	Online self-reported questionnaire.	Only 2 women chairpersons, not large enough to detect association.	8

Spalluto et al., 2017[80]	USA	Pre/post intervention	Describe development & implementation of LIFT-OFF leadership program.	June, 2015 – May, 2016	39 participants, needs assessment RR = 89.7% Questionnaire RR = 76.9%	Self-reported questionnaire.	Findings limited by lack of longitudinal data on effectiveness of intervention.	10
Stadler et al., 2017[81]	Singapore, Qatar, & UAE	Cross-sectional	Describe gender differences of international clinician educators & leaders in emerging international competency-based residency programs.	June 2013-June 2014	359 leaders, 69 were women RR = 76.3%	Program websites or through individual researchers who work for each respective institute.	No methodological deficits were identified.	10
Weiss et al., 2014[54]	USA	Cross-sectional	Evaluate number of women chairs, program directors, & division chiefs in surgical specialties.	NA	249 programs	National Residency Matching Program for programs, AAMC report for resident & faculty, & program websites for information on chairs.	*Lack of contextual career data*: dual leadership appointments or formal leadership training.	9.5
White et al., 2012[82]	USA	Retrospective cohort	Explore factors that may be involved in the persistent paucity of women leaders in U.S.	1980-2006	534 Medical school deans	AAMC faculty roster & Council of Deans database.	*Lack of contextual demographic data:* Ethnicity, marital status.	10.5

			academic medicine & to provide baseline gender-related data for developing strategies to promote gender equity in academic medicine leadership.					
Willett et al., 2015[83]	USA	Cross-sectional	Determine whether salary disparities exist between women & men Internal Medicine residency program directors, & if so, to identify factors associated with the disparities.	Aug, 2012	370 program director, RR= 65.1%	Association of Program Directors in Internal Medicine for Programs, & online self-reported questionnaire.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: medical specialty, dual leadership appointments, or formal leadership training.	10.5
Woodward et al., 2017[84]	USA	Cross-sectional	Determine the ratio of women occupying program directors' positions to division chiefs in gastroenterology fellowships, & to evaluate factors associated with this.	2015	163 gastroenterology programs	American College of Gastroenterology, AAMC website, & program websites.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: career stage, dual leadership appointments, or formal leadership training. Does not differentiate community-based & academic programs.	9.5

Wright et al., 2003[85]§	USA	Cross-sectional	Determine reasons for gender disparities in leadership.	1999-2000	418 faculty, RR= 48%	College of Medicine Personnel database, Online self-reported questionnaire.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	7

Abbreviations: MERSQI, Medical Education Research Study Quality Instrument; N, Population; RR, response rate; ELAM, Executive Leadership in Academic Medicine; NA, not available.
¶ Studies that report various leadership positions within one specialty (e.g. editorship, society membership), here we report only those which are academic.
§ Studies with a study purpose beyond leadership (e.g. scholarly production).
^ reported in 2 papers Hofler et al., 2016 Hofler et al., 2015
# reported in 2 papers Dannels et al., 2008, Dannels et al., 2009, McDade et al., 2004 also reported in a 2nd paper Morahan et al., 2010

Supplementary material 4

Quality of studies included using the MERSQI (n=33 excluding the case study)

Item (max. points)	Detailed scores	No. (%)
Study design (3)	Cross-sectional (1)	19 (58.82)
	Single-group pretest and posttest (1.5)	4 (8.82)
	Non-randomized, 2 groups (including cohort studies) (2)	10 (32.35)
Sampling institutions (1.5)	1 institution (0.5)	9 (27.2)
	3 or more institutions (1.5)	24 (72.7)
Sampling: response rate (1.5)	NA	17 (51.5)
	<50% or not reported (0.5)	7 (21.2)
	50%-74% (1)	6 (18)
	> 75% (1.5)	3 (9)
Type of data (3)	Assessment by study participants (1)	14 (42.4)
	Objective (3)	19 (57.6)
Validity evidence (3)	NA	23 (69.7)
	Internal Structure (1)	5 (15)
	Content (1)	8 (24.2)
	Relationship to other variables (1)	2 (6)
Data analysis: sophistication (2)	Descriptive analysis only (1)	2 (6)
	Beyond descriptive analysis (2)	31 (93.9)
Data analysis: appropriate (1)	Data analysis appropriate for study design and type of data (1)	33 (100)
Outcome (2)	Attitudes, perceptions, opinions, general facts (1)	29 (88)
	Knowledge, skills (1.5)	2 (6)
	Behaviors (2)	2 (6)

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Women's leadership in academic medicine: A systematic review of extent, condition, and interventions.

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Women's leadership in academic medicine: A systematic review of extent, condition, and interventions.

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Abstract

Objectives

Because culture reflects leadership, the making of diverse and inclusive medical schools begins with diversity amongst leaders. The inclusion of women leaders remains elusive, warranting a systematic exploration of scholarship in this area. We ask: 1) What is the extent of women's leadership in academic medicine? 2) What factors influence women's leadership? 3)What is the impact of leadership development programs?

Design: Systematic review

Data sources: A systematic search of six online databases (OvidMEDLINE, EMBASE, CINAHL, PsycINFO, the Cochrane Library, and ERIC) from the earliest date available to April 2018 was conducted. Bridging searches were conducted from April 2018 until October 2019.

Eligibility criteria: 1) Peer-review; 2) English; 3) quantitative studies (Prospective and retrospective cohort, cross-sectional, and pre-post interventions); evaluating 4) the extent of women's leadership at departmental, college, and graduate program levels; 5) factors influencing women's leadership; 6) leadership development programs. Quantitative studies that explored women's leadership in journal editorial boards and professional societies and qualitative study designs were excluded.

Data extraction and synthesis: Two reviewers screened retrieved data of abstracts and full-texts for eligibility, assessment, and extracted study-level data independently. The included studies were objectively appraised using the MERSQI instrument with an inter-rater reliability of (κ= 0.93).

Results

Of 4024 records retrieved, 40 studies met the inclusion criteria. The extent of women's leadership was determined through gender distribution of leadership positions. Women's leadership emergence was hindered by institutional requirements such as research productivity and educational credentials, while women's enactment of leadership was hindered by lack of policy implementation. Leadership development programs had a positive influence on women's individual enactment of leadership and on medical schools' cultures.

Conclusions

Scholarship on women's leadership inadvertently produced institute-centric rather than women-centric research. More robust contextualized scholarship is needed to provide practical-recommendations; drawing on existing conceptual frameworks and utilizing more rigorous research methods.

Strengths and limitations of this study

- Unlike other reviews addressing women's careers in academic medicine, this review focuses solely on studies exploring the leadership of women, a central component of gender equity initiatives.
- The systematic approach provided a rigorous framework by which study objectives were set and studies were identified and appraised.
- Exclusion of qualitative literature may limit the conceptual argument of this study.
- Reviewed studies are Western, therefore, findings of this review are not generalizable to non-Western contexts.

Introduction

Inclusivity and diversity are goals every medical school hopes to achieve for its learners and faculty members.[1-3] An impediment to realizing these goals is the culture of academic medicine, commonly criticized for reinforcing gender and ethnic inequalities.[4-8] By bringing a transformative perspective, women leaders are often thought of as catalysts of organizational culture change, capable of creating better career experiences for the diverse workforce that has come to makeup medical education and practice.[9-11] Despite the recognition, it has been challenging for scholars to study and develop women's leadership. The difficulty, in part, stems from the remaining barriers' cultural nature: traditional models of work,[11] implicit gender bias,[12] limited access to support systems both mentors[9] and sponsors[13], gender stereotyping,[14] gendered views of leadership,[15] and culture-abiding self-imposed constraints.[16 17]

Such barriers are, of course, not unique to women leaders or to the context of academic medicine. The wealth of literature exploring women's careers, much of it reviewed in 2 systematic reviews,[12 18] 1 narrative review,[19] and 2 overviews [6 20] conclude that broadly, women faculty face the very same hurdles as they join[12] and progress in academic medicine in their roles as physicians [20], teachers,[18] and researchers.[19] Often, these barriers become reason enough for women to leave academia.[21] Although these reviews, and the studies within them, broaden our understanding of women's experiences, they have treated women's leadership as ancillary to a bigger discourse on career progression, often coming to leadership as one solution to gender inequity. By doing so, these reviews ignore the centrality of leadership in shaping culture and the change needed to realize gender equity. The current systematic review, therefore, aims to address this gap in the research by exclusively reviewing literature on women's leadership in academic medicine.

