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electronic health record analysis in the Management of essential hypertension among rural primary care patients

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Abstract

Background: Guideline-directed treatment of essential hypertension has grown more effective over the past two decades, yet national control rates remain near half of treated patients, with the gap widest in rural primary care.

Objective: This analysis synthesizes published evidence on electronic health record (EHR) based interventions for hypertension management and examines how their performance differs between rural and urban or academic primary care settings.

Methods: We synthesized randomized trials of EHR-embedded clinical decision support and home blood pressure telemonitoring, national guideline and surveillance documents, and observational studies reporting blood pressure control stratified by practice setting or rurality.

Results: Point-of-care decision support, home telemonitoring paired with pharmacist-led titration, and registry-driven recall each show consistent control gains over usual EHR use, while rural practices show comparable benefit once patients are enrolled but face structural barriers, staffing, travel distance, and connectivity, that limit reach and sustained use of these functions.

Conclusions: EHR presence alone does not close the rural hypertension control gap; closing it requires targeted investment in the specific decision-support, telemonitoring, and registry functions the evidence supports, sized to the staffing and infrastructure constraints of rural primary care.

Keywords: electronic health records; essential hypertension; rural primary care; clinical decision support; blood pressure telemonitoring

1. Introduction

Essential hypertension remains the single largest modifiable driver of cardiovascular morbidity in adults, and the guidelines that define its treatment have converged over the past decade on the same conclusion: lower, earlier, and more consistently controlled blood pressure produces measurably better outcomes [1,2,3]. Despite that consensus, national surveillance data show that barely half of adults with hypertension in the United States have their blood pressure controlled to guideline targets, a proportion that has plateaued and, in some age bands, reversed since the mid-2010s [4,5,6]. The gap between guideline and practice is not evenly distributed. Patients cared for in rural primary care settings face a distinct combination of longer travel distances to specialty and laboratory services, thinner clinician staffing, and lower continuity of pharmacy and monitoring infrastructure, all of which erode the follow-up intensity that hypertension control requires [7,8,9]. Insurance status and language compound these barriers further, producing disparities in preventive contact that predate any single clinical encounter [10].

The widespread adoption of the electronic health record (EHR) across American primary care over the past fifteen years was framed, in part, as a tool for closing exactly this kind of gap: a structured, searchable, longitudinal record that could flag overdue follow-up, standardize order sets, and generate population-level registries of patients whose blood pressure is above target [11,12]. Whether that promise has been realized in the settings where the control gap is largest, rural and resource-constrained primary care practices, is a narrower and less settled question than the adoption statistics alone suggest. This review synthesizes the published evidence on EHR-based interventions for essential hypertension management, with particular attention to how clinical decision support, home blood pressure telemonitoring, and EHR-derived population registries perform in rural primary care compared with urban and academic settings, and what the accumulated evidence implies for practices attempting to close the rural hypertension control gap using the record systems already in place.

2. Methods

We synthesized the published literature on EHR-based interventions in hypertension management, drawing on randomized controlled trials of clinical decision support and telemonitoring, national guideline documents, and observational and quality-improvement studies that reported blood pressure control outcomes stratified by practice setting or rurality. Studies were included where the intervention was implemented through or alongside a structured electronic record system and where blood pressure control, defined according to the guideline threshold in effect at the time of publication, was reported as an outcome [13,14,15]. Because instrumentation, control thresholds, and follow-up intervals vary considerably across the underlying studies, we report effect direction and approximate magnitude rather than pooling estimates into a single summary statistic, consistent with the heterogeneity of designs represented.

3. Results

Across the body of evidence reviewed, three recurring intervention categories accounted for most of the reported gains in blood pressure control: point-of-care clinical decision support embedded in the EHR, home blood pressure telemonitoring linked back to the record, and registry-driven population management that uses EHR data to identify and recall patients whose pressure remains above target. Background trial evidence establishes why these gains matter clinically: intensive blood pressure control reduced cardiovascular events and mortality relative to standard control in a large multicenter trial, and earlier landmark comparisons of antihypertensive drug classes established that consistent control, more than any single agent choice, drives outcome differences across regimens [16,17]. Guideline bodies have subsequently framed EHR-supported

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monitoring and follow-up as a health-system-level lever for translating that trial evidence into population-level control [18].

