Executive Summary

Atherosclerotic cardiovascular diseases (ASCVD) such as heart attack and stroke have their roots beginning in childhood and adolescence with the inception of risk factors such as high blood pressure (hiBP). Unfortunately, data from others (PMID: 17712071) and ourselves (PMCID: PMC5647583) show hiBP is grossly under-recognized in youth, leading to the American Academy of Pediatrics to reformulate the abnormal thresholds in September 2017 (PMID: 28827377). Texas Children’s Pediatrics, the largest primary care pediatric group practice in the USA, formulated a multipart intervention to improve hiBP recognition in January 2019, one part of which was an electronic health record-based EPIC pop-up Best Practice alert for medical assistants and separately medical providers highlighting a measured hiBP and then suggested further actions that indirectly signal provider recognition of hiBP as the key outcome of interest defined as ICD10 diagnosis, hiBP on the problem list, referral to specialist provider, or hiBP medication. We compiled data on all adolescents visiting TCP practices 14 months pre-intervention (n=7,444) and 14 months post-intervention (n=4,546) on these hiBP recognition indicators. This data analysis showed a 66% relative increase in hiBP recognition indicators (pre 15% vs post 25.4%, p<0.0001). Medication treatment specifically relatively increased by 67% (1.9% vs 3.1%, p=0.001). Temporal trends showed complex patterns. Therefore, the TCP hiBP intervention was associated with higher proportions of recognition and treatment, but acceptable levels are not yet being achieved.
**Clinical Problem and Pre-Intervention Performance**

Cardiovascular disease (CVD) risk factors are now highly prevalent among children. Roughly 20% have abnormal cholesterol and 14% have hiBP.\(^{(9, 22)}\) Focusing on BP, hiBP in youth is associated with seizures and cognitive abnormalities in childhood and predicts future adult CVD events and mortality.\(^{(4, 24, 25)}\) A moderate proportion of pediatric hiBP tracks into adulthood.\(^{(26-28)}\) Longstanding guidelines recommended frequent screening for hiBP. But despite this importance, studies repeatedly show that provider recognition of hiBP in pediatric primary care practice is inadequate, ranging from 10-25%.

There may be several reasons for this care gap including: difficult-to-parse age-sex-height referenced normative values, challenges in proper measurement technique, lack of proper equipment to measure blood pressure, lack of knowledge or interest in hiBP management, and the necessity to follow BP measurements across time since 3 separate episodes are required for a hypertension diagnosis which in turn is predicated on provider signaling recognition. In September 2017, the American Academy of Pediatrics promulgated a Clinical Practice guideline in which hiBP screening was recommended frequently, but at a minimum yearly, with properly sized cuffs, using proper techniques, and encouraged but did not require electronic health record (EHR)-based solutions to support clinical provider recognition of hiBP. Critically, the abnormal threshold for youth 13 and older was simplified to systolic at or above 130mmHg and diastolic at or above 80mmHg. Multiple episodes of hiBP are required to diagnose true hypertension, making hiBP recognition, signaling and tracking across visits crucial for initiating management.

Indicators of hiBP recognition signaling is defined by the AAP and previous literature as the key quality measure. HiBP recognition is defined as ICD10 diagnosis, hiBP on the EHR problem list, referral to hiBP specialties Nephrology or Cardiology, and/or the initiation of hiBP pharmacotherapy, treated collectively as the primary numerator of interest, or each of the four components individually treated as secondary numerators. Investigations were not included as indicators as CPG deemphasized testing. The denominator of interest is hiBP recorded in the EPIC EHR defined as at or above 130/80. These outcome proportions were examined in patients aged 13-19 years old of all sexes or genders, all races and ethnicities visiting TCP primary practices for whom this threshold is applicable. There were no exclusion criteria. Data was extracted from EPIC. From 10/2017 to 11/2018, the average monthly proportion with any recognition was 15.0%, specifically with ICD10 diagnosis in 10.1%, hiBP on the problem list 5.6%, specialty referral 5.2%, and medication therapy in 1.9% with patients possibly being in more than one category. Improvement was targeted from these very low levels.
Design and Implementation Model Practices and Governance

