Evaluating Data Quality in Initial and Repeat Blood Pressure Measurements

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Introduction

Approx 45% of US Adults have Hypertension (240,000 at Geisinger).

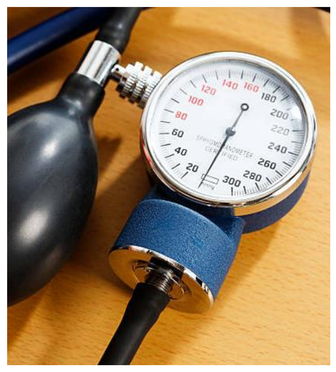
Less than Half of Hypertension is Controlled

AMA's "MAP" Program (Measure accurately, Act rapidly, Partner with patients)
- Recommends using automated BP cuffs
- Remeasuring initial BP ≥ 140/90 mmHg

Study Population: Geisinger Primary Care Visits from April 2024 to March 2025 (58 offices, 240,254 patients, 444,024 office visits)

Methods

Measuring BP
- BP is evaluated for all office visits
- Manual BP devices display only even values and guidelines recommend rounding to those values
- Automated BP devices display blood pressure digitally, including odd and even values



Classifying BP Measurement:
- Offices using mostly manual devices reported infrequent odd values (typically around 5%)
- Offices with >30% odd values were presumed to be regularly using automated devices

Identifying Discrepancy
- Visual review, comparing to normal distribution curve based on mean and standard deviation
- Local normalization to the normal distribution around 140mmHg (134-145mmHg)
- Standardized residuals (SR) to evaluate adjacent intervals (V_{M1} and V_{M2}), and estimate p-value.

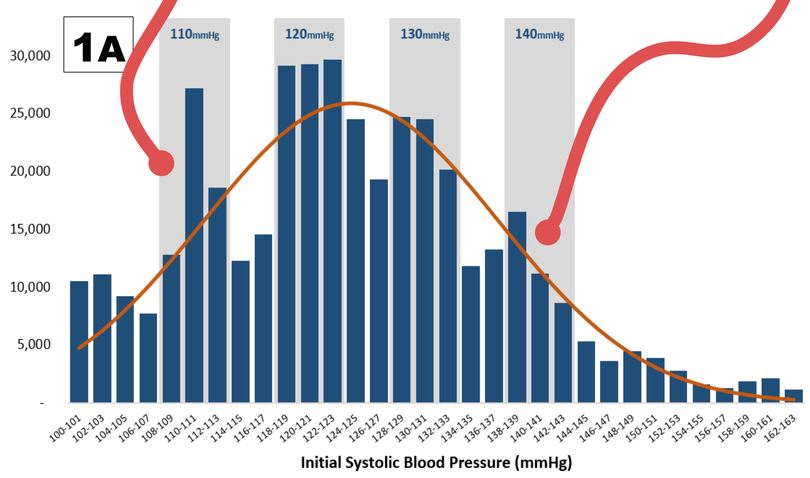
$$SR = \frac{V_M - V_E}{\sqrt{V_E}} \qquad V_E = \frac{V_{M_1} + V_{M_2}}{2}$$

Results

110-111mmHg 79% over-represented (SR =28, p << 0.01)

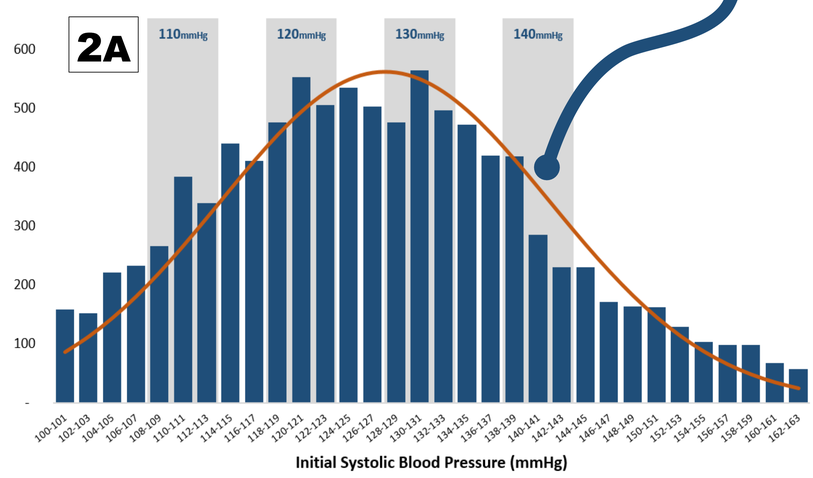
Average SR for all intervals: 10.4 (p << 0.01)