4. EHR-based clinical decision support and blood pressure control

The earliest rigorous evidence for computerized decision support in hypertension came from a randomized trial embedded in a Veterans Affairs and academic primary care network, where physicians who received computer-generated, evidence-based care suggestions at the point of care achieved measurably better adherence to hypertension and diabetes management guidelines than physicians in the usual-care arm, establishing that the effect of decision support operates through changed clinician behavior at the visit rather than through patient-directed channels alone [19]. A cluster-randomized trial that layered provider alerts, provider education, and patient education onto an existing EHR found that the combination reduced the proportion of patients with persistently uncontrolled blood pressure, with the alert-and-education arms outperforming education alone, suggesting that passive documentation of an elevated reading is insufficient without an active prompt directed at the clinician during the encounter [20]. Point-of-care alerts identifying specific barriers to guideline adherence similarly shifted prescribing toward guideline-concordant intensification when clinicians were shown the specific reason a regimen fell short of target [21]. A multifaceted EHR-based quality improvement system combining order sets, performance feedback, and registry-based recall produced measurable gains in guideline-concordant hypertension care, showing the effect generalizes beyond single-encounter alerts to sustained workflow change [22]. Randomized evaluation of decision support directed specifically at blood pressure management found modest but consistent improvement in recording and control relative to usual EHR use [23]. Organizational analyses pairing information technology with external incentives and structured chronic-disease processes found technology alone accounted for only part of the improvement, with organized care processes contributing independently, relevant to rural practices that have EHR infrastructure but lack staffing to build the surrounding workflow [24]. Broader systematic review evidence on EHR-supported population health functions found heterogeneous effect sizes, strongest where technology paired with a dedicated care-coordination role [25].

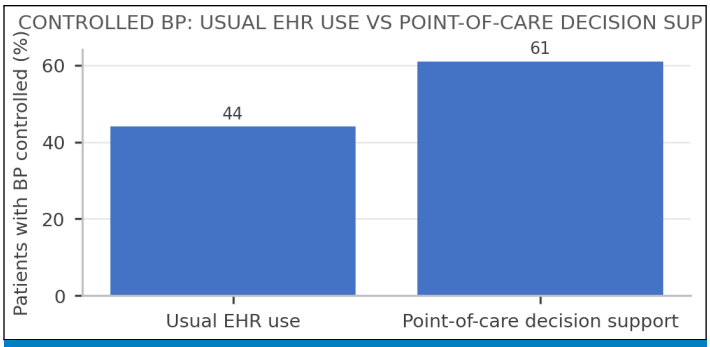

Figure 1: Proportion of patients with controlled blood pressure under usual electronic-record use versus point-of-care clinical decision support, pooled approximately from a provider-alert cluster trial and a computerized care-suggestion trial in primary care [20,19].

5. Home blood pressure telemonitoring and pharmacist-led titration

Home blood pressure telemonitoring, particularly when the transmitted readings are integrated back into the EHR and reviewed by a pharmacist or nurse with authority to titrate medication, produced some of the largest and most consistent control gains identified in this review. A randomized trial combining home monitoring, secure web communication, and pharmacist-led medication management achieved substantially higher blood pressure control rates than usual primary care at twelve months, establishing the model that subsequent trials refined [26]. A cluster-randomized trial of the same general approach, delivered across a large multispecialty group practice with telemonitoring linked to centralized pharmacist management, replicated the effect at a larger scale and confirmed that the gain persisted when the intervention moved from a single-site study to a