Background

In the quest to provide patient-centered care, safe learning environments for trainees, and engaging work environments for faculty, the culture of medical education and practice became an area of much scrutiny.[5 21-24] Hostility, disrespect, abuse, and discrimination are widely documented (e.g. US [21 25-28], Canada,[29-31], UK [32-34]) as normalized behaviors. The National Initiative on Gender, Culture, and Leadership in Medicine: C-Change has benchmarked the culture of academic medicine from the perspective of faculty and with special regard to gender equity, both in the US and internationally.[35] As the fulcrum of several studies,[4 5 21 23 24 36-41] C-Change links unhealthy behaviors to culture, and summates that for culture to change, underpinning values need to change first.

But how do values change? According to the organizational literature, cultural values are the values of founding leaders, are adopted by subsequent leaders and members of the culture, and are kept firmly in place by policies and procedures that were developed and implemented over time.[42 43] Although the dynamic interplay between these forces is important, we draw attention to the locus, cultural values are ultimately the values of leaders. In his 2007 speech "Culture and the courage to change",[44] the American Association of Medical Colleges president Kirch spoke to this very point "…This new culture also requires a different kind of leader…search committees will need to look far beyond the weight of a candidate's curriculum vitae, considering factors such as their ability to build alignments, foster trust, and make adaptive changes".[44]

Against the backdrop of need for culture change and a leadership to see it through, we take up women's leadership in academic medicine, often viewed as both savior and victim of culture.[8 22] Such a portrayal illustrates the inevitable role women must play as leaders, especially given their

increased numbers,[10] but it also indicates conceptual immaturity. From the emerging conceptual discourse,[10 17 45-47] we know that scholarship on women's leadership lacks depth, where leadership emergence is commonly restricted to the pipeline metaphor, while enactment of it remains grounded in the generic leadership literature.

Leadership emergence

How women emerge as leaders is often conceptualized using the pipeline metaphor. The metaphor suggests that increasing the number of women in male-dominated fields will eventually lead to an increase in the number of women leaders. According to Magrane and Morahan[10] the metaphor misses pertinent organizational nuances, namely the implicit gender bias women face. For example, while men have many role models and a robust support system, women do not. The metaphor falsely assumes the presence of role models at the end of the pipeline willing to help women transition to leadership. Given the conceptual limitation, the authors propose frameworks that recognize the complex organizational systems women must navigate to emerge as leaders: the leadership continuum[47], and systems of career influences.[45] Such frameworks prompt us to ask questions about the emergence of women's leadership. For example, whether women self-nominate or are appointed to leadership positions in what Northouse[43] calls *assigned leadership*, how long they hold leadership positions, whether they go on to hold dual leadership appointments, and if they indeed have mentors or sponsors who support their careers?

Leadership enactment

Much of women's leadership studies remain grounded in the broader leadership literature.[17] As a result, our conceptualizations of leadership enactment draw on theories developed upon the study

of male leaders, making such scholarship inherently male. For example, the older 'great man' theory exclude women entirely, associating leadership with agentic qualities e.g. authoritative and assertive, qualities that women supposedly do not possess. Newer collaborative theories e.g. participatory, distributed, and transformational leadership seem accommodating for women leaders because of their emphasis on social accountability and collaborative work, however, they risk trapping women in gender stereotypes, e.g. nurturing, that nominate women for less prestigious leadership positions e.g. course coordinator.

A more nuanced conceptualization of leadership enactment, may offer new insights that would help us address stereotyping. For example, women may take on informal leadership roles, in what Northouse[43] calls *emergent leadership,* referring to leadership that develops organically and is based on building alignments and fostering trust. Moreover, our understanding may be expanded by exploring the values that inform women's decisions, the behaviors they model, and the actions they take to improve the quality of medical education and practice whether formally or informally. Addressing these gaps situates women leaders as critical actors in culture change.[22 45 47] and begins to conceptually ground women's enactment of leadership in their lived experiences, rather than the broader generic leadership literature.[17]

It is with the wider need for culture change in academic medicine and the more focused need for conceptual understanding of women's leadership studies in mind that we systematically reviewed studies on women's leadership in academic medicine. It is our aim to first synthesize work done in this area. We ask: 1) What is the extent of women's leadership? 2) What factors influence women's leadership? 3) What is the impact of leadership development programs on

women's individual careers and on medical schools' cultures? We concede that our research questions are broad in scope. We believe it is necessary to cross-cut through these interconnected areas to meet our second aim, which is to present an analysis of such works in the field and critique their collective conceptual framework. We concern ourselves, not only with what was done thus far, but how produced knowledge helps or hinders women's leadership.

Methods

Eligibility Criteria

Search results were independently reviewed against a set of a priori inclusion criteria that included all peer-reviewed 1) English-language articles; with 2) quantitative methodologies (Prospective and retrospective cohort, cross-sectional, and pre-post interventions); reporting studies that evaluated 3) the extent of women's leadership in academic medicine at a departmental, college, and medical graduate program level; 4) hindering factors to women's leadership as perceived by women and men faculty members and leaders; 5) studies that document leadership interventions and their efficacy as reported by women participants of such programs and their home medical schools. We included a case study because it presented quantitative descriptive information on women in leadership across non-Western multinational settings. Although we recognize the interconnection, we excluded quantitative studies that explored women's leadership in professional societies, journal editorial boards, and journal editorships, focusing our examination solely on leadership within medical schools and graduate residency programs. In addition, qualitative study designs were excluded.

Information sources

A primary systematic search was conducted by the first author between April-May 2018 to cover the publication period of earliest date available to April 2018 using the following databases: 1) Ovid MEDLINE (1946-May 2018); 2) EMBASE (1974 - May 2018); 3) CINAHL (1989 -May 2018); 4) Ovid PsycINFO (1967 -April 2018); 5) all EBM Reviews on Ovid-ACP Journal Club, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, and Cochrane Central Register of Controlled Trials (1st quarter); and 6) ERIC (1965 - April 2018). In addition, experts in the field were identified and contacted for published studies not revealed through the databases search. Secondary database searches were performed during the submission process to find additional pertinent material (following the same primary search strategy) to cover the period of April 2018 to the 14th of October 2019. The first author followed a systematic and rigorous plan according to best review practices. A librarian's help was not available. Following the PRISMA protocol,[48] she then screened the compiled results, excluding irrelevant articles, and inductively developed a preliminary thematic framework (Figure 1).

Search Strategy

Systematic searches were performed on the selected 6 online bibliographic databases using a combination of key terms including, but not limited to, "women", "female", "females", "girl", "girls", "leadership", "leader", "academic medicine", and "medical education". The keywords were searched for in the "title" and "abstract" search fields. The searches were filtered by applying the inclusion criteria and literature was identified by using keywords and applying Boolean operators 'OR' and 'AND'. Key terms were defined based on the preliminary readings of the literature to ensure the comprehensiveness of our search key terms. For example,

"Women", in our search context included articles with a clear indication that the participants in the published studies identified as "females". The literature did not differentiate between sex at birth and gender identity in women's leadership. As a result, we do not differentiate sex and gender in this review. An example of a database search strategy is as follows:

"MEDLINE search: Ovid

1. (Women or woman or female or females or girl or girls).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
2. limit 1 to English language
3. (Leadership or Leader or leaders or leading).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
4. limit 3 to English language
5. (Medical education or academic medicine or health professions education or health profession education or professional development or faculty development).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]
6. limit 5 to English language
7. 2 and 4 and 6"

An updated literature search followed the same search strategy for the period of April 2018 to October 2019.

Study selection

Eligibility assessment of the second list of articles titles/abstracts and thematic framework were independently reviewed by both authors based on the inclusion/exclusion criteria. The full texts of nominated articles were then retrieved and read carefully for data extraction and further assessment. At this stage, the bibliographies of nominated articles were reviewed for potential relevant studies. The two authors discussed their findings and differences were reconciled.

Data collection process

An Excel spreadsheet was used to collate extracted data. It contained the following information:

1. Details on the eligible study: the first author's name and year of publication as the study ID, title, publication, study period, and country.
2. Purpose of the study.
3. Population of interest.
4. Methodological variables: study design, sample size, response rate if applicable, and use of validation/reliability measures.
5. Strengths, weaknesses, and limitations.

