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What is Moving Averages…

and How to Deploy it

Data Innovations®
Delivering Tomorrow's Lab, Today

Learning Objectives

At the end of the course

- Attendees will be able to
  - Understand the concept behind Moving Averages and how it applies to the clinical lab
  - Understand the principles behind choosing a starter set of assays.

Typical Practice – Quality Control (QC)

- Material with known (established) values
- Run at specified intervals (once per day, once per shift, every x patients)
- Results compared to acceptable range
- Assay is acceptable or not acceptable
- Limitations:
  - Only know the instrument performance at that time – what happens between QC?
  - Delay in identifying potentially inaccurate results which may have been acted on
  - Expensive – cost of reagents and cost of QC material itself.

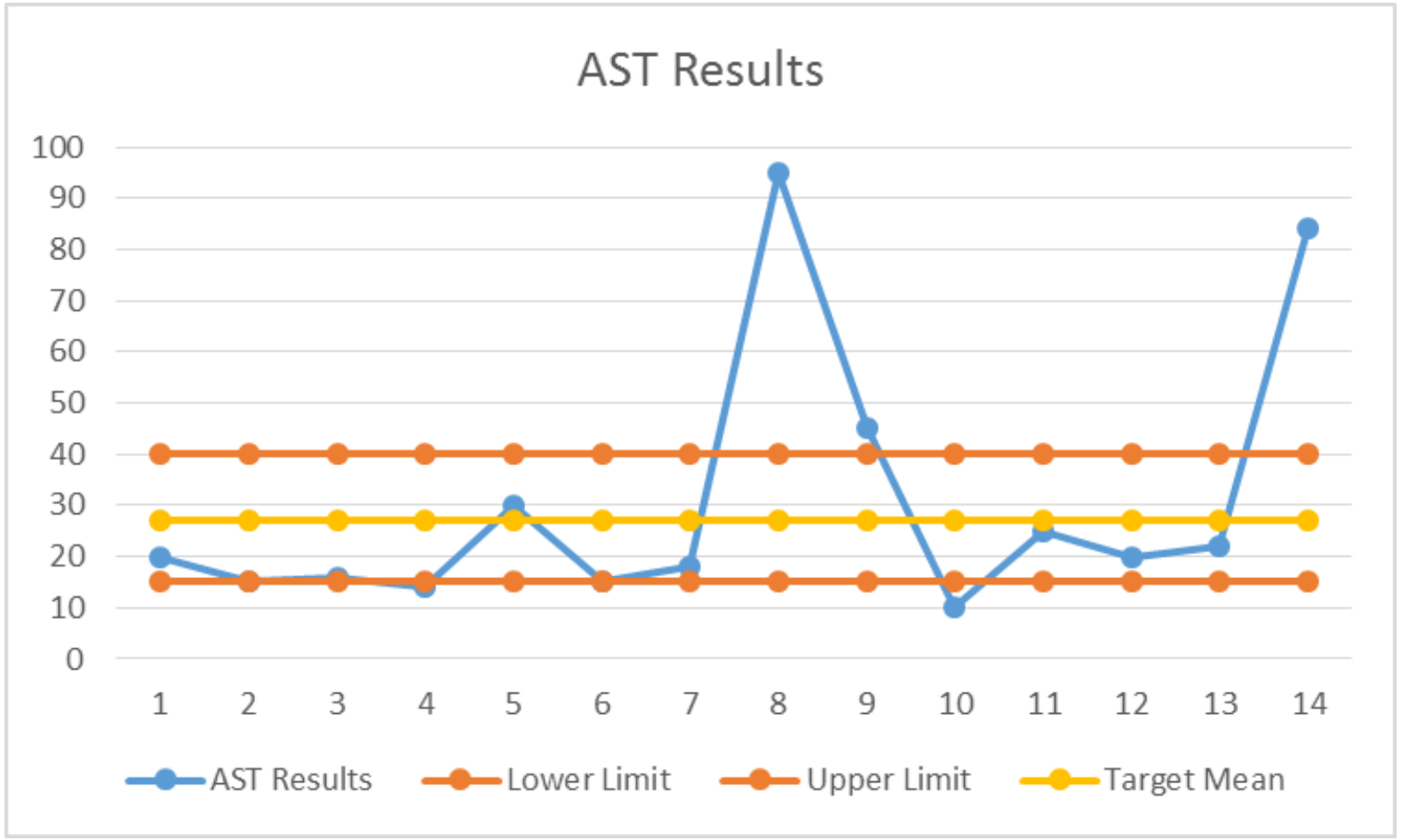
Moving Averages – The Stock Market

Moving Averages – The Laboratory

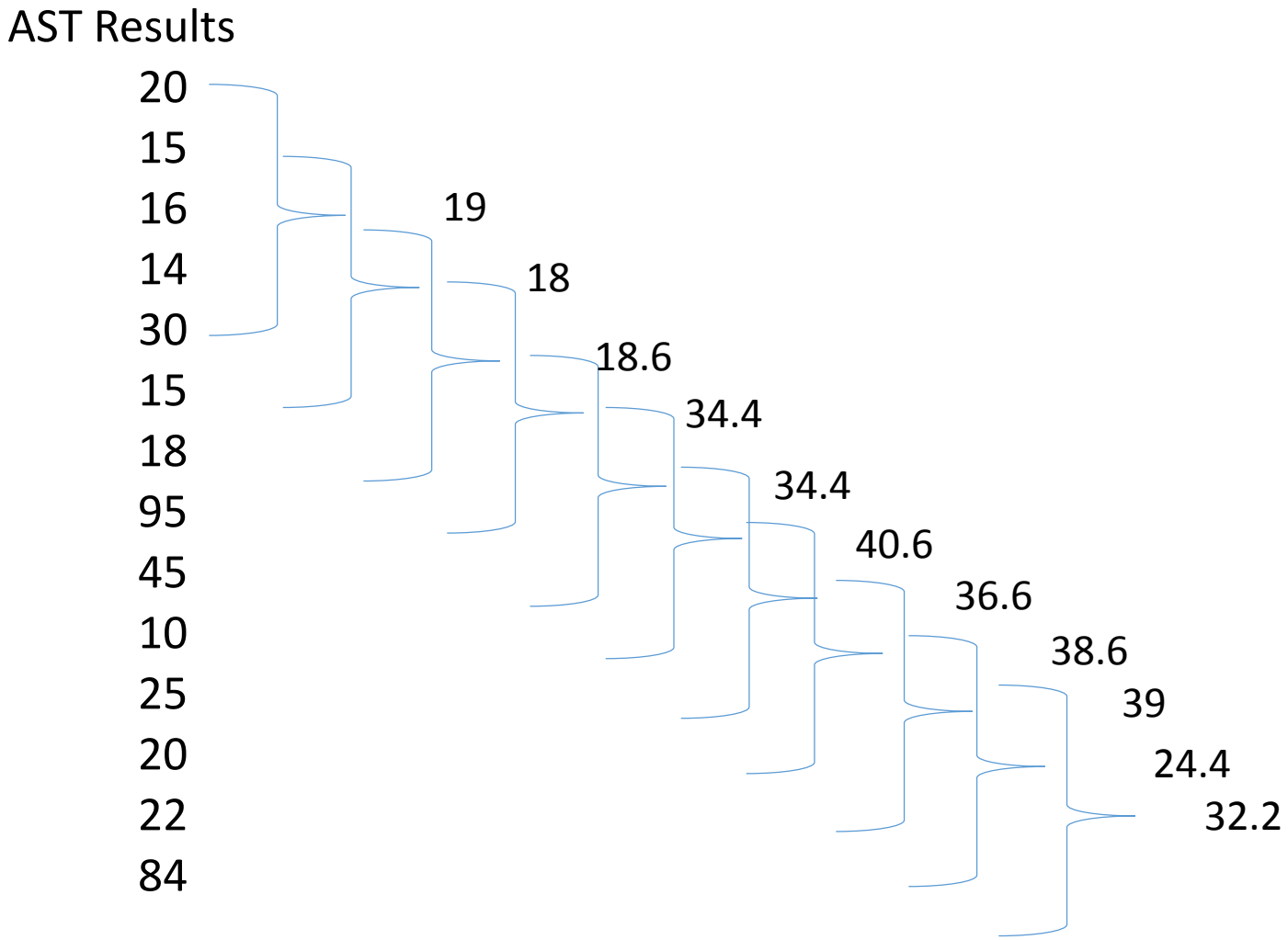
- Provides Continual Monitoring between QC events.
- Identify issues more quickly
  - Faster resolution
  - Better Patient Care
  - Fewer corrected reports
- Uses patient results – no additional material or reagent costs
- Limitation
  - Not applicable to every analyte
- Compliment to current QC practice, does not replace them.

