Equivalent QC – some myths about internal monitoring systems

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Outline

- Equivalent QC (EQC)
- Preventing medical errors
- Internal monitoring systems (IMS)
- Unit Use and POCT devices
- The EQC validation protocol
- Errors QC does and does not detect
- Cost benefit analysis

Scope

- This presentation covers the majority of today's instrument assay systems (no specific products mentioned)
- Excludes some newer technologies (without mentioning products) which require special considerations regarding QC.

The EQC premise

- Traditional QC may be redundant to internal monitoring systems
- On passing a 10 day test, labs may reduce QC to once a month

For a summary of equivalent QC, see:
http://www.cms.hhs.gov/clia/6606bk.pdf

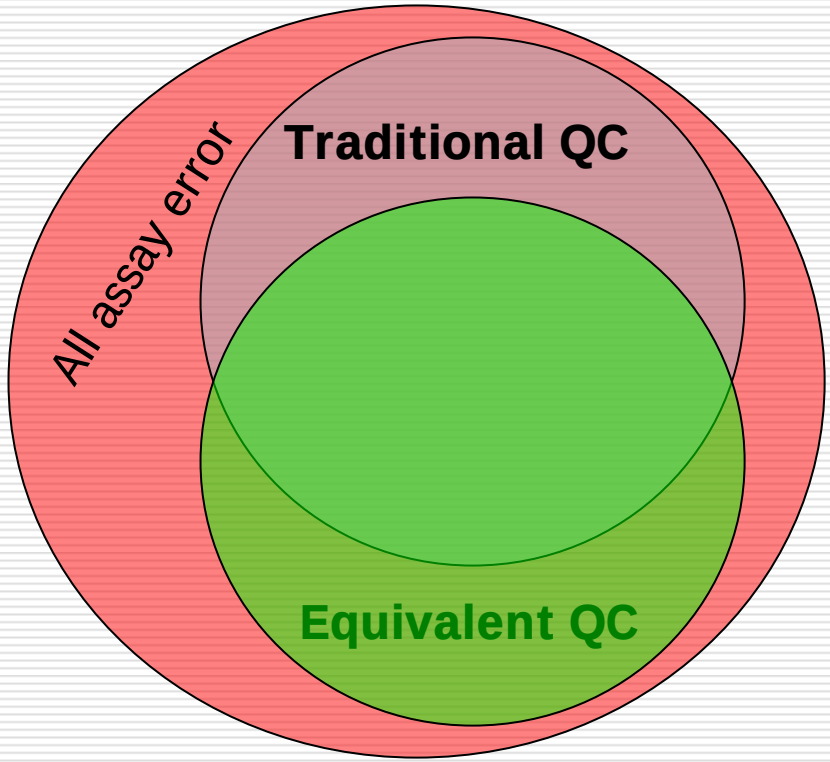
For the entire regulation, see:
http://www.cms.hhs.gov/manuals/pm_trans/R32SOM.pdf

For a previous essay on this topic, see:
http://krouwerconsulting.com/Essays/Equivalent.htm