Risk of bias assessment

We draw on a strategy suggested by the Best Evidence Medical Education Collaboration,[49 50] to provide a narrative of the results. Moreover, using the Medical Education Research Quality

Study Instrument (MERSQI),[51] we give a score and comment on the strength of individual studies, assessing their quality in terms of study design, sampling strategy, type of data, instrument validation, data analysis and outcome measures. The 10-item tool was designed to evaluate quantitative medical education studies, giving a total possible score of 5 to 18. The agreement between raters was very good ($\kappa = 0.93$). Where there was disagreement, the authors resolved their differences by discussion. Furthermore, we point out specific methodological issues (e.g. lack of contextual demographic or career data, limited population, lack of statistical adjustments, and lack of follow up) not covered by the MERSQI assessment (see Supplementary material 1, Methodological limitations).

Patient and public involvement

Patients were not directly involved in this systematic review.

Results

Overview

The initial database search revealed 4024 citations. Review of the titles and abstracts led to the retrieval of 93 full-text articles for further assessment. In the secondary review, 6 studies were identified. Forty two articles met the inclusion criteria and were included in this review (Figure 1), 3 of which were identified through the bibliography search.[52-54] No studies beyond those identified were revealed by the 17 contacted scholars. Original data were available for 40 studies, described in 42 articles.[5 15 52-91] See supplementary material 1 for an overview of included studies.

The majority of studies (n=35) were conducted in the United States, 6 included Canadian respondents,[61 76] information on Canadian programs,[60 77 79] or schools' leadership,[55] 1 study was conducted across 3 countries (UAE, Qatar, and Singapore),[87] 1 study was conducted across 3 European countries (Sweden, the Netherlands and Austria),[70] 1 study was conducted across 4 European countries (Germany, Sweden, Austria, and the UK),[71] 1 study in Norway,[72] and 1 study in Croatia.[80] The earliest study was conducted in 1999,[72] and more than 50% of the studies were published in the past 5 years alone. The design of 9 (26%) studies was retrospective cohort,[15 55 56 69 76 80-82 88] 1 (3%) prospective cohort,[58] and 6 (15%) were pre/post interventions.[62 66 73 75 86] Eleven studies were cross-sectional self-reported questionnaires.[5 61 63 64 68 70 83 84 85 87 89 91] Where questionnaires were used, the response rates ranged from 22 to 100%. Thirteen studies were cross-sectional surveys of publicly available or archives of data,[54 57 59 60 65 67 69 72 74 77 78 79 90] and 1 study was a case report.[71]

Eighteen articles were published by medical education journals, 13 were published by medical specialty journals (Internal Medicine = 3, Hospital Medicine =1, Ophthalmology =1, Obstetrics/Gynecology = 2, Urology = 2, Surgery = 1, Otolaryngology = 1, Roentology =1, Radiology = 1), 5 articles were published by The Women's Health Journal, 3 by general medicine journals (British Medical Journal = 1, the Human Resource for Health Journal = 1, and Cureus =1). Finally, 1 was published by the Journal of Faculty Development.

Many of the studies have methodological limitations. Twelve studies used websites and publicly available data.[15 54-56 59 63 67 69 78 87 90] Six studies did not reveal how their questionnaires were developed or if they were tested.[63 66 83 84 89 91] Many of the questionnaires were self-reported with

modest response rates. The pre/post intervention studies had small number of participants due to the small number of participants in leadership development programs. Moreover, nearly all pre/post studies did not present longitudinal findings on the effectiveness of their interventions.

Only 8 studies provided contextual demographic (ethnicity or age) and career (career-stage, other leadership appointments, or leadership training) data on the studied populations.[5 55 59 62 66 70 85 86] The MERSQI scores of all studies ranged from 7 to 12.5 (supplementary material 1 and 2). In what follows, we present our findings grouped according to 3 theme: the extent of women's leadership and its emergence, the factors influencing women's leadership emergence and enactment, and the impact of leadership programs on women's leadership enactment.

Extent of women's leadership and its emergence

Twenty five studies reported the extent of women's leadership in academic medicine by comparing the number of women attaining leadership positions to the number of men.[54-60 63 67 69 70 72 74 77-84 87 90 91] The studies, however, differed in their approaches and which organizational positions they chose to highlight (Table 1). Three studies merely described the representation of women in specialty leadership positions,[57 67] or within a medical school.[80] One study determined if the proportion of leadership positions in Obstetrics and Gynecology held by women is consistent with the proportion of women entering residency.[55] Six studies compared the composition of chairs and/or program directors' gender to faculty members of medical schools,[59 78 82-84 90] 5 studies compared composition of residency program directors to medical residents composition,[69 74 83 84 90] while 2 studies compared the proportion of residents to department chairs.[83 84] Two studies compared the number of women in leadership positions in one medical specialty to other specialties.[56 69]

While all studies restricted their study to the gender distribution of leadership positions, 3 studies [62 74 85] examined leadership emergence (Self-nomination versus appointment, length of time in position, dual-leadership appointment, and having a mentor/sponsor). For example, Doyle et al.,[63] found that women were assigned to their positions. The authors also found that women leaders on average held positions for 5.3 years compared to men leaders who held positions for 9.1 years.

Factors influencing women's leadership emergence and enactment

Sixteen articles examined factors associated with leadership gender disparities,[5 15 58 61 63 66 68 70 72 73 75 76 81 82 86 88] revealing that women's leadership emergence was challenged by institutional-level barriers: research productivity requirements, educational requirements, and timing of academic appointment, and an interpersonal-level barrier: perceived lack of mentorship. Leadership enactment, on the other hand, was challenged by an institutional-level barrier: poor gender equality policy development and translation, as well as an interpersonal-level barrier: gender stereotyping (Table 2).

On what hinders women's emergence as leaders, 3 studies investigated research productivity.[58 70 81] In 1 study, gender was significantly associated with position through publication activity (β=−.08, 95%CI=−.14 to −.04, p=.003). However, in another study, women were almost half as likely as men (OR, 0.49; 95% CI, 0.35–0.69) to hold leadership positions despite the number of research publications.[58]

White et al.[88] observed notable differences among women and men medical school deans in the type of advanced degrees (Doctorate in male deans vs. business-related degrees in female deans) and the rank of the deans' medical school education and training (more men graduating from the top 50 NIH-ranked schools than women), presenting what seems like a probable association. Little or lack of mentorship was documented as a hindering factor to women seeking leadership.[63]

On what hinders women's enactment of leadership, 3 studies explored women's leadership through the perceptions of medical schools deans,[61] faculty within Psychiatry departments,[63] and faculty at 1 private medical college.[5] For example, Pololi and colleagues [5] reported that women faculty, in comparison to men, were less likely to perceive their institutions as family-friendly ($T = -4.06$, $p < 0.001$), making efforts towards addressing gender diversity ($T = -9.70$, $p < 0.001$), and that their personal values were less congruent with institutional values ($T = -2.06$, $p < 0.05$). Four studies addressed stereotyping and its effects on women's leadership.[15 63 66 72] Sexism was reported as a significant barrier to women faculty as they progressed in their careers in Psychiatry departments ($p = 0.0001$).[63]

In a pre/post intervention, Girod et al.[66] investigated the association between implicit gender biases and leadership positions. The authors found that gender and age were significantly in favor of men (β male = 0.18, $p = 0.001$; β age = 0.04, $p = 0.004$), suggesting that being an older male faculty is inherently associated with leadership than with other age and gender combinations.

The impact of women's leadership programs on leadership emergence and enactment

Seven studies document the impact of women's leadership interventions on individual career satisfaction [62 68 73 75 85 86] and on medical schools' environments.[61] A positive effect of leadership development programs was observed on the values, behaviors, style, and actions women academicians embraced (Table 3). In terms of values, 1 study evaluated leadership programs through the perceptions of medical school deans. In their survey of US and Canadian medical school leadership, Dannels et al.[61] investigated the influence of the Executive Leadership in Academic Medicine (ELAM) program on organizational climate. The authors report that deans had positive perceptions (M = 5.62, SD = 0.961) of the ELAM program and the influence brought to medical schools by its alumnae.[61] The authors also found a significant difference between men and women deans in how they developed leadership in faculty, with women deans reporting more frequent use of practices than did men (p = 0.032). These practices included publicly supporting the person when she/he makes a difficult decision, appointing a faculty member to high-level committees or task forces, and nominating faculty to leadership training outside the institution.

In terms of behaviors, styles, and actions, programs improved women's negotiation skills[68 73 75] and provided networking opportunities.[68 73 75 86] Alumnae of leadership programs were more likely to attain leadership positions,[62 86] they were more likely to have knowledge and confidence in leadership skills, and were more likely to have knowledge of organizational structures and processes.[62] Most studies employed a pre/post design to evaluate leadership programs.

