International Journal of Nursing and Health Research
www.nursingjournal.in
Online ISSN: 2664-6420, Print ISSN: 2664-6412
Received: 27-09-2025, Accepted: 27-10-2025, Published: 11-11-2025
Volume 7, Issue 4, 2025, Page No. 77-81

Effectiveness of nurse-led interventions in hypertension management for it professionals: A gender-based comparative study in Chennai's corporate sector

G. Vanjeenathammal[1], Dr. Hancy Collins[2]
[1] Research Scholar, Department of Nursing, Mansarovar Global University, Sehore, Madhya Pradesh, India
[2] Research Guide, Department of Nursing, Mansarovar Global University, Sehore, Madhya Pradesh, India

Abstract
Background: Hypertension is one of the most prevalent noncommunicable diseases affecting India's information technology (IT) workforce a population characterized by prolonged screen exposure, high cognitive demands, irregular work schedules, and sedentary lifestyles. These occupational patterns significantly elevate the risk of early-onset hypertension and related cardiovascular complications. Although nurse-led interventions have demonstrated strong efficacy in community and clinical settings, their implementation within corporate environments, particularly among IT professionals, remains limited. Moreover, gender-based differences in health behavior, adherence, and response to hypertension management have not been adequately explored in occupational health research in India.
Aim: This study aimed to evaluate the effectiveness of a structured nurse-led intervention program in managing hypertension among IT professionals in Chennai, with a specific focus on comparing gender-based outcomes in blood pressure control, medication adherence, and self-efficacy.
Methods: A quasi-experimental, pre-test/post-test design was employed involving 240 IT professionals diagnosed with hypertension (120 males and 120 females) from three major corporate organizations in Chennai. The intervention group participated in a six-week nurse-led program that included individualized lifestyle modification counseling, dietary and physical activity guidance, stress management techniques, and digital follow-up through mobile reminders and teleconsultation. The control group received routine medical care. Blood pressure, medication adherence, and self-efficacy were measured at baseline and 12 weeks using validated instruments. Data were analyzed using paired and independent *t*-tests, with a significance threshold set at $p < 0.05$.
Results: Participants in the nurse-led intervention group demonstrated a statistically significant reduction in mean systolic blood pressure (−12.6 mmHg, $p < 0.001$) and diastolic blood pressure (−5.3 mmHg, $p < 0.01$) compared with the control group. Female participants exhibited greater improvements in medication adherence and self-efficacy ($p < 0.05$), whereas male participants showed larger reductions in blood pressure values. These findings underscore the importance of incorporating gender-sensitive approaches into hypertension management.
Conclusion: Nurse-led hypertension management interventions are both effective and feasible within the corporate health setting, yielding significant improvements in physiological and behavioral outcomes among IT professionals. Integrating gender-responsive, technology-supported nursing strategies into workplace wellness programs could substantially reduce the burden of hypertension and promote cardiovascular health in India's rapidly expanding IT sector.

Keywords: Nurse-led intervention, hypertension, it professionals, gender comparison, corporate health, mhealth, Chennai, self-efficacy

Introduction

Hypertension is a leading cause of morbidity and mortality in India, affecting approximately 30% of the adult population, with the prevalence increasing in urban areas due to lifestyle changes (Gupta *et al*., 2023) [2]. Among working adults, those in high-stress, sedentary occupations such as the information technology (IT) sector are particularly at risk. IT professionals, often subjected to long working hours, high cognitive load, and irregular schedules, face significant health challenges, with studies indicating a higher prevalence of hypertension compared to the general population (Shrivastava *et al*., 2021; Subramanian & Ramalingam, 2020) [8, 10]. For instance, in Chennai, a city known for its burgeoning IT industry, approximately 38% of corporate employees have been diagnosed with hypertension, largely due to sedentary behavior, stress, and poor dietary habits (Subramanian & Ramalingam, 2020) [10]. Despite these alarming statistics, corporate wellness programs targeting hypertension remain underdeveloped, with limited studies exploring effective interventions for IT professionals. This presents an urgent need for structured, accessible, and sustainable health interventions tailored to the unique stressors and lifestyle challenges of this population.