138-139 mmHg 37% over-represented (SR = 16, p << 0.01)



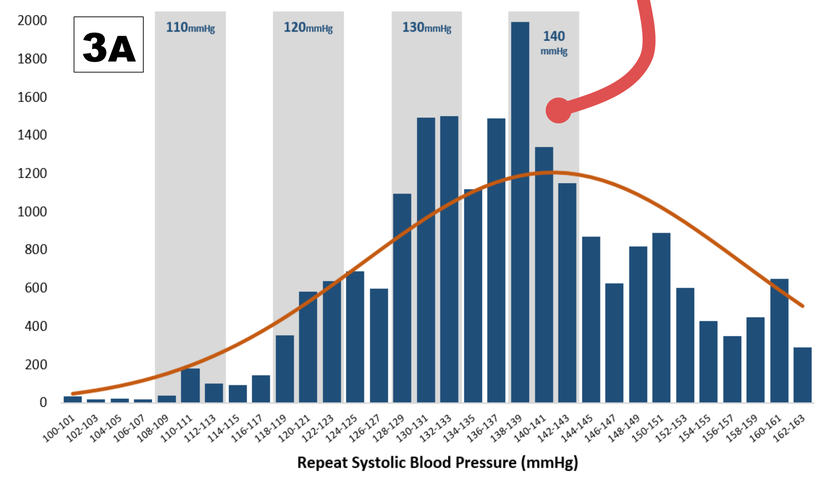
Average SR for all intervals: 0.8 (p = 0.42)

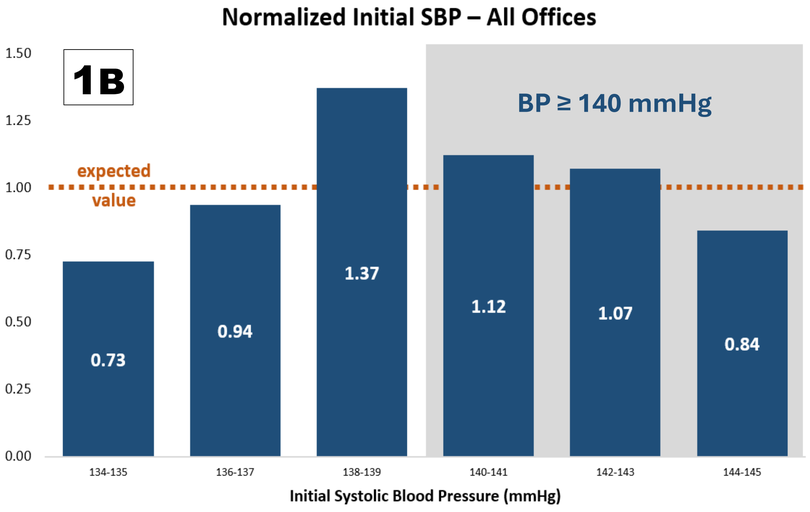
138-139 mmHg 14% over-represented (SR = 2.5, p = 0.012)