Equivalent QC and QC

Traditional and equivalent QC

- are not completely redundant
- do not detect all errors



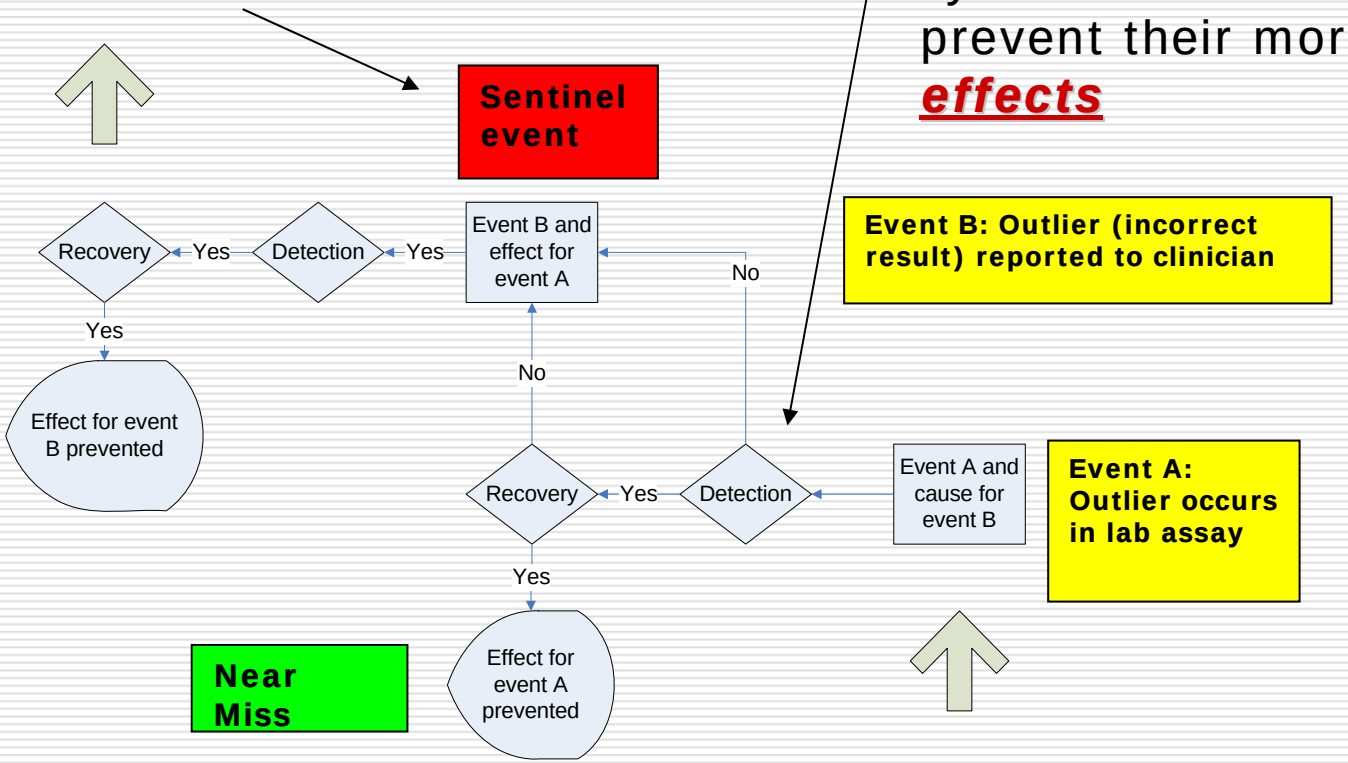
Preventing medical errors

- Next slide will show that…
  - Preventable medical errors are the result of a cascade of error events
  - The cascade can be terminated early by:
    - Preventing the error or
    - Detecting and recovering from the error
- QC or internal monitoring systems ***detect*** errors

Preventing medical errors

Patient gets wrong treatment

QC or internal monitoring systems detect errors and prevent their more serious ***effects***



Internal monitoring systems (IMS)

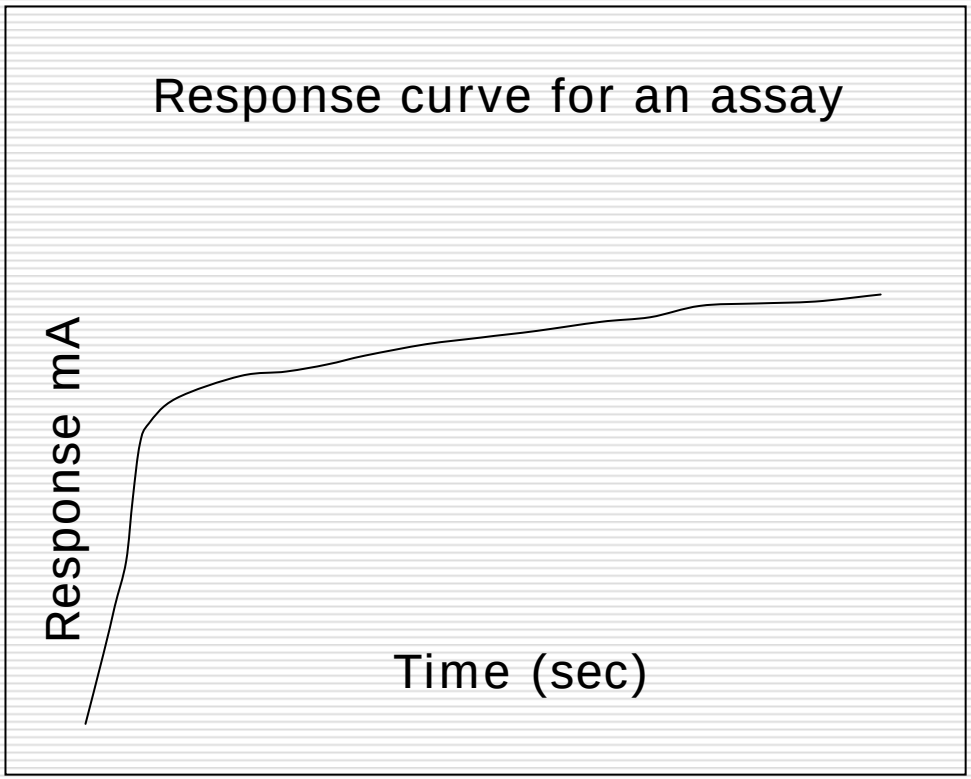
- IMS are a collection of hardware and software that detect errors and prevent the effect of the error from occurring
  - Example: Noise in the signal of a patient sample is detected, the result is flagged and not reported
- IMS are not new – although always improved, they have been in systems for over 30 years