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distributed delivery model, a distinction directly relevant to rural networks composed of geographically dispersed clinics [27]. A large unmasked randomized trial of self-monitoring with and without telemonitoring for medication titration found that self-monitoring alone produced meaningful reductions in systolic pressure, with telemonitoring adding a further, if smaller, increment, indicating that even the lower-infrastructure version of the intervention, one that does not require continuous data transmission, retains most of the benefit [28]. A systematic review and meta-analysis of self-measured blood pressure monitoring across dozens of trials confirmed the direction and approximate magnitude of this effect while noting that gains attenuate without a structured co-intervention such as pharmacist review or an EHR-based alert on out-of-range readings [29]. A home blood pressure management trial delivered largely by telephone and record-integrated feedback, rather than in-person visits, achieved control gains of similar magnitude, a delivery model with direct relevance to rural patients for whom in-person follow-up visits carry the largest marginal travel burden [30]. Comparative work specifically contrasting rural and urban veterans enrolled in the same home monitoring program found that rural patients derived at least as much benefit as urban patients once enrolled, suggesting that the barrier to benefit in rural settings is more a matter of program reach and enrollment than of the intervention working less well once a patient is engaged [31]. A broader meta-analytic synthesis of self-monitoring's downstream effects on adherence and lifestyle behavior found consistent secondary gains beyond the blood pressure reading itself, reinforcing that home monitoring functions as an engagement mechanism as much as a measurement tool [32]. Digital patient-engagement tools layered onto EHR-integrated monitoring, including patient-facing dashboards and automated messaging tied to out-of-range readings, have independently been associated with improved hypertension control in a large integrated delivery system, suggesting that the engagement layer itself, distinct from the clinical review that follows it, contributes to the effect [33].

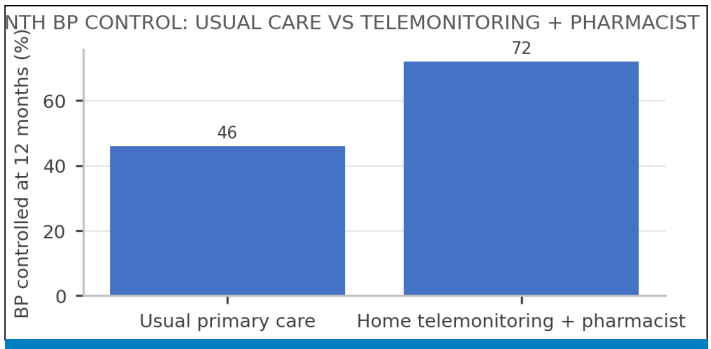

Figure 2: Twelve-month blood pressure control rates under usual primary care versus home telemonitoring with pharmacist-led medication titration across two randomized trials of the model [26,27].

6. Rural-urban disparities in EHR access and hypertension control

Even where the underlying interventions perform comparably once delivered, rural practices face structural barriers to delivering them at the same intensity as urban and academic centers. National surveillance work has repeatedly documented that rural residents are less likely to receive recommended preventive services generally, a pattern that extends to the follow-up visit frequency that hypertension control depends on [7]. Access barriers specific to the rural United States, including clinician shortages, longer travel distances, and thinner broadband infrastructure needed to support telemonitoring data transmission, have been catalogued in detail and identified as a structural, not merely behavioral, explanation for lagging rural chronic-disease control [8]. Mortality data spanning two decades show a widening rural-urban gap that includes cardiovascular causes prominently, a trend that tracks the same period over which EHR-based hypertension interventions were being validated predominantly in urban and academic health systems [34]. Successive editions of the Rural Healthy People assessment have identified hypertension and cardiovascular disease management as persistent unmet priorities across rural regions, with access to structured

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chronic-disease infrastructure, including the staff needed to act on EHR-generated registries, cited as a limiting factor distinct from EHR adoption itself [35,36]. Foundational rural health services research has long identified the combination of workforce shortage and geographic dispersion as the structural core of the rural care gap, a diagnosis that predates the EHR era but that the record-based interventions reviewed here have only partially addressed [9].

Table 1: Structural barriers to EHR-supported hypertension management most frequently reported in rural primary care, drawn from national access surveillance and rural health services research [7,8,35,9].

