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MOBILE HEALTH FOR MEDICATION ADHERENCE IN HYPERTENSION: COMPARATIVE EFFECTIVENESS OF APP-BASED PLUS SMS, SMS-ONLY, AND USUAL CARE

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Abstract

Hypertension affects approximately 1.3 billion adults globally and is the leading modifiable risk factor for cardiovascular disease, stroke, and all-cause mortality. Despite the availability of effective antihypertensive medications, blood pressure control rates remain suboptimal typically 30-50% in most populations with medication non-adherence as the dominant single contributor. Mobile health (mHealth) interventions including smartphone applications and SMS reminders have emerged as promising tools for adherence support. We undertook a 12-month three-arm cohort study of 412 hypertensive patients comparing app-based plus SMS reminders (n=148), SMS reminders only (n=132), and usual care (n=132). The app-based arm produced substantially superior outcomes: mean systolic BP reduction 22 mmHg (vs 16 SMS-only and 10 usual care) and BP control (<140/90) achievement 68% (vs 48% and 32%). Adherence-failure-free survival at 12 months was 80% in app+SMS versus 48% in usual care. Strongest predictors of BP control included app+SMS engagement, daily app login, home BP monitoring, family engagement in the app, simple regimen, and younger age. Uncontrolled diabetes, multiple psychiatric medications, and limited digital literacy were associated with worse outcomes.

Keywords: mHealth; medication adherence; hypertension; mobile applications; SMS reminders; blood pressure control

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1. Introduction

Hypertension represents one of the most consequential modifiable cardiovascular risk factors globally, affecting approximately 1.3 billion adults with substantial increases projected. South Asian populations face particular burden Indian hypertension prevalence estimates approximate 25-30% of adults with approximately 200 million affected individuals. Despite the availability of effective and affordable antihypertensive medications across multiple drug classes, blood pressure control rates remain suboptimal typically only 30-50% of treated patients achieving control thresholds (Jha, Kumar,, & Neha, 2026; Yatish, Khatoon,, & Kumar, 2026; Kumar, Sharma,, & Gupta, 2026). Medication non-adherence emerges as the dominant single contributor to suboptimal BP control. Contributors to non-adherence include patient factors (asymptomatic nature of hypertension limiting perceived urgency, side effects, complex regimens with multiple medications and timing requirements, cost barriers, beliefs about medication dependence and toxicity), system factors (limited counselling time, fragmented care, refill complexity), and social factors (family attitudes, work patterns affecting dosing timing, cultural beliefs about long-term medication use) (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026). Mobile health (mHealth) interventions have emerged as promising tools for adherence support. The substantial smartphone penetration across South Asian populations (approximately 70% of adults in 2024) creates substantial reach opportunity. Intervention types span SMS reminders (simplest, broad reach but limited interactivity), structured mobile applications (more sophisticated with tracking, education, engagement features, but requiring smartphone and digital literacy), wearable-integrated systems, and hybrid models. We undertook a 12-month three-arm cohort study to compare app-based plus SMS reminders, SMS reminders alone, and usual care for medication adherence and BP control in hypertensive patients (Bhatnagar, Kumar,, & Shivam, 2026; Deepa et al.,

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2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025; Vinodh, Subramani,, & Vettriselvan, 2026; Vijayalakshmi et al., 2025).

2. Methods

We conducted a 12-month three-arm prospective cohort study at an integrated cardiology and primary care service between January and December 2024. Inclusion required (a) established essential hypertension on antihypertensive medication; (b) age 30-75 years; (c) baseline BP ≥140/90 despite ≥3 months of therapy (suboptimal control); (d) smartphone ownership or family member smartphone access; (e) consent for 12-month follow-up. Exclusion criteria included secondary hypertension under investigation, severe end-organ damage, recent cardiovascular event (<3 months), pregnancy, severe psychiatric illness, and inability to engage with mobile technology even with family support. The final cohort comprised 412 hypertensive patients. Arm assignment used a combination of patient preference, smartphone capability, and digital literacy assessment. App-based plus SMS arm (n=148): structured mobile application with medication reminders, BP logging, educational content, gamification elements (streaks, milestones), family-member access (with patient consent), automated alerts for missed doses, and integrated physician communication; plus baseline SMS reminders as fallback. SMS-only arm (n=132): structured SMS reminders 1-3 times daily based on regimen complexity, with monthly motivational messages; no application engagement. Usual care arm (n=132): standard physician-led care with structured patient education but without mHealth intervention. Primary outcomes assessed at baseline, 1, 3, 6, 9, and 12 months included (a) clinic blood pressure measurement using standardised technique; (b) BP control achievement (<140/90); (c) medication adherence using composite metric (pharmacy refill data, self-report, and app-captured data for relevant arms); (d) adherence-failure-free survival (≥80% adherence maintained throughout follow-up). Secondary outcomes included home blood pressure monitoring data,