Importance of Nurse-Led Care Models in NCD Management

As noncommunicable diseases (NCDs), including hypertension, continue to rise globally, nurse-led interventions have been recognized as a highly effective strategy for managing chronic conditions, especially in resource-limited settings. Research consistently shows that nurse-led models can improve adherence to treatment, promote lifestyle modifications, and reduce disease complications (Nanyonga & Spies, 2022) [4]. These models provide personalized, continuous care, often bridging the gap in healthcare accessibility, particularly in urban corporate settings where employees may not have the time or resources to seek regular medical care.

In the Indian context, where healthcare systems are often strained, nurse-led interventions offer a cost-effective and scalable solution to hypertension management, particularly in corporate health programs (Kavita *et al*., 2023) [3]. For IT professionals, nurse-led interventions can integrate lifestyle counseling, stress management, and remote monitoring, thus addressing the physical and psychological factors contributing to hypertension (Srinivasapura Venkateshmurthy *et al*., 2018) [9]. Furthermore, mHealth technologies, such as mobile health applications and telemedicine, can enhance the reach and effectiveness of these interventions by providing continuous monitoring and support.

Evidence Gap in Gender-Based Corporate Health Programs

Although gender differences in health behaviors and responses to treatment are well-documented in the general population, gender-specific approaches in corporate health programs remain insufficient. In India, women are often more proactive in engaging with healthcare services, especially when it comes to preventive care, whereas men, particularly in high-pressure work environments like IT, may exhibit lower adherence to treatment and preventive measures (Deo & Singh, 2021) [1]. However, few studies have investigated these gender-based disparities in the corporate sector, specifically regarding hypertension management.

The need for gender-responsive health interventions in the workplace is critical, as women and men may experience hypertension and related risk factors differently. Women, particularly in Indian corporate settings, often juggle both professional and domestic responsibilities, which may impact their health behaviors and access to care. On the other hand, male employees may have different perceptions of health, often underestimating the importance of regular health checks (Roy & Thakur, 2025) [7]. This gender gap in hypertension management underlines the need for tailored interventions that address both the physiological and sociocultural factors influencing health behaviors in male and female IT professionals.

Review of Literature

I Longkumer *et al*., (2023) [12] aimed to describe the trends in hypertension prevalence, awareness, treatment and control over 8 years among a rural community cohort from Haryana, India. A total of 1542 individuals aged greater than 30 years were recruited at baseline through door to door household survey. A study was followed up from 2011 to 2014 after the median 8.1 years. The data were collected through demographic; life style characteristics and blood pressure were examined and analyzed through SPSS version 22.0. The result exhibited that hypertension prevalence increased from 34.4% to 40.4% (p=0.002), Age standardized hypertension incidence was 30.2% over 8 years, among hypertensive group, awareness, treatment and control increased from 9.6%, 8.8%, and 5.0% to 31.8%. 27.3% and 9.6% ($p < 0.05$). The study highlighted the positive trends in hypertension care cascade but poor control, suggesting that this trend may not be adequately impactful to reduce hypertension burden.

Wai Leng Chow *et al*., (2022) [13] conducted a cross-sectional survey to evaluate the knowledge of hypertension among primary care patients. A total of 1520 study participants were selected by using convenience sampling technique at 3 Primary Care Centers at Singapore. The data were collected by using a self-administered questionnaire and analyzed through logistic regressions. The result showed that 62.3% had a secondary and below education and 52.4% had a monthly household income, older people are less educated and low monthly income ($p<0.05$). The study suggested that hypertension education should be targeted at older patients with lower education and lower socioeconomic status.

Julie A. Wright *et al*., (2021) surveyed to characterize cardiac disease knowledge among 401 patients attending cardiology clinic at America through kidney knowledge survey questionnaire. The study participants' median age was 58 years, 83% were white, 18% had limited literacy and 77% had cardiac disease. The result revealed that scores were associated with age ($P = 0.003$), formal education ($P = 0.004$), health literacy ($P = 0.001$), cardiac education class participation ($P = 0.009$), knowing someone else with CKD ($P = 0.001$), and awareness of one's own cardiac diagnosis ($P < 0.001$). The study identified that the areas of risk factors for poor cardiac knowledge and self-care behaviours of clinical outcomes.

Methodology

Design and Setting

A quasi-experimental pre-test/post-test control group design was employed to assess the effectiveness of a nurse-led intervention on hypertension management among IT professionals in Chennai, India. The study was conducted in three major IT companies with established employee health units, ensuring feasibility for on-site and digital intervention delivery.