IMS are pervasive in systems

IMS details (e.g., specific algorithms) are mostly unknown to labs

- Each sample checked for
  - Range
  - Noise
  - Curve shape
  - Endpoint

Remember the SMAC strip chart recorder?



Internal monitoring systems

- Internal monitoring systems don't detect all errors, because
  - Complexity of instrument systems prevents perfect failure mode models
  - There is management pressure to release new products quickly
  - There is insufficient knowledge to "design things right the first time"

Internal monitoring systems (IMS)

- IMS are developed through FMEA* and fault tree (FT) analysis:
  - The assay process is flowcharted (also called process mapping)
  - Potential errors and their causes are listed in fault trees and FMEAs
  - Errors are classified and ranked
  - Mitigations are applied to highest priority errors

*Failure Mode Effects Analysis

FMEA and Fault Trees

- FMEA is required to be performed yearly in hospitals by JCAHO
- Hazard analysis (fault trees) are required by FDA for instrument systems
- FMEA and FT well known in engineering
- Krouwer Consulting will present a mini workshop at IFCC/AACC in Orlando on reducing risk of lab errors using FMEA and fault trees (Monday, July 25, 2005)

Internal monitoring systems

- The effort expended on “quality activities” (FMEA and FT) varies by manufacturer and project
  - Viewed as a chore by some engineers and scientists (e.g., a regulatory requirement)
  - Can be viewed as adversarial (e.g., challenging the design)
  - Not valued financially compared with other programs (resource limited)