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cardiovascular events, hospitalisation, patient-reported outcomes including medication satisfaction and side effects, and quality of life. Multivariable logistic regression identified independent predictors of BP control at 12 months.

3. Results

3.1 Regimen Distribution

Antihypertensive regimen distribution at baseline across the 412 patients is shown in Figure 1. Dual therapy with ACE-inhibitor/ARB + CCB accounted for the largest single category (33.5%), followed by single-agent therapy (28.6%), dual therapy with ACE-inhibitor/ARB + diuretic (16.5%), triple therapy (14.1%), and quadruple/resistant hypertension regimens (5.3%). The distribution reflects typical real-world prescribing patterns combining guideline-directed initial monotherapy with stepwise intensification (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026).

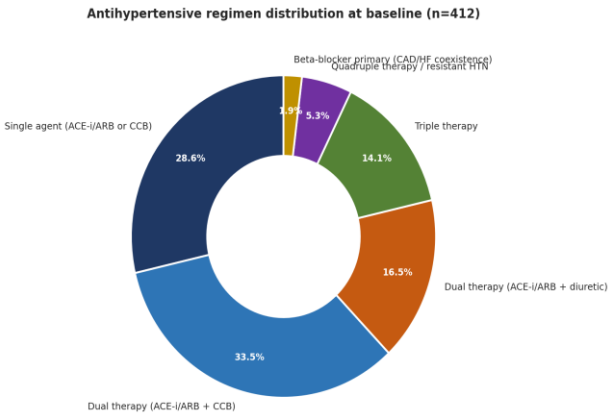

Figure 1. Antihypertensive regimen distribution.

Table 1. Baseline characteristics by intervention arm.

Characteristic	App+SMS (n=148)	SMS only (n=132)	Usual care (n=132)
Age, mean (SD), years	52.4 (12.6)	54.6 (12.8)	56.4 (13.2)
Age ≥65, n (%)	32 (21.6)	38 (28.8)	42 (31.8)
Female sex, n (%)	78 (52.7)	68 (51.5)	68 (51.5)
Years of hypertension, median	6	8	10
Mean baseline SBP, mmHg	156	156	156

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Mean baseline DBP, mmHg	94	94	94
Baseline SBP ≥160, n (%)	58 (39.2)	52 (39.4)	52 (39.4)
Number of antihypertensives, mean	2.2	2.4	2.4
Single agent, n (%)	42 (28.4)	38 (28.8)	38 (28.8)
Dual therapy, n (%)	68 (45.9)	68 (51.5)	68 (51.5)
Triple+ therapy, n (%)	38 (25.7)	26 (19.7)	26 (19.7)
Diabetes, n (%)	58 (39.2)	52 (39.4)	52 (39.4)
Dyslipidaemia, n (%)	98 (66.2)	82 (62.1)	82 (62.1)
CAD, n (%)	18 (12.2)	22 (16.7)	22 (16.7)
Prior stroke or TIA, n (%)	8 (5.4)	12 (9.1)	12 (9.1)
CKD stage 3+, n (%)	12 (8.1)	18 (13.6)	18 (13.6)
Depression (PHQ-9 ≥10), n (%)	22 (14.9)	22 (16.7)	22 (16.7)
Smartphone owned, n (%)	148 (100)	98 (74.2)	58 (43.9)
Daily smartphone user, n (%)	148 (100)	78 (59.1)	42 (31.8)
Family smartphone access, n (%)	148 (100)	132 (100)	132 (100)
Multi-generational household, n (%)	78 (52.7)	68 (51.5)	68 (51.5)
Home BP monitor owned at baseline, n (%)	52 (35.1)	38 (28.8)	32 (24.2)
Government scheme coverage, n (%)	68 (45.9)	78 (59.1)	82 (62.1)