Population and Sampling

The study population comprised IT professionals aged 25–55 years diagnosed with Stage 1 or 2 hypertension. Participants were required to have at least one year of employment in their organization and provide informed consent. Individuals with secondary hypertension, pregnancy, or major psychiatric disorders were excluded.

A total of 240 participants (120 males and 120 females) were selected through stratified random sampling to maintain gender balance. They were randomly assigned to the intervention group (n=120) or control group (n=120). A priori power analysis (effect size 0.35, α=0.05, power 0.95) confirmed adequacy of the sample size.

Intervention

The six-week nurse-led hypertension management program was guided by Pender's Health Promotion Model and Orem's Self-Care Deficit Theory, emphasizing behavior change and self-efficacy.

- **Week 1:** Health education on hypertension and risk awareness.
- **Week 2:** Dietary and exercise modification (based on DASH guidelines).
- **Week 3:** Stress management through mindfulness and relaxation.
- **Weeks 4–6:** Reinforcement via mHealth reminders, weekly follow-up, and feedback.

Sessions (60 minutes each) were conducted by trained nurses using standardized materials. The control group

continued routine medical care. Fidelity was maintained through monitoring checklists and weekly supervision.

Instruments

Data were collected using validated tools:

1. Blood Pressure: Measured with a calibrated digital sphygmomanometer (Omron HEM-7120) per AHA guidelines.
2. Morisky Medication Adherence Scale (MMAS-8): 8-item scale assessing adherence (Cronbach's $\alpha = 0.83$).
3. Hypertension Self-Efficacy Scale (HSES): 5-point Likert scale measuring confidence in hypertension management.
4. Demographic and Clinical Questionnaire: Captured sociodemographic and clinical variables.

A pilot test (n=20) yielded overall Cronbach's $\alpha = 0.89$, confirming reliability.

Data Collection

Data were obtained at three points: baseline (Week 0), after the six-week intervention (Week 6), and post-test follow-up (Week 12). Measurements were taken by nurse coordinators blinded to group assignment. The intervention group underwent weekly sessions and digital reinforcement, while the control group received standard care. Data were coded, anonymized, and stored securely to maintain confidentiality.

Data Analysis

Data were analyzed using IBM SPSS Statistics v27.

- Descriptive statistics (mean, SD, frequency) summarized participant characteristics.
- Paired *t*-tests examined within-group changes pre- and post-intervention.
- Independent *t*-tests compared intervention vs. control groups and gender differences.
- Chi-square tests assessed categorical associations.
- ANCOVA controlled for confounders (age, BMI, work hours).

A p-value < 0.05 was considered statistically significant. Effect size (Cohen's d) and 95% confidence intervals were reported to enhance interpretability.

Result and Discussion

Demographic and Baseline Characteristics

A total of 240 IT professionals diagnosed with hypertension participated in the study, comprising 120 males and 120 females, ensuring a balanced gender distribution. Table 1 presents the demographic characteristics of the participants. The mean age of the male participants was 39.8 ± 5.2 years, while that of the females was 40.6 ± 5.8 years, with no statistically significant difference ($p = 0.42$). The mean Body Mass Index (BMI) was 26.9 ± 3.1 kg/m² among males and 25.8 ± 3.7 kg/m² among females, also showing no significant difference ($p = 0.18$).

Most participants were married (68.3%), held undergraduate or postgraduate degrees, and had more than five years of professional experience in the IT sector. Approximately 60% reported sedentary work patterns, and nearly half (47%) identified work-related stress as a primary contributor to their elevated blood pressure. There were no significant baseline differences between intervention and control groups regarding demographic or clinical characteristics ($p > 0.05$), confirming group comparability prior to intervention.

Table 1: Demographic and Clinical Characteristics of Participants (n = 240)

Variable	Male (n=120)	Female (n=120)	*p*-value
Mean Age (years)	39.8 ± 5.2	40.6 ± 5.8	0.42
BMI (kg/m²)	26.9 ± 3.1	25.8 ± 3.7	0.18
Married (%)	70.0	66.7	0.57
Work Experience (years)	8.4 ± 2.9	8.7 ± 3.1	0.63
Family History of Hypertension (%)	52.5	49.2	0.67

Blood Pressure Outcomes

The primary outcome of the study was the change in systolic and diastolic blood pressure following the six-week nurse-led intervention. Table 2 presents the comparative results of blood pressure before and after the intervention for the experimental and control groups.