Discussion

To our knowledge, this systematic review is the first that synthesizes evidence on women's

leadership in academic medicine. The 40 studies address 3 themes: the extent of women's leadership and its emergence, factors influencing their leadership emergence and enactment, and the impact of leadership development programs on women's leadership. Deeper analysis revealed that included studies are levered by imperceptible underpinnings. Oriented by a positivist paradigm, it seems much of the reviewed literature inadvertently embraced a narrow understanding of leadership, creating institute-centric rather than women-centric scholarship. Drawing on the findings of our review, in what follows, we unsettle the conceptual foundation of the reviewed studies. We argue that women's leadership studies provide a mere diversity/inclusion performance indicator for institutes that does not necessarily serve women. We then argue the need to shift to a more nuanced women-centric understanding of leadership.

Leadership as organizational position

Our review revealed that in medical schools, women had less access to leadership positions, the evidence showed fewer than 50% of leadership positions –chairs, program directors, or unit heads- were occupied by women faculty members (Table 1). Rooted in understanding leadership as occupancy of an organizational position, in what Northouse[43] calls *assigned leadership*, nearly 60% of the studies' main objective was to document the gender distribution of leadership positions, and often to correlate this with the number of faculty or residents who are women. This conceptualization is based upon a positivist understanding of leadership, which ultimately sees leadership as a quantifiable variable. The rationale for this approach may be that determining gender ratio in leadership will establish a performance indicator for the institute in terms of inclusion and diversity i.e. the number of women in leadership reflects gender equity/inequity. We question the benefit of this reduction to women leaders. Although, we do not think the two are in conflict, we believe institute-centric thinking neglects the value women

leaders bring to leadership and the organizational complexities they must navigate to become leaders. Leadership is not merely an organizational position for women faculty to occupy. Moreover, the number of women occupying leadership positions at a given point in time, an idea perpetuated by the pipeline metaphor,[10] does not by itself reflect equity in leadership. Indeed, the goal is not a critical mass of women who are assigned leaders but "a critical mass of women with sustained success as leaders".[47]

Most studies that examined gender distribution neglected women's emergence as leaders. It is for this reason, and drawing on Northouse's[43] work, that we devised a metric (Table 1). Although not exhaustive, the qualitative metric is an initial attempt to introduce the construct of *leadership emergence* into the discourse on women's leadership in academic medicine. For example, we found that only 2 studies commented on women being appointed,[63 78] and no studies mentioned whether women self-nominated. Our intuition is that informal leadership is common amongst women but whether they self-nominate for formal leadership remains to be seen.

Furthermore, even within the parameters of positivist thinking, all studies are methodologically poor, having a MERSQI range of 7-12.5. Of the 40 studies, 62.5% were cross-sectional. Most studies used websites (which may be outdated or inaccurate, compromising the validity of the findings) or self-reported surveys for data. The median response rates where questionnaires were used was 60% (range, 22%-100%). Many studies failed to explain how their questionnaires were developed or if they were validated.

Leadership as process of influence

Recognizing the limitation of a positivist paradigm, we suggest a women-centric approach. This understanding aligns with organizational traditions, where leadership is conceptualized as a process of influence between leader and followers;[43 92 93] that is a series of actions and exchanges take place at the interpersonal level for leadership to occur. Here scholars recognize the importance of a leader's capacity for influence and how such influence shapes culture.[42 43 94]

First, to explore capacity for influence, we put women at the heart of inquiry: What are women's leadership capacities; that is their motivations, knowledge, skills, and experiences? Many studies did not mention whether women aspired to leadership. Many studies assumed prior leadership knowledge amongst their respondents, a few mentioned formal leadership training and only 1 documented the role of mentors.[63]

We found instead, that studies focused on what hinders women's leadership at an institutional level such as requirement of research production[58 70 81] and certain educational backgrounds.[88] and at an interpersonal-level e.g. gender bias[66] We believe such study objectives are important. However, they may steer women, who aspire to leadership, towards meeting institutional requirements that are not necessarily crucial to becoming a leader. Indeed, Carr et al.[58] showed that women were almost half as likely as men (OR, 0.49; 95% CI, 0.35–0.69) to hold leadership positions despite the number of research publications. By studying what the institute seemingly requires, studies that focus on hindering factors make scholarship on women's leadership institute-centric.

To be women-centric, we grouped hindering factors to the stage of leadership (emergence and enactment) where we believe such factors manifest (Table 2), then we grouped these studies according to the perspective each one took, whether institutional, interpersonal, or individual. Both categorization bring focus to women's capacities for leadership and how they can be best developed.

For example, beyond documenting lack of mentorship,[63] the first categorization prompt us to consider mentorship according to leadership stage. Do women leaders need mentors to emerge as leaders or when they are enacting leadership? Such a distinction draws focus to different nuanced elements. Studying mentoring relationships at an emergence stage may deepen our understanding of women's motivation or lack thereof for leadership. While studying mentoring relationships at an enactment stage may deepen our understanding of women's length of service in formal positions, and the leadership knowledge and skills they gain because of such relationship. This is especially important because, while we found studies that examined hindering factors on the institutional level e.g. policy implementation[60] and the interpersonal level e.g. gender bias,[66] we did not find studies that examined barriers on the individual level e.g. lack of motivation, knowledge, or skills amongst women.

Second, social interactions are the essence of leadership and in time produce culture; the *values* and *beliefs* that govern our behaviors in organizations.[42] From our review, the current culture, is shaped by stereotypical beliefs[5 15 60 65] and a lack of gender equality policy development and implementation.[60] This culture may sometimes feel static and unchanging, but it is recreated and reinforced in the daily interactions. In the proposed conceptualization, we come to recognize that

culture and leadership are two sides of the same coin,[4 41] understanding one requires exploring the other.

Once more we put women at the heart of inquiry: How do women leaders shape culture? From our review, many studies neglected women's *enactment* of leadership. Many studies did not mention whether women had informal leadership roles, in what Northouse[43] calls *emergent* leadership (leadership that develops organically and is based on building alignments and fostering trust). Many studies did not mention what values informed women's decisions, what behaviors they modelled, or what actions they took to improve the quality of medical education and practice whether formally or informally. Many studies did not explore the leadership styles women embraced.

Addressing these gaps situates women leaders as critical actors in culture change.[22 45 47] and conceptually grounds women's leadership in their lived experiences and not the broader generic leadership literature.[17] The exception to the rule is studies examining leadership development programs. [62 68 73 75 85 86] Such programs may be an ideal place to explore women's emergence and enactment of leadership. We found leadership development program studies paid attention to the values, behaviors, actions and styles women embraced and enacted (Table 3).

Study limitations

Our study has some limitations. First, we restricted the review to quantitative literature and argued for studying contextual organizational nuances, which might have been explored in qualitative studies. Second, we defined leadership as a process of influence between leaders and followers but have limited our discussion to the leader's perspective. Third, we found that all

studies except one[87] were conducted in North America and Europe. As a result, the presented evidence may not reflect non-Western contexts, but we have forgone discussion of this finding. Addressing these limitations requires more space and further research which we hope to embark on and invite others to do so.

Conclusion

After reviewing the quantitative literature on women's leadership, we recognize the need for broader conceptual foundations. We also recognize that in problematizing the current conceptual foundation, we join other scholars [5 17 22 47 53] in arguing for more innovative research questions and rigorous methods. Our argument for broadening the conceptual foundation is two-fold. First, by focusing on women's experiences, we can offer readership of this field, who we assume are largely women faculty, practical knowledge that can help them pursue their own leadership. Second, leadership and culture are inextricably linked.[47] Consequently, the culture change we aspire to in academic medicine cannot happen without a deeper understanding of this relationship.

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Figure legends:

Figure 1: Flowchart of search strategy using PRISMA protocol.

Table 1: The extent of women's leadership and its emergence in academic medicine.

Table 2: Thematic analysis of the 15 quantitative articles that examined the hindering factors associated with women's leadership emergence and enactment.