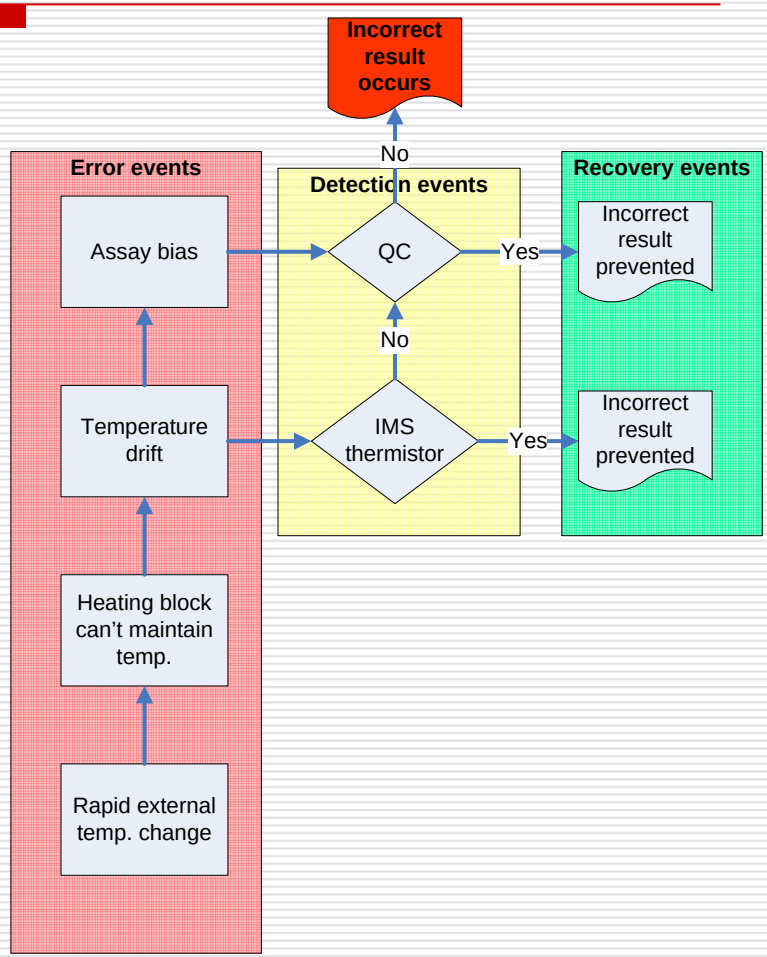
QC compared to IMS

- IMS are a model of how the system can ***potentially*** fail
  - Models can be both incomplete and incorrect!
  - Even when the model is correct, detection algorithms have tradeoffs
- QC is largely observational
  - The QC “model” describes higher level effects: see next slide

QC compared to IMS

QC can detect this bias even if there is no knowledge of lower level errors

In the IMS model, the assay result is a function of temp., and temp. is assumed to be constant. The thermistor checks for this.



QC compared to IMS

Another view of equivalent QC

Given each error, what are the frequencies summed across all errors in each colored box. The green boxes are consistent with reduction of QC, the red box isn't.

	QC detects error	QC misses error
IMS detects error	N=?	N=?
IMS misses error	N=?	N=?

IMS effectiveness

- Complex systems have high failure rates during development
- Improvements are made throughout development
- But released systems still fail
  - Failures are often reliability related (e.g., system won't run)
  - Failures can also cause incorrect results

IMS effectiveness

- Calibration is difficult for IMS
  - "Reasonable" signals are accepted but may be incorrect
  - Leads to bias in all patient results until next calibration
- QC is good at detecting calibration bias and is ***different*** than IMS
  - QC result is compared to "truth" (e.g., QC run on ***other*** systems)

The fallacy of complete coverage

- An IMS that monitors the complete analytical process provides no guarantees
  - Much of IMS are software, where “100% coverage” is unachievable due to branching
  - There is also the detection tradeoff problem (next slide)

The detection tradeoff problem

- An IMS detection algorithm has the same properties as a medical test
  - There is often overlap in the error and error-free signals
- In the real world, the red boxes exist and are often traded off against each other

Truth	Test is positive	Test is negative
Failure occurs	IMS prevents error	Wrong result allowed
Failure doesn't occur	Good result suppressed	IMS allows result to be reported

Unit use and POCT devices

- It is often suggested that QC has no role in a unit use device because…
  - QC of a single unit (good or bad result) does not inform about other units [same argument would apply to non POCT analyzers in main lab that use discrete (unit use) reagent packs]
  - IMS fulfills QC role in unit use devices
- Unit use and continuous flow systems are not that different

Unit use and POCT devices

In theory, neither system should experience failures

Unit Use Devices	Continuous Flow Devices
IMS - 100% of units tested for electrical contacts in system	IMS – Electrical contacts part of system test
QC - Units sampled at plant to test for reagent quality	QC - Reagent lot tested at plant for reagent quality
Lab QC – Failure implies other units have problem since units likely produced in same batch, or system problem, user error	Lab QC – Failure implies problem with reagent lot, or system problem, user error