TCP identified hiBP recognition as a priority for optimal care based. This grass-roots decision was then endorsed and supported by the Chief Medical Officer of TCP to mobilize material resource procurement and technological support expertise. Key instruction leaders from clinical provider and medical assistant personnel cadres were selected and met with multidisciplinary Project Team to develop and verify the retraining program adhered to 2017CPG guidelines. Finally, our team introduced a bespoke Best Practice alert (BPA) for clinical decision support to highlight hiBP to medical assistants/nurses (staff) and separately to clinical providers with management recommendations.

The intervention was multi-level. One, the full array of blood pressure cuff sizes and related equipment were purchased and deployed in each of the more than 50 multi-provider practices. Second a retraining program was implemented for staff and providers on proper BP measurement technique based on AAP 2017 CPG, including EHR embedded diagrams for proper technique. Third was the clinical decision support tool BPA. Briefly, hiBP on automated oscillometric methods entered in EPIC by staff triggers the staff BPA to repeat and inform the provider. When the provider enters the patient chart the provider BPA supports further management predicated on the number of previous hiBP episodes and height of hiBP. Based on 2017CPG guidelines for ICD10 diagnoses and problem list entries, referral to specialists, laboratory measures, and therapies including lifestyle management and pharmacotherapy are included.

The intervention design process, training, and implementation was coordinated between TCP’s informatics champion and Preventive Cardiology champion with support from TCP’s Quality Team, nursing, and medical assistant leadership to assist in training and support of appropriate BP measurement techniques. Implementation decisions and majority of intervention testing, especially BPA, were made primarily by the TCP Physician Informaticist with oversight by the CMO and TCP operations team directors. Several iterations were developed in identifying a single workflow applicable to the more than 50 multi-provider practice sites comprising the TCP, the largest primary care pediatric group practice in the USA. After development, a live webinar was delivered and archived for clinical providers and medical assistants to roll-out the BPA and reinforce stand-of-care AAP2017CPG. Uptake was enhanced by the extensive familiarity of TCP providers and staff with previous BPAs for unrelated conditions and the trainings were completed within roughly 3 months for staff and providers.
Clinical Transformation enabled through Information and Technology

The Technology enhanced workflow begins when a hiBP is entered into EPIC for an ≥13 year old:

When a hiBP is entered in EPIC by staff, the following pop-up display deploys:

While dismissal is possible at each stage, this alert intends to highlights the BP, reiterates proper technique with an infographic, and encourages standard-of-care to recording of auscultatory manual BP measurements.

Then the measured manual BPs are presented in a separate provider BPA for review as below.

Using the Acknowledgement buttons at the bottom of this BPA, the provider can designate a BP category.
Subsequent support depends on degree of elevation and initial versus repeated episode as follows:

**Provider Interpretation**

- **Normal**: No further alerts in current encounter
- **Elevated**: Review the manual BP readings above

**Stage 1**
- Previous Stage 1 or Stage 2?
  - No: Show Stage 1 Initial BPA
  - Yes: Show Stage 1 Initial BPA

**Stage 2**
- Previous Stage 2?
  - No: Show Stage 2 Initial BPA
  - Yes: Show Stage 2 Initial BPA

Initial Management Provider BPA supports vigilance at 3 visits for BP measurement, lifestyle management (or immediate medication as guideline-directed), and recognition signaling, e.g. problem list:
An example of Initial Visit Smartset is as follows:

**SMARTSET**

Subsequent hiBP Stage 1 Visit BPA for example (Stage 2 differs slightly):

SmartSet in Stage1 2nd visit:
At a 3rd visit with hiBP the BPA encourages investigation and other guideline-directed actions through BPA, Smartset, and Order Set with CPG recommended orders toggled on as default:
**Improving Adherence to the Standard of Care**