Table 3: Women's leadership programs in academic medicine and their influence on leadership enactment

Table 1

The extent of women's leadership and its emergence in academic medicine

Source	Population/Setting	Outcome	Examination of leadership emergence			
			Self-nomination versus appointment	Length of holding position	Dual position appointment	Mentor/sponsor
Women in leadership positions within one-specialty						
Baecher-Lind 2012[55]	Obstetrics & gynecology departments associated with the council of University Chairs of Obstetrics & Gynecology.	20% of DCs ($p < 0.001$)	None	None	None	None
Cancian et al. 2017[57]	US Urology leadership programs.	1.6% of DCs, & 11.2% of RPDs	None	None	None	None

Cheng et al. 2006[59]	US Emergency departments.	7.5% of DCs & 15% of PDs. Departments chaired by women had significantly higher percentage of women faculty (p = 0.01). Departments chaired by women were more likely to have women PDs (p < .01)	None	None	None	None
Counter et al. 2019[60]	US faculty in academic Pediatric Radiology	56.8% of director, chair, division head/chief 66.7% vice chair, assistant/associate director	None	None	None	None
Doyle et al. 2016[63]	US Psychiatry chairs	10% of chairs were women Male chairs were more likely than female chairs to head large departments (p = 0.02, 95% CI -17.1-69.1).	Women leaders were appointed.	Women leaders on average held position for 5.3 years, compared to men leaders	None	Women leadrs had mentors

				who held positions for 9.1		
Epperson et al. 2019[65]	US Otolaryngology residency and fellowship programs	18.6% of residency and fellowship directors 5.1% of chairs	None	None	None	None
Han et al. 2017[67]	US Urology residency programs	3.3% of DCs, 4.5% of vice chairs, & 7.9% of division directors. For educational leadership roles, women comprised 9.4% of fellowship directors, 8.1% of residency directors, and 27.4% of medical student clerkship directors.	None	None	None	None
Moghimi et al. 2019[77]	Nuclear Medicine in Canada & US	13.6% of leadership	None	None	None	None

Monroe et al. 2015[78]	Department of Medicine at Johns Hopkins University	50% of PDs, 33% PDs assistant/associate director, 27% fellowship PDs, 80% of fellowship program assistant/associate director, & 37% of educational PDs. Women assistant professors were more likely to hold leadership positions than were men assistant professors (p = 0.03).	Women leaders were appointed.	None	None	None
Odell et al. 2019[79]	Neurosurgery in Canada and US	7.45% primary leadership 4.69% secondary leadership	None	None	None	None
Rotbart et al. 2012[82]	Promotion track faculty the University of Colorado School of	25% of section heads & 14% of vice-chairs.	None	None	None	None

	Medicine's Department of Pediatrics					
Shah et al. 2007[83]	US Radiology residency program directors.	10.7% of DCs, 42.9% of PDs. Gender composition of radiology faculty & residents does not differ significantly according to gender of leaders.	None	None	None	None
Shah et al. 2010[84]	US Ophthalmology residency programs directors.	2% of DCs, & 34% of PDs. Gender composition of ophthalmology faculty & residents does not differ significantly according to gender of leaders.	None	None	None	None
Woodward et al. 2017[90]	US Gastroenterology fellowship programs.	18% of PDs, 28% of associate PDs, 7% of division chiefs. Gender of fellowship PDs & gender of division chief	None	None	None	None

		(p= 0.0327), no association with faculty or resident composition.				
Women in leadership positions across several-specialties						
Burden et al. 2015[56]	US academic adult Hospital Medicine (HM) & General Internal Medicine (GIM) programs	16% of division or section heads of HM were women 35% of division or section heads of GIM were women (p = .008)	None	None	None	None
Hofler et al. 2016[69]	US academic departments of Anesthesiology, Diagnostic Radiology, General Surgery, Internal Medicine, Neurology, Obstetrics & Gynecology, Pathology,	women comprised 13.9% of DCs, 22.6% of vice chairs, 21.6% of division directors, & 39% of PDs. Women significantly underrepresented in the combined leadership positions	None	None	None	None

	Pediatrics, & Psychiatry.	for all specialties (Ratios 0.61 or less; all $p < .001$) except anesthesiology & radiology				
Long et al. 2011[74]	US residency program identified as the largest in JAMA (Brotherton SE, Etzel SI. Graduate medical education, 2009–2010. JAMA 2010;304:1255–1270)	25.8% of PDs overall were women. PDs 35.2% Obstetrics, 49% Pediatrics, 23.6% Family Medicine, 34.6% Psychiatry, 24.3% Internal Medicine, 18.8% Emergency Medicine, 29% Anesthesiology, 10.8% Surgery, 27.7% Radiology, 6.5% Orthopedics.	None	None	None	None
Puljak et al. 2008[80]	University of Split School of Medicine in Croatia.	18-21% of DCs in 1997-2006.	None	None	None	None

Reed et al. 2011[81]	women scholarly clinicians employed at Mayo Clinic with 20 or more years of service at Mayo Clinic, who spend more than 25% of their professional effort directly providing patient care.	56% of women held divisional, departmental, institutional or national positions during their careers. Total leadership position attainment between men and women ($p < 0.001$)	None	None	None	None
Weiss et al. 2014[54]	US General Surgery, Orthopedic Surgery, Otolaryngology, Neurosurgery, Plastic Surgery,	General surgery chairs 3% & PDs 10% (p = .002) Orthopedic Surgery 0% & PDs 6% (p = .002)	None	None	None	None

	and Urology programs.	Otolaryngology 5% of chairs & 13% of PDs (p = .045) Neurosurgery 1% of chairs & 3% of PDs Plastic Surgery 6% of chairs & 9% of PDs Urology 3% of chairs & 6% PDs				
Wright et al. 2003[91]	Faculty members of the school of medicine at the University of Arizona	55% served as committee chair, 10% as section or division head, & 8% as DCs. As compared to men: (p=0.03), (p=0), (p=0.003)	Comment on self-assessed leadership potential. Women were appointed.	None	None	None
Women leaders across several institutions or countries						
Carr et al. 2018[58]	US academic medical faculty	10% of women in sample had leadership roles (p < 0.0001). After adjusting for scholarly productivity,	None	None	None	None

		the OR = 0.49 (95% CI, 0.35-.69)				
Kvaerner et al. 1999[72]	Norwegian physicians.	6.4% of women were leaders. 95% CI (2.6-13.9)	None	None	None	None
Stadler et al. 2017[87]	Clinician educators & leadership of competency based graduate medical education in Qatar, Singapore, & UAE	22.1% of PDs & 22.1% of associate PDs.	None	None	None	None

Abbreviations: DC, department chairs; PD, program director

Table 2

Thematic analysis of the 16 quantitative articles that examined the hindering factors associated with women's leadership emergence and enactment.

Theme	Sub-theme	Level	Outcome	Result
Leadership emergence	Research Production	Institutional	Increased production of research is associated with leadership attainment.	Senior leadership positions were more likely held by male faculty despite research publications (OR = 0.49; 95% CI, 0.35–0.69).[58]
			Timing of leadership appointments (mid-career) negatively affected by modest research production.	Women published fewer articles throughout their careers than men (M = 29.5, SD = 28.8 versus M = 75.8, SD = 60.3 – p = .001). However, after 27 years, women produced a mean of 1.57 more publications annually than men (p = .001). Throughout their careers, women held fewer leadership roles than men (p = .001).[81]
			Decreased research production	Gender was indirectly significantly associated with clinical position through publication activity (β=−.08, 95%CI=−.14 to −.04, p=.003). The negative association between gender and publication activity (β=−.21, p The negative association between gender and publication activity (β=−.21, p < 0.001)[70]

	Mentorship	Interpersonal	Lack of mentorship may hinder women from becoming leaders.	Women chairs were more likely than men chairs to perceive barriers in their career development citing little or no mentorship (p=0.04).[63]
	Time of academic appointment	-	Entering academia belatedly may contribute to leadership disparities.	Women faculty in the UCSOM Department of Pediatrics entered academia at a later career stage, in part, resulted in women trying to advance at a later stage than men in academic position and tenure.[82]
	Educational background & advanced degrees	Institutional	Educational background & types of degrees may influence leadership selection.	A greater percentage of male deans graduated from the top 50 NIH-ranked research-award schools than women deans (p = .005, ω2 = 23.3%, η2 = 25.4%) Doctorate degrees were more prevalent among men deans as opposed to business-related degrees among women (MBA, MHA, MPH, or JD).[88]
Leadership enactment	Policy development & translation	Institutional	Dismissal of work-life balance measures.	Out of the 15 family-friendly policies, only 3 were available at more than 68% of medical schools: benefits for part-time faculty, paid maternity & paternity leave.[61]
		Institutional	Dismissal of diversity & inclusion measures.	Fewer than 14% of schools implemented gender equity specific policies.[61]