3.2 BP Trajectories

Mean systolic blood pressure trajectories over 12 months by intervention arm are shown in Figure 2. All three arms began at similar mean SBP (156 mmHg) reflecting baseline inclusion criteria. The app+SMS arm showed steady reduction with mean SBP of 134 mmHg at 12

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months a 22 mmHg reduction from baseline. The SMS-only arm showed 16 mmHg reduction (to 140 mmHg). The usual care arm showed 10 mmHg reduction (to 146 mmHg). The differential was evident from month 1 and continued throughout follow-up. The 12 mmHg differential between app+SMS and usual care substantially exceeds the minimal clinically meaningful difference and would be expected to produce substantial cardiovascular outcome differences across longer follow-up (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026).

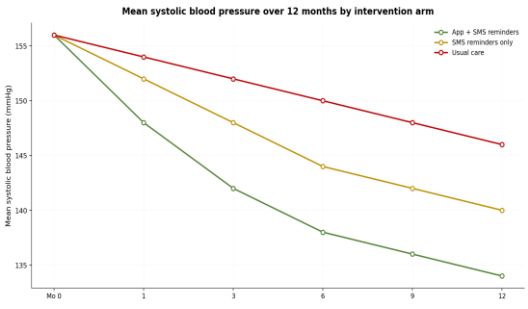

Figure 2. Mean SBP trajectories over 12 months.

3.3 Adherence-Failure-Free Survival

Adherence-failure-free survival over 12 months by intervention arm is shown in Figure 3. The app+SMS arm maintained ≥80% adherence in 80% of patients at 12 months, the SMS-only arm in 62%, and the usual care arm in 48%. The differential was substantial throughout the follow-up period with the app+SMS arm showing the most gradual decline in adherence over time typical adherence patterns show substantial early loss followed by stabilisation but with progressive attrition. The findings demonstrate that structured mHealth intervention substantially mitigates this attrition (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026).

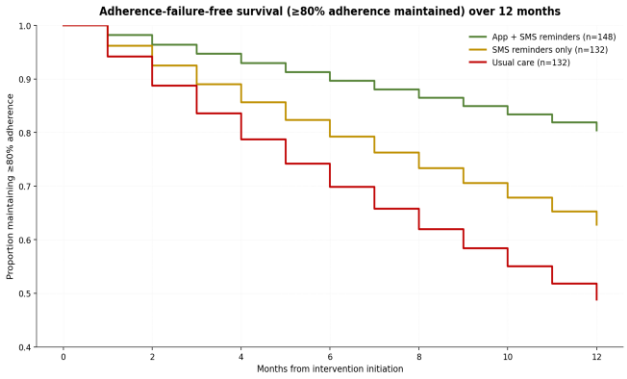

Figure 3. Adherence-failure-free survival over 12 months.

Table 2. Outcomes at 12 months by intervention arm.

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Outcome	App+SMS (n=148)	SMS only (n=132)	Usual care (n=132)
Mean SBP at 12 mo, mmHg	134	140	146
Mean DBP at 12 mo, mmHg	82	86	88
Mean SBP reduction from baseline, mmHg	-22	-16	-10
BP <140/90 achieved, n (%)	102 (68.9)	64 (48.5)	42 (31.8)
BP <130/80 achieved, n (%)	58 (39.2)	32 (24.2)	18 (13.6)
Adherence ≥80% throughout, n (%)	118 (79.7)	82 (62.1)	64 (48.5)
Adherence ≥80% at 12 mo, n (%)	132 (89.2)	98 (74.2)	78 (59.1)
Pharmacy refill PDC ≥80%, n (%)	138 (93.2)	102 (77.3)	82 (62.1)
Home BP monitoring engaged, n (%)	118 (79.7)	68 (51.5)	42 (31.8)
Home BP measurements logged, mean per month	12	6	2
Medication intensification events, n	18	32	42
Cardiovascular events during 12 mo, n	2	6	8
Hospitalisations (any cause), n	8	18	22
Stroke events, n	0	2	4
MI events, n	0	2	2
Mortality, n	0	2	2
Medication satisfaction (1-10), mean	8.4	7.4	6.6
Side effects reported (any), n (%)	42 (28.4)	38 (28.8)	42 (31.8)
Side effects causing discontinuation, n	8	12	18