Plot Results

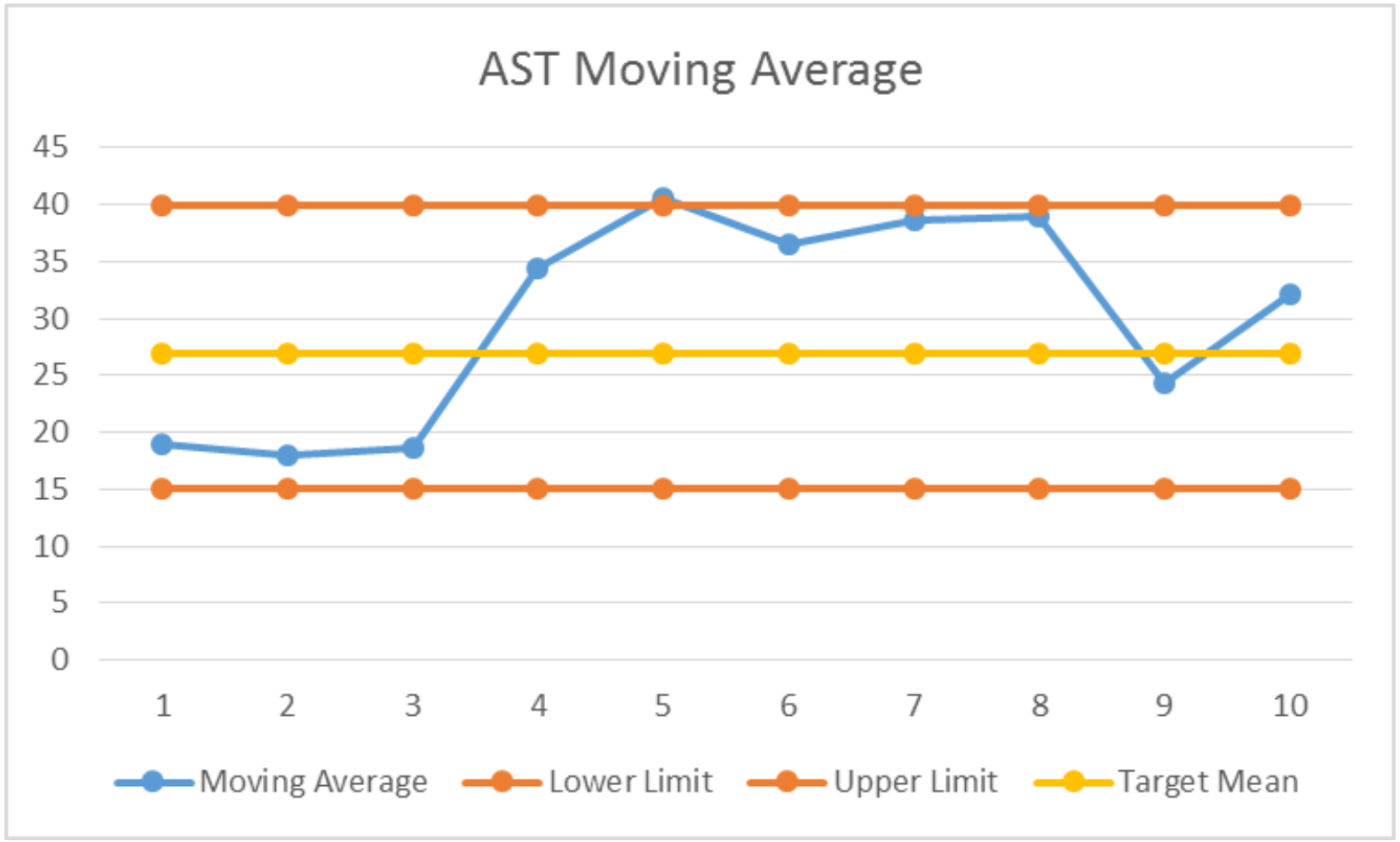
AST Results
20
15
16
14
30
15
18
95
45
10
25
20
22
84



How does it work?



What does it look like?



Use of Moving Averages

- Phase 1: Select based on attributes
  - Small number to build familiarity
  - Refine protocols
- Phase 2: Add more analytes
  - Continue to refine the protocols
  - Some analytes may ‘never’ be useful for MA (low test volume, TDM’s etc)
  - List of analytes will vary from lab to lab and instrument to instrument

Biological Considerations -

- Ideal - Single Reference Range across Ages and Genders
  - Separate Protocols may be established based on age or gender.
  - Separate Ranges that are very similar will work.
- Ideal - Relatively narrow Reference Range
  - Should not go through zero (or patients results infrequently are zero)
  - AST will work, Troponin might not
- Ideal - Relatively stable across disease states
  - Analyte is ‘normal’ for most diseases
  - Filter out patients based on location, physician, diagnosis etc. for specific analytes