Evaluation of EQC

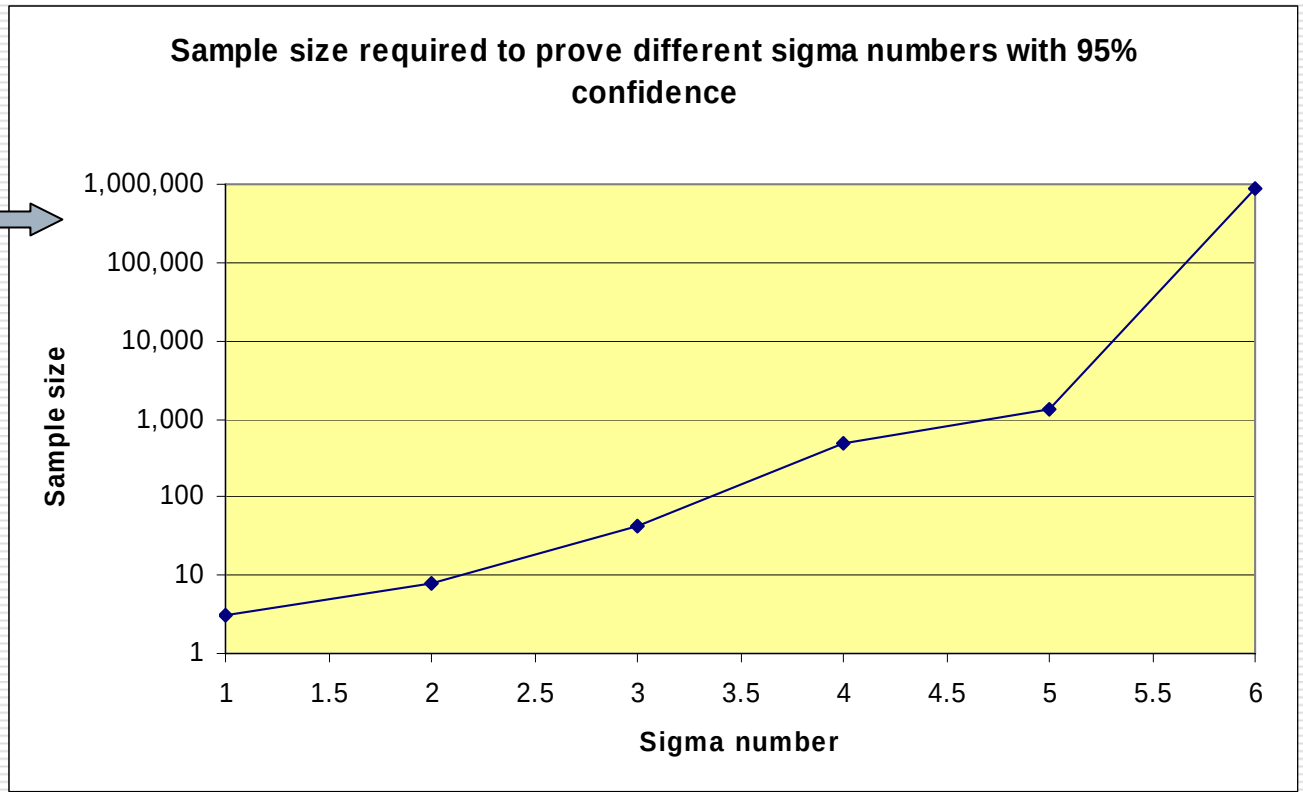
- Minimum CMS protocol is 2 QCs per day for 10 days with one failure allowed that does not repeat
- This guarantees with 95% confidence no more than a ***21.6%*** QC failure rate!
  - This is about a 2.1 sigma process in six sigma terms

Evaluation of EQC

- Mistake to think that failed QC that repeats OK is not an issue
  - A short term bias could affect several patient samples (and QC) and then disappear