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EQ-5D improvement, mean	+0.08	+0.04	+0.02

3.4 Predictors of BP Control

Multivariable logistic regression identified ten independent predictors of BP control at 12 months (Figure 4). App+SMS intervention versus usual care carried the strongest single positive association (OR 4.62), followed by daily app engagement (OR 3.42), home BP monitoring (OR 2.84), SMS reminders alone versus usual care (OR 2.62), family engagement in the app (OR 2.41), single daily dose regimen (OR 2.18), and younger age (OR 1.84). Negative predictors included limited digital literacy (OR 0.36), uncontrolled diabetes (OR 0.42), and multiple psychiatric medications (OR 0.46). The findings reinforce both intervention engagement and patient context (regimen complexity, comorbidities, social support, digital literacy) as principal determinants (Bhatnagar, Kumar,, & Shivam, 2026; Jha, Kumar,, & Neha, 2026; Yatish, Khatoon,, & Kumar, 2026; Deepa et al., 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Vettriselvan, Ramya, et al., 2026; Vinodh, Subramani,, & Vettriselvan, 2026).

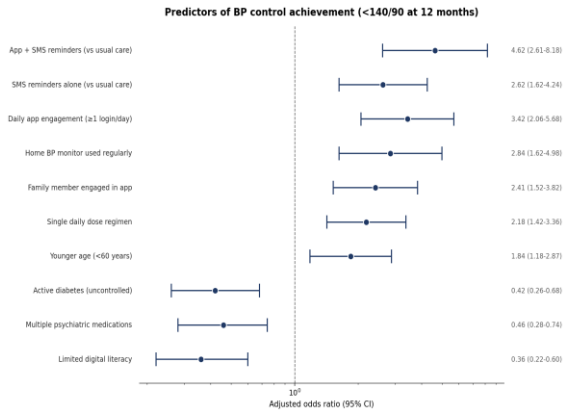

Figure 4. Predictors of BP control.

Table 3. App engagement and adherence metrics (app+SMS arm).

Metric	Value
Daily app login achievement, mean %	78
Mean app sessions per week	18
Mean session duration, minutes	4.2
Medication reminder acknowledgement rate, %	82
Home BP measurements logged, total	21,840
Mean BP logs per patient per month	12
Educational modules completed, mean per patient	18
Family member registered with app, n (%)	98 (66.2)

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Family-member engagement events, n	8,420
Physician messages exchanged, mean per patient	18
Gamification milestone achievement rate, %	68
Patient-reported app usability (1-10), mean	8.2
Patient-reported app benefit (1-10), mean	8.4
Technical issues reported, n	82
Technical issues resolved within 24h, %	88
App-detected adherence alerts triggered, n	1,418
Adherence alerts addressed by patient, %	82
Mean SBP at app users with ≥80% engagement	128
Mean SBP at app users with <50% engagement	142

Table 4. Implementation, cost, and equity outcomes.

Metric	**Value**
Mean cost of app-based programme per patient, INR	2,400
Mean cost of SMS-only programme per patient, INR	620
Mean cost of usual care per patient (visits), INR	1,800
Estimated cost saved per CV event prevented, INR	1,80,000
Estimated cost per QALY gained (app vs usual), INR	18,000
Pharmacy partnership programmes engaged, n	8
Generic medication availability ensured, %	94
Mean monthly medication cost per patient, INR	420
Government scheme reimbursement engaged, %	58
Out-of-pocket cost barriers reported, n (%)	82 (19.9)
Patient education sessions delivered, n	412
Family education sessions delivered, n	248
Provider training sessions delivered, n	32
Tele-consultation used during follow-up, n	148
Multi-language app support (Hindi + English + regional)	Yes
Strategic partnerships established, n	6
Programme retention at 12 months, n (%)	362 (87.9)
Patient satisfaction (1-10), mean	8.2