			Women faculty showed more negative perceptions on equity for women (T=−19.82, p<0.001); institutional change efforts for diversity (T=−9.70, p<0.001).[5]
	Institutional	Incongruence between organizational values & individual values.	Women faculty showed more negative perceptions on values alignment (T= -2.06, p<0.05).[5]
Stereotyping	Institutional	Existence of gendered language in leadership associated policies.	Being a leader is associated with being male (M= 2.4, SD=2.2 – OR= 6, CI 1.02, 35.37) & traditionally male associated traits: analytical (M=2.5, SD=2.4); independent (M= 3.1, SD= 2.6 – OR=1, CI 0.2, 5.1); & individualistic (M=1.8, SD= 1.5 – OR= 1, CI 0.2, 5.4)[15]
	Interpersonal	Existence of implicit gender bias, favoring men as leaders.	Slight implicit preference for men leaders over women (IAT D score = .16, SD = 0.42).[66]

Table 3

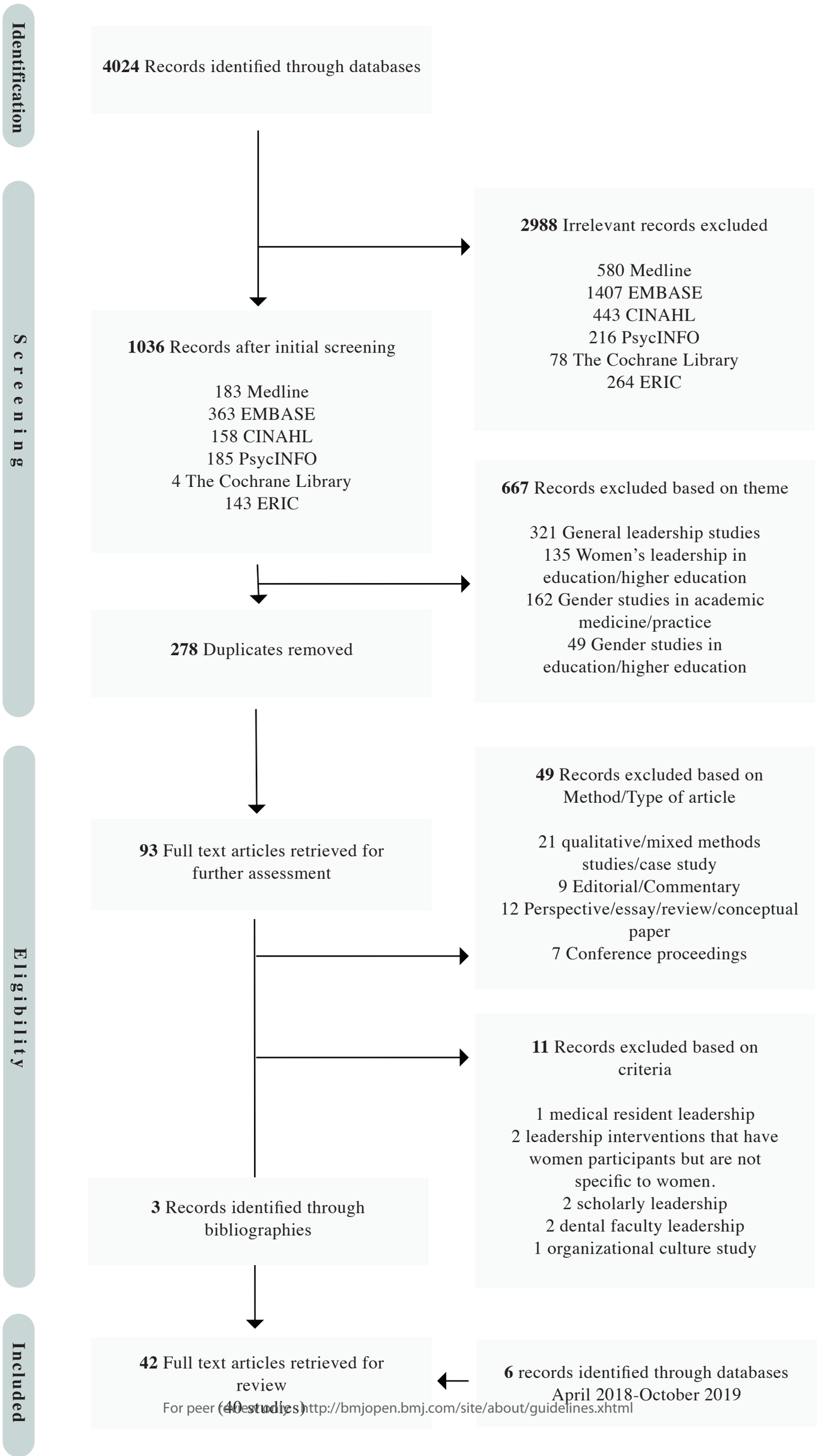
Women's leadership programs in academic medicine and their influence on leadership enactment

Citation	Program	Purpose	Result	Examination of leadership enactment			
				Values	Behaviors	Actions	Styles
Dannels et al. 2009[62]	ELAM	Evaluate a leadership program & its impact from medical school leadership perspective.	Medical school deans' (M = 5.62 out of 7), with those having more fellows reporting greater benefit (*p* = 0.01), positive influence on alumnae (M = 6.27), & increase their eligibility for promotion (M = 5.7)	Yes	Yes	Yes	Yes
Dannels et al. 2008[63]	ELAM	Determine the extent to which program participants, compared with women from two comparison groups, aspire to leadership, demonstrate mastery of leadership	ELAM participants scored higher than AAMC & NON-groups in 15 of the indicators, and for 1 indicator they scored higher than the AAMC group (aspiration to leadership outside academic health centers).	Yes	Yes	Yes	Yes

		competencies, and attain leadership positions.	The differences were statistically significant for 12 indicators. Indicators, including 7 of the leadership competencies, 3 of the administrative leadership attainment indicators, & 2 of the leadership aspirations & education indicators.				
Helitzer et al. 2014[68]	EWIM MidWIM ELAM	Perceptions of CPD program alumnae of CPD.	Across all 3 CPDs leadership aspiration was aligned with career stage; full professors reported more interest in leadership than associate professors (p = .043)	None	Yes	Yes	Yes
Levine et al. 2015[73]	Johns Hopkins	Evaluation of 3 cohorts of a	Significant improvement across 11 leadership	Yes	None	None	Used Myers Briggs

	University School of Medicine Leadership Program for Women Faculty	longitudinal program.	domains except: public speaking & working in teams.				Type Indicator from the generic leadership literature to ascertain leadership style.
McDade et al. 2004[75]	ELAM	Measures impact of ELAM program.	Increased leadership capabilities across all ten identified constructs.	None	Yes; Networking and coalition building.	Yes; conflict resolution, financial management	Asked about women's leadership styles
Skarupski et al. 2019[85]	Johns Hopkins University School of Medicine Leadership Program for Women Faculty	Participants' perceptions in 3 areas: program impact, leadership preparedness, and barriers to leadership advancement.	Increased leadership capabilities across 4 constructs: Foundational skills, personal experience of leadership, sense of professional community and belonging, and networking	Yes	Yes	Yes	Yes

Spalluto et al. 2017[86]	LIFT-OFF	Report of design, implementation, & evaluation of leadership intervention to further the training of female faculty.	31% of educational modules were useful.	None	None	None	None


Identification
Screening
Eligibility
Included
4024 Records identified through databases
2988 Irrelevant records excluded
580 Medline
1407 EMBASE
443 CINAHL
216 PsycINFO
78 The Cochrane Library
264 ERIC
1036 Records after initial screening
183 Medline
363 EMBASE
158 CINAHL
185 PsycINFO
4 The Cochrane Library
143 ERIC
667 Records excluded based on theme
321 General leadership studies
135 Women's leadership in education/higher education
162 Gender studies in academic medicine/practice
49 Gender studies in education/higher education
278 Duplicates removed
49 Records excluded based on Method/Type of article
21 qualitative/mixed methods studies/case study
9 Editorial/Commentary
12 Perspective/essay/review/conceptual paper
7 Conference proceedings
93 Full text articles retrieved for further assessment
11 Records excluded based on criteria
1 medical resident leadership
2 leadership interventions that have women participants but are not specific to women.
2 scholarly leadership
2 dental faculty leadership
1 organizational culture study
3 Records identified through bibliographies
42 Full text articles retrieved for review
(40 studies)
6 records identified through databases
April 2018-October 2019

Supplementary material 1

Characteristics of the 40 articles reviewed from earliest date available – October 2019.