TCP targeted improvement was targeted from previous very low levels in the context of APP 2017 CPG encouraging full recognition signaling of all hiBP. HiBP recognition is defined as ICD10 diagnosis, hiBP on the EHR problem list, referral to hiBP specialties Nephrology or Cardiology, and/or the initiation of hiBP pharmacotherapy, treated collectively as the primary numerator of interest, or each of the four components individually treated as secondary numerators. Investigations were not included compared to previous publications because the 2017CPG deemphasized testing in probable essential hypertension. The denominator of interest is hiBP recorded in the EPIC EHR defined as at or above 130/80. These outcome proportions were examined in patients aged 13-19 years old of all sexes or genders, all races and ethnicities visiting TCP primary practices for whom this threshold is applicable. The exclusion criteria for the post intervention period was previous recognition, i.e. evidence of hiBP recognition in the pre-intervention period. Data on the indicator numerators and denominator were extracted from EPIC provider entered data.

In the post-intervention period from 2/2019 to 3/2020, the proportion of hiBP with any recognition increased relatively by 66% (25.4%), ICD10 diagnosis by a relative 100% (20.1%) and problem list by 137% (13.1%)[Table 1].

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Post- vs Pre- Intervention difference in average monthly proportion (95% Confidence Interval)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Recognition/hiBP</td>
<td>+10.4%(8.7,12.0)</td>
<td>4.6x10⁻⁹</td>
</tr>
<tr>
<td>ICD10/hiBP</td>
<td>+10.0%(8.2, 11.8)</td>
<td>1.9x10⁻⁸</td>
</tr>
<tr>
<td>Problem List/hiBP</td>
<td>+2.3%(1.0, 3.6)</td>
<td>1.2x10⁻⁶</td>
</tr>
<tr>
<td>Specialty Referral/hiBP</td>
<td>+1.2%(0.6, 1.9)</td>
<td>0.002</td>
</tr>
<tr>
<td>Medication/hiBP</td>
<td>+7.6%(5.7, 9.5)</td>
<td>0.001</td>
</tr>
</tbody>
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The below chart show monthly data of 1) AnyRecognition as a proportion of hiBP in pre-intervention period with 95%CI “control limit” (blue) and post-intervention (orange), including color-matched trendlines and goal recognition noted at 100%. A clear “level change” in the trendlines is seen post versus pre-intervention, but a declining slope is still seen after the intervention very similar to pre-intervention pattern. The ideal 100% recognition is not met, in context of a “Dismiss” option in the BPA.
Pediatric hiBP recognition should trigger further management. Beyond signaling recognition, management actions could include referral to specialists for further attention or lifestyle management initiation from providers in Nephrology, Cardiology and medication therapy. Previously, investigations had also been included but the AAP2017CPG deemphasized investigations in patients with probable essential hypertension coupled with alternate co-existing triggers for investigations such as obesity, lipid disorders, or fatty liver. For these management outcomes, specialty referral relatively increased by 44% (7.5%), and medication therapy relatively increased by 67% (3.1%) [Table 1].

The below chart shows clinical actions including 2) Specialty referral pre- (light blue) vs post-intervention (dark blue) including 95% errors with color-matched trendlines and 3) BP medication pre- (light green) vs post-intervention (dark green) and trendlines. There are not widely accepted goals on the desired proportion of these outcomes given that many youth will improve with PCP management and do not need specialty referral.
Accountability and Driving Resilient Care Redesign

Real time aggregate performance metrics were not made available to providers for their personal practice nor group practice. Post implementation no substantive modifications were made to the intervention. However, at inception of this project aggregate performance measures of recognition and clinical outcomes within practices and comparing practices as well as sociodemographic disparity analyses were envisioned and are currently ongoing. Furthermore, the non-seasonal declining patterns over time and gap vs desired recognition goal offer ample grounds for ongoing analyses to design methods to improve including planned interrogation of providers for long-term usability, “workarounds” and modified patient care flows.

HIMSS Global Conference Audience Guidance

Clinical Informatics and Clinician Engagement
Healthcare Applications and Technologies Enabling Care Delivery
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