Evaluation of EQC

It's not easy to prove that errors are rare



EQC Cost / Benefit

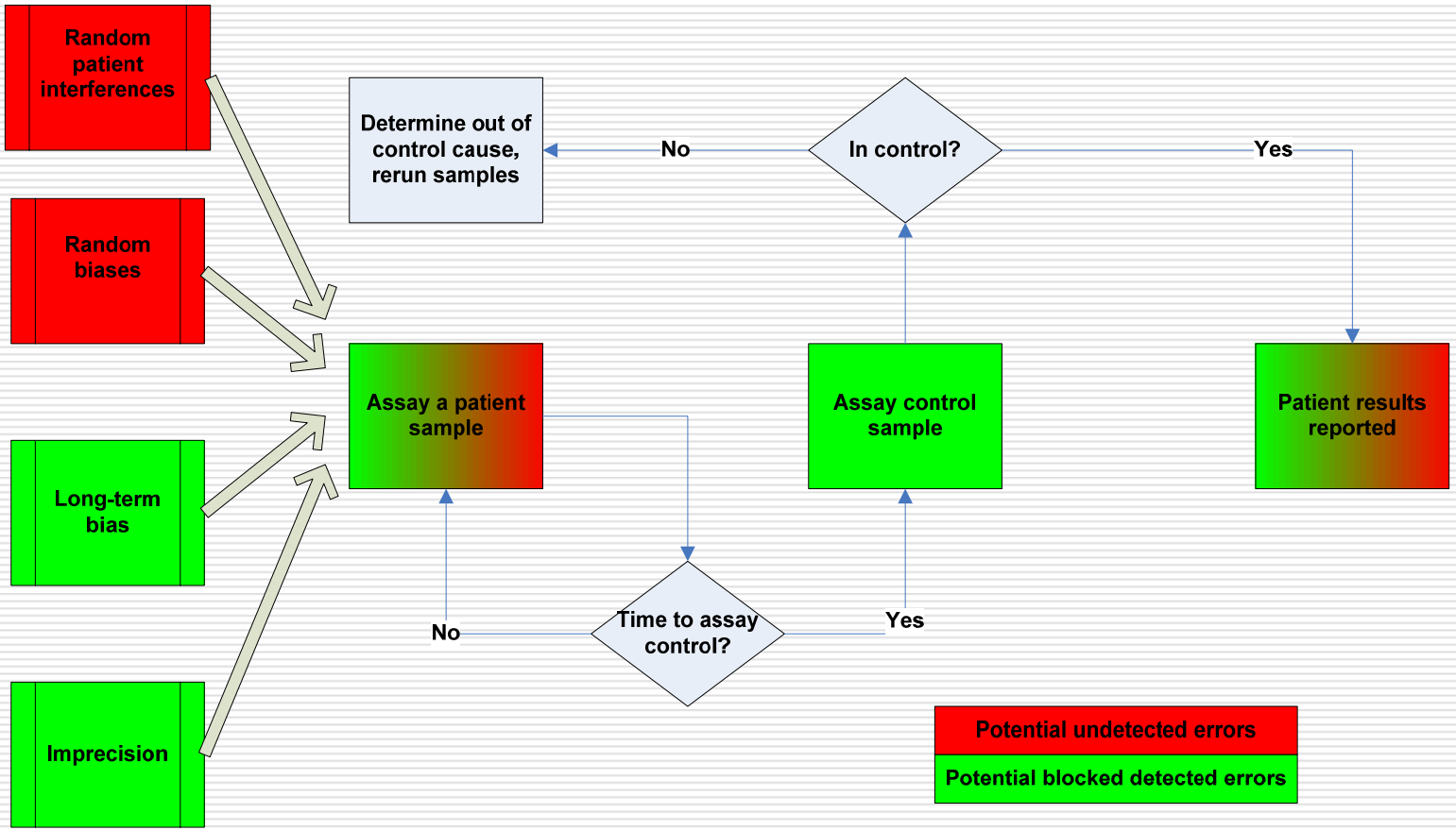
- Upside - reducing QC reduces assay cost which
  - Allows more people to be tested
  - Information from more frequent testing reduces morbidity and mortality
- Downside – reducing QC may cause
  - More undetected lab errors, which increases morbidity and mortality

EQC Cost / Benefit

- The cost/benefit question needs to be answered with data, but not by asking every lab to answer question.
- We must be careful …
  - With less QC there may still be errors, but if these errors* would not be caught by traditional or increased QC, then reduced QC is valid.

*Example – random patient interferences

QC doesn't detect all errors



QC doesn't detect all errors

- ***random patient interferences*** – are interferences that cause a bias in the (patient) result and are often different (e.g., apparently random) in each patient specimen. QC does not detect this error.
- ***random bias*** – is any short term bias that lasts for a few samples and is not specific to a particular patient specimen. QC probably won't detect this error since the probability of the error occurring during a QC sample is low.

The effect of changing QC frequency on error detection

Error Source	QC Scheme		
	Increased	Current (2 per day)	Reduced
Random patient interference	No effect	No effect	No effect
Short term bias	Detects more errors	Detects fewer errors	Detects even fewer errors
Long term bias	No effect	No effect	Detects fewer errors[1]
Imprecision	No effect	No effect	No effect

[1]For example, if a system is calibrated weekly, and there is calibration error, running QC monthly will frequently miss this error

Conclusions

1. IMS and QC don't detect all errors
2. Assertion that QC is redundant to IMS is anecdotal, not backed by data
3. Arguments presented here suggest assertion is incorrect
4. Protocol for labs to reduce QC is inadequate
5. Reducing QC without increasing lab error would be a good thing

Recommendation

- CMS should either…
  - justify Equivalent QC with data, or
  - propose a protocol that will provide this data

Thanks

- Thanks for your interest
- For other topics in lab quality and patient safety, see:

  http://krouwerconsulting.com/Essays/ListofEssays.htm