Citation	Country	Study Design	Study Purpose	Time Frame	N +/- RR	Data Source	Methodological limitations	MERSQI Score
Baecher-Lind 2012[55] ¶	USA	Retrospective cohort	Determine whether the proportion of leadership positions in OBS/GYNE held by women is consistent with the proportion of women entering residency.	July-Aug 2012	155 academic departme nt chairs	Department websites for name & sex of leader & state medical license databases for graduation year.	*Limited population*: no report on other leadership positions: vice-chairs, program directors, or unit heads. *Lack of contextual demographic data:* ethnicity, marital status, or age. *Lack of contextual career data*: career stage, dual leadership appointments, or formal leadership training. Does not differentiate community-based & academic programs.	10.5
Burden et al. 2015[56]	USA	Retrospective cohort	Determine the existence of gender disparities among academic hospitalists in leadership & scholarly productivity & compare the results	Oct, 2012 – Aug, 2014	69 Hospital Medicine (HM) Programs 80 General Internal Medicine	Graduate Medical Education Directory (AAMC listed members fully accredited by the Liaison Committee on Medical Education) for programs & department	No *information on* or *adjustment for* size, age or geographic location of HM or GIM departments. It was unclear whether HM departments were divisions or sections of GIM departments.	10.5

			with academic general internists.		(GIM) Programs	websites for sex of leaders, & number/sex of faculty, & Program contacted through email if necessary		
Cancian et al. 2018[57] ¶	USA	Cross-sectional	Determine the number of women in urological leadership positions.	July 2016	NA	Accreditation Council for Graduate Medical Education.	*Lack of contextual demographic data:* ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments, or formal leadership training. Not clear which departments were academic vs community.	8.5
Carr et al. 2018[58]$	USA	Retrospective cohort	Identify predictors of advancement, retention, & leadership for women faculty from a 1995 National Faculty Survey.	1995-2012/13	1995: 1801 faculty, RR = 60% 2012: 1273 faculty, RR = 48%	Mailed national faculty questionnaire conducted in 1995 & a follow-up online self-reported questionnaire in 2012-13	No methodological deficits were identified.	12
Cheng et al. 2006[59]	USA	Cross-sectional	Determine if there is an association between the gender	Dec, 2004	133 EM programs	Society for Academic Emergency	Authors claim retrospective design & although trend of chairperson gender is	9.5

			of the chairperson/program director & the gender of Emergency Medicine (EM) faculty.			Medicine online residency catalog, program websites, & program contacted through email if necessary.	reported, this does not qualify as a retrospective cohort. *Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	
Counter et al. 2019[60]	USA and Canada	Cross-sectional	Assess the evidence of gender disparities and gender differences in academic performance in pediatric radiology departments in USA & Canada	Jan 2017 to Jan 2018	n=279 of 170 US and 13 Canadian programs	FREIDA and CaRMS	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training	9.5
Dannels et al. 2009[61]#	USA	Cross-sectional	Elicit the perceptions of deans on their medical schools' organizational climate & its effect on faculty, policies affecting faculty, processes deans use for developing faculty leadership, and the impact of	May, 2006	142 medical school deans: Overall RR= 58% 72 men RR=57%	AAMC for medical schools & online self-reported questionnaire.	Small sample size of women deans limits detecting relevant statistical effect. *Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership	10.5

			the ELAM Program for Women.		11 women RR=69%		appointments or formal leadership training.	
Dannels et al. 2008[62]#	USA	Pre/post intervention & prospective cohort	Determine the extent of leadership aspiration, mastery of leadership competencies, & attainment of leadership positions amongst graduates of the ELAM compared to 2 comparison groups (NON-ELAM & AAMC group).	2002-06	78 ELAM graduates, RR = 73% 63 NON-ELAM group, RR= 44% 468 AAMC group, RR= 38%	Online self-reported questionnaires.	No methodological deficits were identified.	12.5
Doyle et al. 2016[63]	USA	Cross-sectional	Investigate the causative factors contributing to gender disparity in senior leadership positions in academic psychiatry.	April, 2014	118 (final n =109) Overall RR = 39% 97 men chairs RR = 34% 12 women	Publicly available data: American Association of Chairs of Departments of Psychiatry (AACDP) for psychiatry chair names, department websites for demographic information, & online self-reported questionnaire.	Problematic survey design: Assumption of prior leadership knowledge. Objective does not align with study design: causation cannot be established in cross-sectional study designs.	8

					chairs, RR= 83%			
Ellinas et al. 2018[64]§	USA	Cross-sectional	Identify factors that promote medical faculty's engagement & gender difference in those factors.	June-Aug, 2013	1456 faculty members RR= 42% 227 women	Online self-reported questionnaire.	No methodological deficits were identified.	9
Epperson et al. 2019[65]	USA	Cross-sectional	Evaluates representation of women in otolaryngology holding residency and fellowship directorships, or chair positions.	2017-18	99 department chairs 102 residency directors 204 fellowship directors	Publicly available data: American Medical Association's Fellowship and Residency Interactive Database. Program websites	Lack of contextual demographic data: ethnicity, marital status, or age. Lack of contextual career data: dual leadership appointments, or formal leadership training.	9.5

Girod et al. 2016[66]	USA	Pre/post intervention	Investigate the implicit & explicit biases favoring men as leaders & assess whether these attitudes change following an educational intervention.	March 2012-April 2013	281 faculty members	Questionnaire for general perceptions of bias, measure of explicit attitudes related to gender & leadership, & Implicit Association Test (IAT).	Findings limited by lack of longitudinal data on effectiveness of intervention.	9.5
Han et al. 2017[67]§	USA	Cross-sectional	Determine the gender & subspecialty of those holding academic departmental, administrative & educational leadership roles in urology.	June-Aug, 2016	124 urology programs	Accreditation Council for Graduate Medical Education for programs & Urology department websites for main data. Program contacted if necessary.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	8.5
Helitzer et al. 2014[68]	USA	Cross-sectional	Explore whether skills acquired by women in career development programs implemented by AAMC & Drexel University would vary by career stage & program attended.	Feb – April, 2011	2537 women participants, RR = 35%	National online self-reported questionnaire.	*Limited population*: Loss of follow-up on participants who left academic medicine.	9

Hofler et al. 2016[69]^	USA	Cross-sectional	Compare the representation of women in OB/GYNE department-based leadership to leadership in other clinical specialties while accounting for the proportions of women in the residency cohorts of 1990.	Nov-2012 to Oct, 2013	851 eligible programs 105 OB/GYN programs	Accreditation Council for Graduate Medical Education 2012-13 for programs & program websites for leadership positions.	*Lack of contextual demographic data:* ethnicity, or age. Assumption that women choose academic medicine early in their career in equal proportion to men.	9.5
Komlenac et al. 2019[70]	Sweden, the Netherlands and Austria	Cross-sectional	Explore gender differences in clinical position among academic physicians at three university hospitals	2012	1333 participants	Questionnaire of the HOUPE II study	Low response rate Leadership positions were limited to clinical positions; no mention of academic leadership posts	8
Kuhlmann et al. 2017[71]	Sweden, Germany, Austria, &UK	Case study	Explore & compare the representation of women in leadership and management in European academic health centers.	May, 2016	4 academic health centers	Unspecified	No methodological deficits were identified.	NA
Kværner et al. 1999[72]	Norway	Cross-sectional	Determine the proportion of women leaders to men leaders.	Oct, 1997	Overall reported 13,844 physician	Norwegian Medical Association records.	No methodological deficits were identified.	9.5

					s; 3939 women. *N* in academic medicine 334; 94 women			
Levine et al. 2015[73]	USA	Pre/post intervention	Describe & evaluate a longitudinal cohort-based leadership program for women faculty at the Johns Hopkins University School of Medicine.	2010-2013	134 women RR cohort 2: 80%, 58% RR cohort 3: 86%, 76% RR cohort 4: 92%, 69%	Self-reported questionnaire.	No follow up on long term effect of program.	8.5
Long et al. 2011[74]	USA	cross-sectional	Compare the gender distribution of residency program directors with gender distribution of residents & faculty	NA	601 female program directors 75,156 Residents	Educational issue of JAMA, 2010 for information on the 10 largest residency specialties. ACGME website for number and program names.	No methodological deficits were identified.	9.5

			in the 10 largest specialties.			AAMC for gender distribution of medical school faculty.		
Marchant et al. 2007[15]	USA	Retrospective cohort	Examine whether the presence of the word "leader" in written tenure criteria may impact the promotion of women in elite medical school differently than men.	2004	24 medical schools	Carnegie Foundation classification system and the National Institutes of Health (NIH) for medical schools. School's website for tenure criteria.	Limited sample size (24/125), does not account for recruitment or departure of tenured female faculty, or the number of faculty who apply for tenure. Wide C.I. (1.02, 35.37) Uncertainty is greater with wider confidence intervals.	11.5
McDade et al. 2004[75]#	USA	Pre/post intervention	Measure the impact of the ELAM program on women academicians' leadership capacities.	1997-2001	79 participants RRs were nearly 100% (pre) & 69% to 76% (post)	Self-reported questionnaire	Only one group, lack of follow-up.	11
McLean et al. 2013[76]	USA	Retrospective cohort	Explore whether geographic mobility is associated with career advancement of women in U.S. medical schools who	2009	345 ELAM participants	ELAM database	Unclear whether Canadian participants were accounted for.	10.5

