Evidence-Based Elections

Lessons Learned: Navigating a Presidential Election Through a Pandemic

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Trustworthiness before trust

– Onora O'Neill

Did the reported winner really win?

- Procedure-based vs. evidence-based elections
  - sterile scalpel v. patient's condition

Security properties of paper ballots

- tangible/accountable
- tamper-evident
- to change many votes requires physical access & accomplices

When can auditing paper provide affirmative evidence reported winners won?

- Ballots marked using untrustworthy technology can't provide affirmative evidence
  - Hand-marked paper ballots are a record of what the *voter* did
  - Machine-marked paper ballots are a record of what the *machine* did: hackable
- Ballots not kept (demonstrably) secure don't provide affirmative evidence
- Paper ballots never examined don't provide affirmative evidence
- Need a solid chain of evidence, not just checks of some failure modes

Evidence = auditability + auditing

Evidence-Based Elections

P.B. Stark and D.A. Wagner

***Abstract*—We propose an alternative to current requirements for certifying voting equipment and conducting elections. We argue that elections should be structured to provide convincing affirmative evidence that the reported outcomes actually reflect how people voted. This can be accomplished with a combination of software-independent voting systems, compliance audits, and risk-limiting audits. Together, these yield a resilient canvass framework: a fault-tolerant approach to conducting elections that gives strong evidence that the reported outcome is correct or reports that the evidence is not convincing. We argue that, if evidence-based elections are adopted, certification and testing of voting equipment can be relaxed, saving money and time and reducing barriers to innovation in voting systems—and election integrity will benefit. We conclude that there should be more regulation of the evidence trail and less regulation of equipment, and that compliance audits and risk-limiting audits should be required.**

***Keywords*-elections, software-independent voting system, risk-limiting audit, resilient canvass framework EDICS SEC-INTE, APP-CRIM, APP-INTE, APP-OTHE.**

I. Introduction

IDEALLY, what should an election do? Certainly, an election should find out who won, but we believe it also should produce convincing evidence that it found the real winners—or report that it cannot. This is not automatic; it requires thoughtful design of voting equipment, carefully planned and implemented voting and vote counting processes, and rigorous post-election auditing.

While approximately 75% of US voters currently vote on equipment that produces a voter-verifiable paper record of the vote, about 25% vote on paperless electronic voting machines that do not produce such a record [1].

Because paperless electronic voting machines rely upon complex software and hardware, and because there is no feasible way to ensure that the voting software is free of bugs or that the hardware is executing the proper software, there is no guarantee that electronic voting machines record the voter's votes accurately. And, because paperless voting machines preserve only an electronic record of the vote that cannot be directly observed by voters, there is no way to produce convincing evidence that the electronic record accurately reflects the voters' intent. Internet voting shares the shortcomings of paperless electronic voting machines, and has additional vulnerabilities.

Numerous failures of electronic voting equipment have been documented. Paperless voting machines in Carteret County, North Carolina irretrievably lost 4,400 votes; other machines in Mecklenburg, North Carolina recorded 3,955 more votes than the number of people who voted; in Bernalillo County, New Mexico, machines recorded 2,700 more votes than voters; in Mahoning County, Ohio, some machines reported a negative total vote count; and in Fairfax, Virginia, county officials found that for every hundred or so votes cast for one candidate, the electronic voting machines subtracted one vote for her [2]. In short, when elections are conducted on paperless voting

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Establishing whether paper trail is trustworthy involves other processes, generically, *compliance audits*

Risk-Limiting Audits

- Endorsed by NASEM, PCEA, ASA, LWV, CC, VV, ...
- ~60 pilot audits in AK, CA, CO, GA, IN, KS, MI, MT, NJ, OH, OR, PA, RI, WA, WY, VA, DK.
- Routine in CO since 2017. Statewide audits in AK, KS, WY in 2020; "almost" statewide in PA in 2021.
- Laws in CA, CO, RI, VA, WA
- Methods for all social choice functions used in US elections

Statistical setting

- SHANGRLA reduces correctness to whether the means of a collection of finite, nonnegative, bounded populations are all $> 1/2$.
- H_{0j}: mean of list j is $\leq 1/2$.
- stop auditing if/when reject all $\{H_{0j}\}$. No multiplicity issue.
- use sequential testing for efficiency
- polling, comparison, "hybrid"
- sampling: clusters, stratified, weighted, Bernoulli, ...

Research questions

- sharpness of SHANGRLA
- sharper risk measures (P-values)
  - new martingales (adaptive betting martingales are promising)
  - adaptive batch-sequential methods
  - batch-sequential methods for sampling without replacement
  - adaptive batch-sequential methods for comparison audits
  - sharper hypothesis tests from stratified samples
  - connections to financial & healthcare auditing, clinical trials
- audits for single-transferrable vote

Research questions

- better logistics
  - ballot accounting, constructing trustworthy ballot sheet manifests
  - voting equipment that reports CVRs linked to ballots
  - keeping track of sheet styles
- education/outreach
  - public understanding and trust of statistics and logic

Evidence-Based Elections: 4 C's

- Voters *CREATE* complete, durable, verified audit trail.
- LEO *CARES FOR* the audit trail adequately to ensure it remains complete and accurate.
- Compliance audits *CHECK* that paper trail is trustworthy
- Risk-limiting audits *CHECK* or *CORRECT* reported results