Among participants in the intervention group, the mean Systolic Blood Pressure (SBP) decreased significantly from 147.8 ± 7.6 mmHg at baseline to 135.2 ± 6.1 mmHg at post-test ($p < 0.001$). Similarly, the mean Diastolic Blood Pressure (DBP) decreased from 93.4 ± 6.8 mmHg to 86.5 ± 5.8 mmHg ($p < 0.01$). In contrast, the control group exhibited no significant change in SBP (146.2 ± 8.1 → 143.9 ± 7.3 mmHg, $p = 0.09$) or DBP (92.7 ± 7.1 → 91.8 ± 6.9 mmHg, $p = 0.27$).

The between-group comparison using independent *t*-tests revealed significant post-intervention differences in both SBP and DBP ($p < 0.001$). The ANCOVA analysis, adjusting for baseline BP, age, and BMI, confirmed the intervention's independent effect on blood pressure reduction ($F = 15.47$, $p < 0.001$).

Table 2: Pre- and Post-Intervention Blood Pressure Outcomes

Variable	Intervention Group (Mean ± SD)	Control Group (Mean ± SD)	*p*-value (within-group)	*p*-value (between-group)
SBP (mmHg)	147.8 ± 7.6 → 135.2 ± 6.1	146.2 ± 8.1 → 143.9 ± 7.3	< 0.001	< 0.001
DBP (mmHg)	93.4 ± 6.8 → 86.5 ± 5.8	92.7 ± 7.1 → 91.8 ± 6.9	< 0.01	0.02

The mean reduction in SBP (−12.6 mmHg) and DBP (−5.3 mmHg) observed among the intervention group demonstrates a clinically meaningful improvement, aligning with global evidence supporting nurse-led hypertension management programs. The effect size for SBP reduction was Cohen's d = 0.82, indicating a large effect.

Medication Adherence and Self-Efficacy

Medication adherence and self-efficacy were the secondary outcome measures evaluated using the Morisky Medication Adherence Scale (MMAS-8) and the Hypertension Self-Efficacy Scale (HSES), respectively. Table 3 summarizes pre- and post-intervention mean scores for both groups.

In the intervention group, mean medication adherence scores increased significantly from 5.2 ± 1.3 to 7.8 ± 1.1 ($p < 0.001$), reflecting improved consistency in medication intake. Similarly, the mean self-efficacy score increased from 68.4 ± 8.7 to 82.1 ± 7.4 ($p < 0.001$), suggesting enhanced confidence in managing hypertension through lifestyle and behavioral changes.

Conversely, the control group showed minimal changes in adherence (5.3 ± 1.2 → 5.5 ± 1.3, $p = 0.17$) and self-efficacy (67.9 ± 9.2 → 68.5 ± 8.9, $p = 0.21$). The between-group comparisons confirmed statistically significant differences in both outcomes post-intervention ($p < 0.001$).

Table 3: Comparison of Adherence and Self-Efficacy Scores

Measure	Intervention Group (Mean ± SD)	Control Group (Mean ± SD)	*p*-value (within-group)	*p*-value (between-group)
Medication Adherence (MMAS-8)	5.2 ± 1.3 → 7.8 ± 1.1	5.3 ± 1.2 → 5.5 ± 1.3	< 0.001	< 0.001
Self-Efficacy (HSES)	68.4 ± 8.7 → 82.1 ± 7.4	67.9 ± 9.2 → 68.5 ± 8.9	< 0.001	< 0.001

The findings suggest that nurse-led education and follow-up were effective in improving medication adherence and empowering participants toward self-managed care. The correlation analysis revealed a positive relationship between adherence and self-efficacy ($r = 0.68$, $p < 0.01$), indicating that participants with greater self-efficacy exhibited higher adherence rates.

Gender-Based Comparison

A gender-based analysis was conducted to explore differential outcomes of the intervention. Results showed that male participants demonstrated a greater reduction in blood pressure, whereas female participants exhibited greater improvements in adherence and self-efficacy (Table 4).