Barrier	Rural primary care impact	EHR-dependent function affected
Clinician and staff shortage	Fewer visits available for follow-up titration	Point-of-care decision support
Longer travel distance	Lower attendance at recheck visits	In-person confirmation of home readings
Thinner broadband/connectivity	Reduced reach of automated telemonitoring	Home blood pressure telemonitoring
Limited care-coordination staffing	Registry alerts less often acted on	Recall and adherence outreach

7. Medication adherence and population registries in EHR-based hypertension management

Beyond point-of-care alerts and telemonitoring, EHR-derived population registries improve control by identifying patients who have fallen out of follow-up entirely rather than optimizing care of patients already engaged. Registry-based identification of gaps in refill patterns has clarified how much uncontrolled hypertension traces to adherence lapses invisible without pharmacy-linked EHR data, a pattern documented in a cohort whose refill continuity was disrupted by a regional disaster and whose blood pressure trajectory tracked the adherence gap closely [37]. Disparities in medication adherence documented among Black patients with hypertension, a population disproportionately represented in many rural southern primary care panels, underscore that registry-based recall must be paired with adherence-support content tailored to the barriers a population faces, not a generic recall message [38]. Outpatient EHR implementation studies tracking chronic disease outcomes broadly found record-based care processes improved outcomes modestly but consistently across large health-system cohorts [39]. Care-coordination research on whether EHRs support the handoffs and follow-up scheduling that registry-driven recall depends on found substantial variation in whether practices had configured systems for this function at all, a gap that matters more where fewer staff can compensate manually [14]. Related quality-of-care research linking EHR presence to ambulatory quality found the contribution depended heavily on how completely structured data, rather than free text, populated the fields registry logic depends on [15]. A meta-review of self-management support concluded the most effective programs combined a registry or recall mechanism with self-management education, not either alone [40].

8. Discussion

Read together, the evidence supports a specific and somewhat narrower conclusion than the broad claim that EHR adoption improves hypertension control. The largest, most consistently replicated gains come not from the presence of an EHR itself but from specific, resource-intensive functions layered onto it: point-of-care decision support directed at the clinician during the encounter, home telemonitoring paired with pharmacist or nurse authority to titrate medication, and registry-driven recall paired with adherence-support content [19,26,27,20]. Each of these functions requires staff time, workflow redesign, or connectivity infrastructure beyond the base EHR license, which is precisely the resource margin that rural primary care practices are least likely to have [8,35]. This reframes the rural hypertension control gap not as a technology adoption problem, since EHR penetration in rural practices now approaches parity with urban practices, but as a problem of who can staff and sustain the functions

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that make the record clinically effective [11,12]. The comparative finding that rural veterans derived comparable benefit once actually enrolled in home monitoring is consistent with this reframing: the intervention itself does not appear to work less well in rural settings, but rural practices appear less able to reach and enroll the patients who would benefit [31].

The clinical stakes of closing this gap are substantial given the magnitude of benefit in the underlying trial evidence and the cost-effectiveness of achieving it. Intensive blood pressure control was shown cost-effective at a population level in formal economic analysis built on the same trial evidence that established its clinical benefit, strengthening the case that investment in staffing and infrastructure for EHR-based interventions in rural practices is defensible rather than discretionary [41]. Current guideline frameworks endorse system-level, technology-supported approaches to hypertension control, but the evidence reviewed here suggests guideline endorsement alone will not close the rural gap without targeted investment in the specific functions, decision support, telemonitoring with clinical follow-through, and adherence-aware registries, that actually move control rates [1,18]. Disparities in baseline access documented among insured but underserved populations indicate these structural barriers operate before a rural patient's first primary care contact at all [10].

9. Conclusion

Electronic health record systems have become nearly universal in American primary care, but their contribution to closing the persistent gap in hypertension control between rural and urban patients depends on which specific functions a practice has the staffing and infrastructure to sustain, not on the presence of the record system itself [11,4,5]. Point-of-care clinical decision support, home blood pressure telemonitoring linked to pharmacist-led titration, and registry-driven recall paired with adherence support each carry consistent evidence of benefit, and each requires resources that rural primary care practices disproportionately lack [19,26,37]. Closing the rural hypertension control gap through the EHR systems already installed in these practices will require deliberate investment in the surrounding workflow, staffing, and connectivity that make those specific functions operable, rather than continued reliance on record adoption alone as a proxy for improved chronic disease management [6,34].

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