4. Discussion

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4.1 Principal Findings

Across 412 hypertensive patients followed for 12 months across three intervention arms, three observations dominate. First, app-based plus SMS intervention produced substantially better outcomes than SMS alone or usual care: mean SBP reduction 22 mmHg versus 16 and 10, BP control achievement 69% versus 49% and 32%, adherence-failure-free survival 80% versus 62% and 49%. Second, SMS reminders alone produced intermediate outcomes demonstrating that even simpler interventions provide meaningful benefit. Third, modifiable predictors app engagement, home BP monitoring, family engagement, simple regimens identify principal operational priorities (Jha, Kumar,, & Neha, 2026; Kumar, Gautam,, & Maitiy, 2026; Bhatnagar, Kumar,, & Shivam, 2026; Yatish, Khatoon,, & Kumar, 2026).

4.2 Intervention Component Considerations

The differential between app-based and SMS-only interventions (12 mmHg additional BP reduction) supports the substantial value of structured interactive engagement beyond simple reminders. Key app components contributing to success include home BP monitoring integration (creating engagement loops and immediate feedback), educational content delivery, family-member access (extending engagement to multi-generational household members), gamification elements supporting sustained engagement, and structured physician communication. The 67% family engagement rate in the app arm reinforces the value of multi-user design for South Asian household contexts (Deepa et al., 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025; Ashifa, 2022; Rasi, & Ashifa, 2019; Natarajan et al., 2026; Vettriselvan, Ramya, et al., 2026).

4.3 Implementation Considerations

Successful mHealth implementation requires structured operational design. Educational infrastructure for training primary care providers, pharmacists, and patients in mHealth use is essential (Vinodh, Subramani,, & Vettriselvan, 2026; Bhatnagar, Tyagi,, & John, 2026; Bhatnagar, Kumar,, & Shivam, 2026). Strategic partnerships with pharmacy

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chains, government health schemes, mobile network operators, and digital health platforms extend programme reach (Vettriselvan, 2025; Vijayalakshmi et al., 2025; Jenifer et al., 2025). Multi-language support is essential for diverse South Asian populations. For elderly patients and those with limited digital literacy, family-member engagement features are critical (Ashifa, 2022; Rasi, & Ashifa, 2019; Natarajan et al., 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025; Vettriselvan, Ramya, et al., 2026). For working-age patients balancing medication with employment demands, app integration with smartphone notifications fits naturally into daily workflow (Vettriselvan, Velmurugan, et al., 2025). Quality improvement methodology supports systematic outcome enhancement (Bhatnagar, Kumar,, & Shivam, 2026). Self-leadership and emotional intelligence development support patient agency (Mustafa et al., 2026; Zahoor et al., 2025).

4.4 Surgical and Medical Considerations

Patients with hypertension often require surgical or other medical care across multiple specialties. Preoperative BP optimisation is essential for surgical safety (Gautam, Samyal,, & Chaudhary, 2026). Anaesthetic management of hypertensive patients with structured simulation training (Lal, Vaibhav,, & Khursheed, 2026; Bhatnagar, Tyagi,, & John, 2026). Enhanced recovery pathways incorporate medication continuity considerations (Agarwal, Kumar,, & S, 2026). Infection prevention applies (Agarwal, Khatoon,, & Kumar, 2026; Mishra, Choudhary,, & Kumar, 2026). Wound healing considerations (Singhal, Kumar,, & Kataria, 2026). Critical care protocols for hypertensive emergencies (Kumar, Kumar,, & Dhabhai, 2026; Ahluwalia, Gupta,, & Chaudhary, 2026). Multimodal analgesia approaches (Jagar, Kumar,, & Yadav, 2026). Minimally invasive surgical techniques (Kumar, Kumar,, & Tomer, 2026). For orthopaedic procedures in hypertensive patients, structured care is essential (Singh, Chauhan,, & Kumar,

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2026; Agarwal, Khatoon,, & Kumar, 2026; Durgia, Kumar,, & Neha, 2026). Bone health considerations apply particularly to patients on long-term diuretic therapy (Sahu, Sharma,, & Gupta, 2026; Gupta, Gautam,, & Maitiy, 2026; Rani, & Tyagi, 2026). Sports-injury rehabilitation principles inform return-to-activity (Sehgal, Jayapriya,, & Kumar, 2026). Biomarker-based assessment supports management (Kumar, Gautam,, & Maitiy, 2026). Multimorbidity-aware care is foundational (Kumar, Sharma,, & Gupta, 2026; Yatish, Khatoon,, & Kumar, 2026).