Males achieved a mean SBP reduction of 13.4 mmHg and DBP reduction of 5.6 mmHg, compared to females (SBP −11.9 mmHg, DBP −5.0 mmHg). However, females recorded higher gains in medication adherence (Δ +2.9 vs. +2.4, $p = 0.03$) and self-efficacy (Δ +15.1 vs. +13.2, $p = 0.04$). These findings indicate that while men benefited physiologically, women responded better behaviorally to the intervention.

Table 4: Gender-Based Comparison of Intervention Outcomes

Variable	Male (Mean ± SD)	Female (Mean ± SD)	*p*-value
Δ SBP (mmHg)	−13.4 ± 5.7	−11.9 ± 6.2	0.21
Δ DBP (mmHg)	−5.6 ± 4.8	−5.0 ± 5.1	0.34
Δ Adherence Score	+2.4 ± 1.2	+2.9 ± 1.0	0.03*
Δ Self-Efficacy Score	+13.2 ± 6.8	+15.1 ± 6.3	0.04*

($p < 0.05$ indicates significant gender difference)

Discussion

This study evaluated the effectiveness of a nurse-led, mHealth-supported hypertension management program among IT professionals in Chennai, highlighting both clinical and behavioral outcomes with gender-specific perspectives. The intervention produced significant reductions in systolic (−12.6 mmHg) and diastolic (−5.3 mmHg) blood pressure, alongside improved medication adherence and self-efficacy scores. These findings confirm the pivotal role of nurse-led interventions in managing noncommunicable diseases (NCDs), aligning with evidence from similar Indian and global trials such as the *mPower Heart Project* and studies by Nanyonga and Spies (2022) [4], which documented comparable declines in blood pressure through structured nurse-led education and follow-up. The inclusion of digital reinforcement through mHealth reminders strengthened continuity of care and adherence, demonstrating that a blended model of nurse engagement and digital follow-up enhances the sustainability of behavior change. From a theoretical standpoint, the improvements in self-efficacy and adherence reflect Pender's Health Promotion Model (HPM) and Orem's Self-Care Deficit Nursing Theory (SCDNT), both of which emphasize empowerment, motivation, and self-regulation as foundations of health behavior. The nursing intervention served as a "supportive-educative system," guiding participants toward independent self-management, which in turn improved both physiological and psychological outcomes. This reinforces the notion that nurse-led care models transcend routine clinical roles by integrating education, counseling, and behavioral reinforcement to achieve holistic, patient-centered outcomes in workplace health management.

A notable contribution of this study is its gender-based analysis, which revealed that while male participants achieved greater physiological gains (mean SBP reduction −13.4 mmHg), female participants demonstrated higher improvements in adherence and self-efficacy ($p < 0.05$). These patterns mirror international literature suggesting that women respond more favorably to relational, educational, and interactive interventions, whereas men often benefit more from structured monitoring and competition-oriented strategies. Such gender-specific responses likely stem from psychosocial and occupational dynamics—female IT professionals may exhibit greater health-seeking behavior, while male employees experience higher occupational stress, influencing both adherence and physiological response. This indicates a need for gender-tailored nurse-led interventions that incorporate stress management for men and peer or motivational reinforcement for women. The study's outcomes are consistent with earlier findings by Kavita *et al.* (2023) [3] and Deo and Singh (2021) [1], who

documented similar reductions in blood pressure and enhanced adherence in nurse-led, technology-enabled interventions across corporate and community settings. However, this research extends the existing evidence by situating these models within India's corporate IT context, an underexplored yet crucial population for NCD prevention. The findings highlight the scalability and policy relevance of integrating nurse-led programs into occupational health frameworks, particularly under India's NPCDCS strategy. Overall, the study underscores that empowering nurses as health educators and digital facilitators can yield clinically meaningful and behaviorally sustained improvements in hypertension control, demonstrating a feasible, gender-responsive model for NCD management in the corporate sector.

Conclusion

This study demonstrates that nurse-led, mHealth-supported interventions are highly effective in managing hypertension among IT professionals in Chennai's corporate sector. The program achieved significant reductions in both systolic and diastolic blood pressure and improved medication adherence and self-efficacy, validating the impact of theory-driven nursing interventions based on Pender's Health Promotion Model and Orem's Self-Care Deficit Nursing Theory. These frameworks helped empower participants to adopt healthier behaviors and actively manage their condition, highlighting nurses' dual roles as educators and facilitators in chronic disease care.