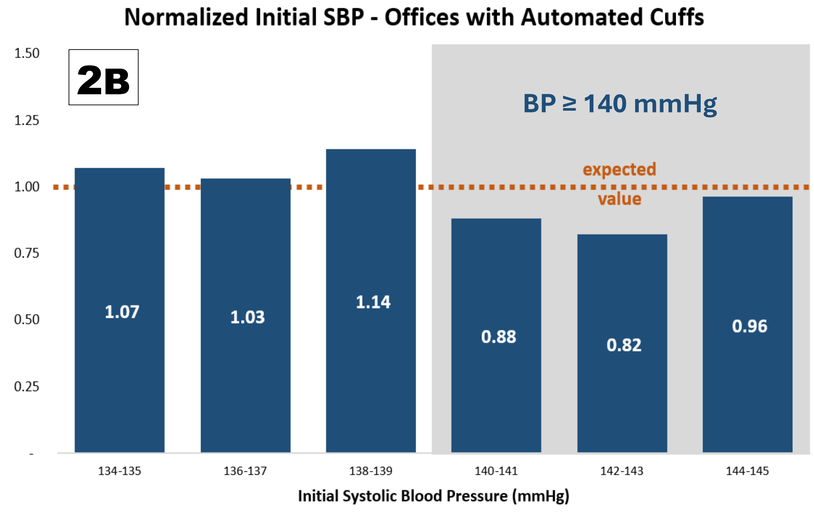


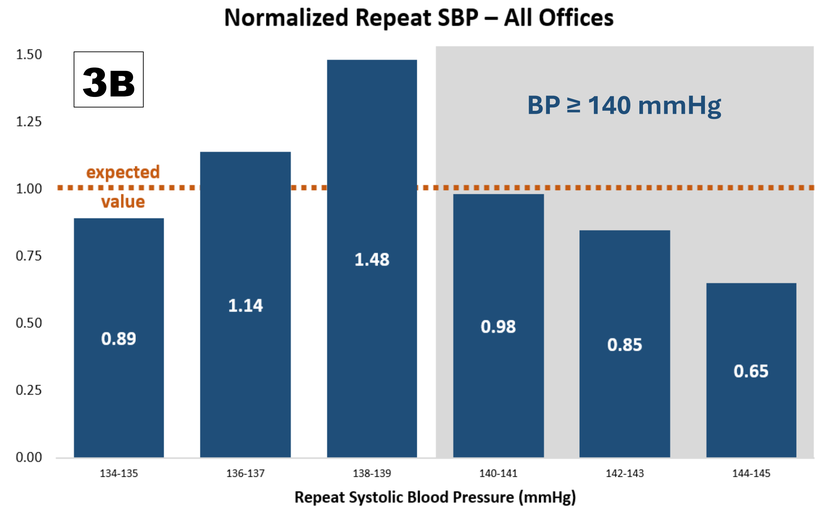
Average SR for all intervals: 2.6 (p < 0.01)

138-139mmHg 48% over-represented (SR = 5.7, p << 0.01)









1A - Initial SBP, All Offices, Apr to Dec 2024, 5% odd (mostly manual) – Mean SBP (±SD) of 124 (±13) represented with overlying curve. Average modified SR for adjacent interval differences was 10.4, indicating very low likelihood (p << 0.01) of an unbiased record.

1B – Distribution near SBP 140mmHg (all initial SBP) – Normalized to the local expected distribution. SBP of 138-9mmHg occurred 37% more frequently than expected, modified SR of 16 (p << 0.01), indicating a very low likelihood that the data was recorded without bias.

2A - Initial SBP, Offices with Automated BP Cuffs, Apr to Dec 2024, 42% odd – Mean SBP (±SD) of 127 (±14) represented with overlying curve. Average modified SR for adjacent interval differences was 0.8 (p = 0.42).

2B – Distribution near SBP 140mmHg (initial SBP in highly automated offices) – Normalized to the local expected distribution. SBP of 138-9mmHg occurred 14% more frequently than expected, with a modified SR of 2.5 (p = 0.012), indicating a low likelihood that the data was recorded without bias, even when regularly using automated blood pressure cuffs.

3A - Repeat SBP, All Offices, Apr 2024 to Feb 2025 – Mean SBP (±SD) of 141 (±16) represented with overlying curve. Average modified SR for adjacent interval differences was 2.6, indicating low likelihood (p < 0.01) of an unbiased record.

3B – Distribution near SBP 140mmHg (all repeat SBP) – Normalized to the local expected distribution. SBP of 138-9mmHg occurred 48% more frequently than expected, with a modified SR of 5.7 (p << 0.01), indicating a very low likelihood that the data was recorded without bias.

Terminal Digit Bias: higher frequency of values ending with certain digits (0 or 5, for example)

Threshold Bias: higher frequency of values just below a threshold (140mmHg, for example)

Saliency Bias: higher frequency of values near specific numbers (120 or 130, for example)

Additional Detail and References

tiny.cc/BPQuality

Main Finding

Blood Pressure, as recorded in typical office workflows, is prone to substantial **threshold** and **terminal digit bias**, which appears not to resolve with manual re-measurement

Conclusions

- Manual BP measurements can be highly discrepant
- BP just below the 140mmHg threshold is reported with much greater frequency than those just above
- Discrepancies can worsen for repeat measurements
- Initiatives to improve care for hypertension and quality metrics must accommodate these biases