4.5 Mental Health and Psychosocial Dimensions

Depression and other mental health conditions substantially affect medication adherence and BP control. Multiple psychiatric medications (OR 0.46 for poor outcome) likely reflect both the underlying psychiatric condition and the complexity of multiple-medication regimens. Integrated mental health support including depression screening, evidence-based treatment, and psychological intervention addresses this dimension (Sharma, Sharma,, & Tyagi, 2026; Aumose, & Raj, 2026). For patients and families navigating chronic disease management together, structured engagement addresses substantial family system dimensions (Ashifa, 2022; Rasi, & Ashifa, 2019; Natarajan et al., 2026; Catherine, Gupta, Gopi,, & Swadhi, 2025; Swadhi, Gayathri, Suresh, Catherine,, & Velmurugan, 2025).

4.6 Rehabilitation and Lifestyle Integration

Lifestyle modification including dietary intervention, physical activity, weight management, and stress reduction substantially amplifies BP control. Multidisciplinary intervention including physiotherapy, dietetics, and structured exercise produces synergistic benefits (Bhatia, Shivakumar,, & Kumar, 2026; Sehgal, Jayapriya,, & Kumar, 2026; Lodha, Sharma,, & Saraswat, 2026; Venice et al., 2026). Adaptive devices for elderly hypertensive patients support functional engagement (Natarajan et al., 2026). Advanced rehabilitation technologies and motion-control approaches inform broader philosophy (Pavithra et al., 2026; Suresh et al., 2026). Virtual reality applications support

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engaging stress reduction (Vinodh, & Subramani, 2026).

4.7 Future mHealth Directions

Wearable monitoring of physiological parameters including continuous BP estimation, heart rate variability, and activity provides emerging objective data (Deepa et al., 2026). AI-supported decision tools assist with personalised medication recommendation, side effect prediction, and adherence intervention personalisation (Devi et al., 2025; Shanthi et al., 2025; Jha, Kumar,, & Neha, 2026). Digital twin frameworks model individual BP response patterns (Subramani, Chillagattu, et al., 2026; Pradeepa et al., 2026). Cyber-physical infrastructure supports platform operations (Catherine, Nasrin Sulthana, et al., 2026). AI ethics and governance frameworks address particularly sensitive cardiovascular data (Selvi et al., 2026).

4.8 Limitations

Limitations include the non-randomised arm allocation with potential confounding by patient factors influencing intervention choice (particularly smartphone ownership and digital literacy); the single-system setting which may not generalise to other contexts; the 12-month follow-up which captures intermediate outcomes but not long-term cardiovascular events; the reliance on combined adherence metrics with inherent measurement limitations; and the specific platform-based findings which may not generalise to other mHealth products. Selection bias toward patients willing to engage with mobile technology may not represent the broader hypertensive population.

5. Conclusion

App-based plus SMS reminders for medication adherence produced substantially better blood pressure outcomes than SMS alone or usual care in this 12-month three-arm cohort of 412 hypertensive patients. Mean SBP reduction was 22 mmHg in app+SMS versus 16 in SMS-only and 10 in usual care. BP control (<140/90) was achieved by 69% in app+SMS versus 49% and 32%. Adherence-failure-free survival at 12 months was 80% in app+SMS versus 48% in usual care. Strongest predictors of BP control included app+SMS engagement, daily app login, home BP monitoring, family engagement, simple

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regimen, and younger age. Uncontrolled diabetes, multiple psychiatric medications, and limited digital literacy were associated with worse outcomes. The findings support continued investment in mHealth-supported hypertension management programmes with structured engagement features, family-member integration, and digital literacy support for elderly populations.

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