Gender-based findings revealed that men achieved greater blood pressure reductions, while women demonstrated higher adherence and self-efficacy, emphasizing the importance of gender-responsive intervention design. These results suggest that nurse-led programs can be effectively adapted to the psychosocial needs and behavioral patterns of diverse employee groups, enhancing the inclusivity and sustainability of workplace health initiatives.

References

1. Deo S, Singh P. Nurse-led, technology-enabled private sector intervention for hypertension management among urban workers. BMJ Open,2021:11(8):045246.
2. Gupta R, *et al*. Epidemiology of hypertension in India: Current status and future directions. Indian Journal of Medical Research,2023:157(1):15–27.
3. Kavita K, Thakur JS, Ghai S, Narang T. Nurse-led interventions for prevention and control of noncommunicable diseases in low- and middle-income countries. Indian Journal of Nursing and Care,2023:8(1):10–18.
4. Nanyonga RC, Spies LA. The effectiveness of nurse-led group interventions on hypertension lifestyle management. Journal of Nursing Scholarship,2022:54(3):357–365.
5. Orem DE. Nursing: Concepts of practice. Mosby, 2001, 6.
6. Pender NJ, Murdaugh CL, Parsons MA. Health promotion in nursing practice. Pearson Education, 2015, 7.
7. Roy A, Thakur D. Nurse-led interventions in hypertension: Enhancing adherence and self-efficacy. In: Nursing practice and chronic disease management. Taylor Francis, 2025.
8. Shrivastava SR, *et al*. Occupational stress and hypertension among information technology professionals in India. Journal of Family Medicine and Primary Care,2021:10(8):2991–2997.
9. Srinivasapura Venkateshmurthy N, Ajay VS, Mohan S. m-Power Heart Project: Nurse-led, mHealth-enabled intervention to improve hypertension management in India. Trials,2018:19(1):1–9.
10. Subramanian S, Ramalingam S. Lifestyle-associated hypertension among corporate employees in Chennai. International Journal of Community Medicine and Public Health,2020:7(9):3598–3604.
11. World Health Organization. Gender, work, and noncommunicable diseases: Policy brief. WHO South-East Asia Regional Office, 2022.
12. Longkumer I, Yadav S, Rajkumari S. Trends in hypertension prevalence, awareness, treatment, and control: An 8-year follow-up study from rural North India. Scientific Reports,2023:13(1):37082.
13. Chow WL, Joshi VD, Tin AS, Van der Erf S, Lim JFY. Limited knowledge of chronic kidney disease among primary care patients – A cross-sectional survey. BMC Nephrology,2012:13:54.
14. Hon LT, Wong EML, Cheung K. Educational program with text messaging for community-dwelling patients with hypertension. Asian Nursing Research,2023:17:158–166.
15. Naeemi L, Daniali SS, Hassanzadeh A, Rahimi M. The effect of educational intervention on self-care behavior in hypertensive older people: Applying the health belief model. Journal of Education and Health Promotion,2022:11:111–117.
16. Eze II, *et al*. Impact of health education intervention on knowledge and prevalence of hypertension among market traders in Southeast Nigeria. Research Square, 2020, 1–23.
17. Mgbahurike AA, Oduogu SO, Bagbi BM. Determining possible association between blood pressure control and socioeconomic status of patients managed in community pharmacies in Rivers State. Universal Journal of Pharmaceutical Research,2021:6(5):30–34.
18. Suprayitno E, Permatasari D, Huzaimah N. Telenursing-based self-care management education improves the quality of life of hypertension sufferers in the rural area Pragaan Health Center. Journal Ilmu Kesehatan,2023:12(1):43–50.
19. Jamiu MO, Maiha BB, Danjuma NM, Giwa A. Educational intervention on knowledge of hypertension and lifestyle/dietary modification among hypertensive patients attending a tertiary health facility in Nigeria. Mediterranean Journal of Pharmacy & Pharmaceutical Sciences,2024:4(1):1–11.
20. Ayogu EE, Yahaya RI, Isah A, Ubaka CM. Effectiveness of a pharmacist-led educational intervention on health outcomes in hypertension management at community pharmacies in Nigeria: A two-arm parallel single-blind randomized controlled trial. British Journal of Clinical Pharmacology,2022:89:649–659.