			are entering mid- to executive-level positions.					
Moghimi et al. 2019[77]	USA and Canada	Cross-sectional	Compare gender representation in academic and leadership positions among faculty members in nuclear medicine in USA & Canada. Study the influences to account for the existing disparity in academic nuclear medicine.	June-December 2016	n=249 Available faculty lists of 75 U.S. and 8 Canadian nuclear medicine programs	FREIDA, AMA, & CaRMS	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	9.5
Monroe et al. 2015[78]	USA	Cross-sectional	Delineate leadership positions in the Department of Medicine held by faculty & compare leadership positions held by male & female.	2012	474 faculty, 181 were women.	Division websites &/or Johns Hopkins referral directory, or division heads.	*Lack of contextual demographic data:* ethnicity, or age. *Lack of contextual career data*: career stage, dual leadership appointments or formal leadership training. Lack of definition of leadership. Response bias.	8.5
Odell et al. 2019[79]	USA & Canada	Cross-sectional	Assess the factors contributing to gender differences in the academic ranks in academic neurosurgery	January - May 2017	n=319 faculty in leadership ranks 89 US and 9	FREIDA and CaRMS	*Lack of contextual demographic data:* ethnicity, or age. *Lack of contextual career data*: career stage, dual	9.5

			programs in Canada & USA		Canadian neurosurgery programs		leadership appointments or formal leadership training.	
Pololi et al. 2012[5]	USA	Cross-sectional	Assess & compare the experiences of women & men faculty of institutional culture including leadership.	2007-2009	4578 faculty, RR= 52%	Online self-reported questionnaire.	No methodological deficits were identified.	10.5
Puljak et al. 2008[80]	Croatia	Retrospective cohort	Determine the extent of women advancing to leadership positions.	1979-2006	NA	University of Split School of Medicine's archives.	*Lack of contextual demographic data:* Ethnicity, marital status, or age.	9.5
Reed et al. 2011[81]	USA	Retrospective cohort	Compare the publication records, academic promotions, & leadership appointments of women and men physicians.	2007	25 women 50 men	Mayo clinic faculty database (CVs).	*Lack of contextual demographic data:* Ethnicity, marital status, or age.	9.5
Rotbart et al. 2012[82]	USA	Retrospective cohort	Determine the extent of gender inequity in a pediatrics department including leadership attainment & to	2009	263 faculty members	Department databases: The Faculty Information Database Online (FIDO), department Web-based software contains data on faculty	No methodological deficits were identified.	9.5

			demonstrate an assessment methodology other departments can use.			members' careers, & PeopleSoft containing salary records.		
Shah et al. 2007[83]	USA	Cross-sectional	Determine if there is any association between the gender of the chairperson/residency program director & the gender of faculty & residents in radiology.	Dec, 2006	188 programs directors, RR= 45%	Online self-reported questionnaire.	Does not account for women self-selecting for leadership positions.	8
Shah et al. 2010[84]	USA	Cross-sectional	Determine if there is any association between the gender of the chairperson/residency program director & the gender of faculty & residents in ophthalmology.	July, 2007	121 program directors, RR=45.45%	Online self-reported questionnaire.	Only 2 women chairpersons, not large enough to detect association.	8
Skarupski et al. 2019[85]	USA	Cross-sectional	Report participants perceptions of a leadership program in 3 areas: 1)program impact; 2)leadership preparedness; and 3)barriers to	May- July 2017	RR =114, 40% of 8 cohorts	Online self-reported questionnaire.	Low response rate.	9

			leadership advancement					
Spalluto et al. 2017[86]	USA	Pre/post intervention	Describe development & implementation of LIFT-OFF leadership program.	June, 2015 – May, 2016	39 participants, needs assessment RR = 89.7% Questionnaire RR = 76.9%	Self-reported questionnaire.	Findings limited by lack of longitudinal data on effectiveness of intervention.	10
Stadler et al. 2018[87]	Singapore, Qatar, & UAE	Cross-sectional	Describe gender differences of international clinician educators & leaders in emerging international competency-based residency programs.	June 2013-June 2014	359 leaders, 69 were women RR = 76.3%	Program websites or through individual researchers who work for each respective institute.	No methodological deficits were identified.	10
Weiss et al. 2014[54]	USA	Cross-sectional	Evaluate number of women chairs, program directors, & division chiefs in surgical specialties.	NA	249 programs	National Residency Matching Program for programs, AAMC report for resident & faculty, & program websites for information on chairs.	*Lack of contextual career data*: dual leadership appointments or formal leadership training.	9.5

White et al. 2012[88]	USA	Retrospective cohort	Explore factors that may be involved in the persistent paucity of women leaders in U.S. academic medicine & to provide baseline gender-related data for developing strategies to promote gender equity in academic medicine leadership.	1980-2006	534 Medical school deans	AAMC faculty roster & Council of Deans database.	*Lack of contextual demographic data:* Ethnicity, marital status.	10.5
Willett et al. 2015[89]	USA	Cross-sectional	Determine whether salary disparities exist between women & men Internal Medicine residency program directors, & if so, to identify factors associated with the disparities.	Aug, 2012	370 program director, RR= 65.1%	Association of Program Directors in Internal Medicine for Programs, & online self-reported questionnaire.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: medical specialty, dual leadership appointments, or formal leadership training.	10.5
Woodward et al. 2017[90]	USA	Cross-sectional	Determine the ratio of women occupying program directors' positions to division chiefs in gastroenterology fellowships, & to evaluate factors	2015	163 gastroenterology programs	American College of Gastroenterology, AAMC website, & program websites.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: career stage, dual	9.5

			associated with this.				leadership appointments, or formal leadership training. Does not differentiate community-based & academic programs.	
Wright et al. 2003[91]§	USA	Cross-sectional	Determine reasons for gender disparities in leadership.	1999-2000	418 faculty, RR= 48%	College of Medicine Personnel database, Online self-reported questionnaire.	*Lack of contextual demographic data:* Ethnicity, marital status, or age. *Lack of contextual career data*: dual leadership appointments or formal leadership training.	7

Abbreviations: MERSQI, Medical Education Research Study Quality Instrument; N, Population; RR, response rate; ELAM, Executive Leadership in Academic Medicine; NA, not available.
¶ Studies that report various leadership positions within one specialty (e.g. editorship, society membership), here we report only those which are academic.
§ Studies with a study purpose beyond leadership (e.g. scholarly production).
^ reported in 2 papers Hofler et al., 2016 Hofler et al., 2015
# reported in 2 papers Dannels et al., 2008, Dannels et al., 2009, McDade et al., 2004 also reported in a 2nd paper Morahan et al., 2010

Supplementary material 2

Quality of studies included using the MERSQI (n=39 excluding the case study)

Item (max. points)	Detailed scores	No. (%)
Study design (3)	Cross-sectional (1)	25 (64.1)
	Single-group pretest and posttest (1.5)	4 (10.26)
	Non-randomized, 2 groups (including cohort studies) (2)	10 (25.64)
Sampling institutions (1.5)	1 institution (0.5)	10 (25.64)
	3 or more institutions (1.5)	29 (74.35)
Sampling: response rate (1.5)	NA	21 (53.84)
	<50% or not reported (0.5)	9 (23.07)
	50%-74% (1)	6 (15.38)
	> 75% (1.5)	3 (7.69)
Type of data (3)	Assessment by study participants (1)	16 (41.02)
	Objective (3)	23 (58.97)
Validity evidence (3)	NA	27 (69.23)
	Internal Structure (1)	6 (15.38)
	Content (1)	8 (20.51)
	Relationship to other variables (1)	2 (5.13)
Data analysis: sophistication (2)	Descriptive analysis only (1)	2 (5.13)
	Beyond descriptive analysis (2)	37 (94.87)
Data analysis: appropriate (1)	Data analysis appropriate for study design and type of data (1)	39 (100)
Outcome (2)	Attitudes, perceptions, opinions, general facts (1)	34 (87.17)
	Knowledge, skills (1.5)	2 (5.13)
	Behaviors (2)	3 (7.69)