Instrument Consideration

- Method Precision (manufacturer claims, QC)
- Sample size and delivery system
- Reagent volume and delivery system
- Measuring System (photometric, ISE, Chemiluminescence, etc.)
  - Endpoint
  - Rate
  - Wavelength
- Calibration Stability
- If modular instrument which module(s) the analyte is performed on

Choosing a Starter set of Analytes for Moving Averages

Information to Gather

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
ALP	50	136	7	480/450	Rate	481	1
ALT	30	65	35	700/340	Rate	510	1
Amylase	25	115	14	405/577	Rate	15	2
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Look for Narrow Reference Ranges

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
ALP	50	136	7	480/450	Rate	481	1
ALT	30	65	35	700/340	Rate	510	1
Amylase	25	115	14	405/577	Rate	15	2
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Look for Small Sample Volumes

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
ALP	50	136	7	480/450	Rate	481	1
ALT	30	65	35	700/340	Rate	510	1
Amylase	25	115	14	405/577	Rate	15	2
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Look for Large Sample Volumes

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
ALP	50	136	7	480/450	Rate	481	1
ALT	30	65	35	700/340	Rate	510	1
Amylase	25	115	14	405/577	Rate	15	2
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Look for Significant Daily Volume

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
ALP	50	136	7	480/450	Rate	481	1
ALT	30	65	35	700/340	Rate	510	1
Amylase	25	115	14	405/577	Rate	15	2
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Look for Unique Method/Module

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
ALP	50	136	7	480/450	Rate	481	1
ALT	30	65	35	700/340	Rate	510	1
Amylase	25	115	14	405/577	Rate	15	2
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

First Pass at Assay Selection

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
~~ALP~~	~~50~~	~~136~~	~~7~~	~~480/450~~	~~Rate~~	~~481~~	~~1~~
ALT	30	65	35	700/340	Rate	510	1
~~Amylase~~	~~25~~	~~115~~	~~14~~	~~405/577~~	~~Rate~~	~~15~~	~~2~~
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Unique Wavelengths/Measurement Type

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
~~ALP~~	~~50~~	~~136~~	~~7~~	~~480/450~~	~~Rate~~	~~481~~	~~1~~
ALT	30	65	35	700/340	Rate	510	1
~~Amylase~~	~~25~~	~~115~~	~~14~~	~~405/577~~	~~Rate~~	~~15~~	~~2~~
AST	15	37	40	700/340	Rate	508	1
BUN	7	18	3	700/340	Rate	920	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Second Pass at Assay Selection

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
~~ALP~~	~~50~~	~~136~~	~~7~~	~~480/450~~	~~Rate~~	~~481~~	~~1~~
ALT	30	65	35	700/340	Rate	510	1
~~Amylase~~	~~25~~	~~115~~	~~14~~	~~405/577~~	~~Rate~~	~~15~~	~~2~~
~~AST~~	~~15~~	~~37~~	~~40~~	~~700/340~~	~~Rate~~	~~508~~	~~1~~
~~BUN~~	~~7~~	~~18~~	~~3~~	~~700/340~~	~~Rate~~	~~920~~	~~1~~
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

First Batch of Assays for MA

Method	Reference Interval - Low	Reference Interval - High	Total Sample Volume (µL)	Wavelength	Measurement Type	Daily Volume	Module
Albumin	3.4	5	5	700/340	End Point	496	1
ALT	30	65	35	700/340	Rate	510	1
Calcium	8.5	10.1	5	700/600	End Point	640	1
Chloride	98	107	10	ISE	End Point	950	ISE

Remember: This Is Just a Place To Start

- Start Small and build on success
- Add other assays as you are ready
- Your population may be unique
- Your Vendor may recommend assays to use

Initial Analyte Selection

- Ideal – Small Reference Range and Precise measuring system
- Typically Strong Candidate Analytes
  - ALP ALT AST Bicarbonate Calcium Chloride Creatinine
  - Glucose Hematocrit Hemoglobin Potassium Sodium Free T4
  - TSH Urea WBC
- Moderate Candidate Analytes
  - Ferritin LD MCV Platelet RBC
- Typically Poor Candidate Analytes
  - Amylase B12 Cholesterol HDL CK FSH Lipase LH Prolactin
  - Triglycerides Troponin

Removing Outlier Results

- Thresholds
  - High level cutoffs
  - Low level cutoffs
- Filters
  - More specific
  - Based on demographics
    - Age, Gender, Location, Diagnosis, Physician, etc.
  - Based on Values
    - Asymmetrical Thresholds
    - Non-numeric results (e.g. > , <, null etc.)

Summary

- Moving Averages is a supplement to, not a substitute for standard QC
- Start with Assays that have:
  - High precision
  - Narrow Reference Range
  - High daily volume

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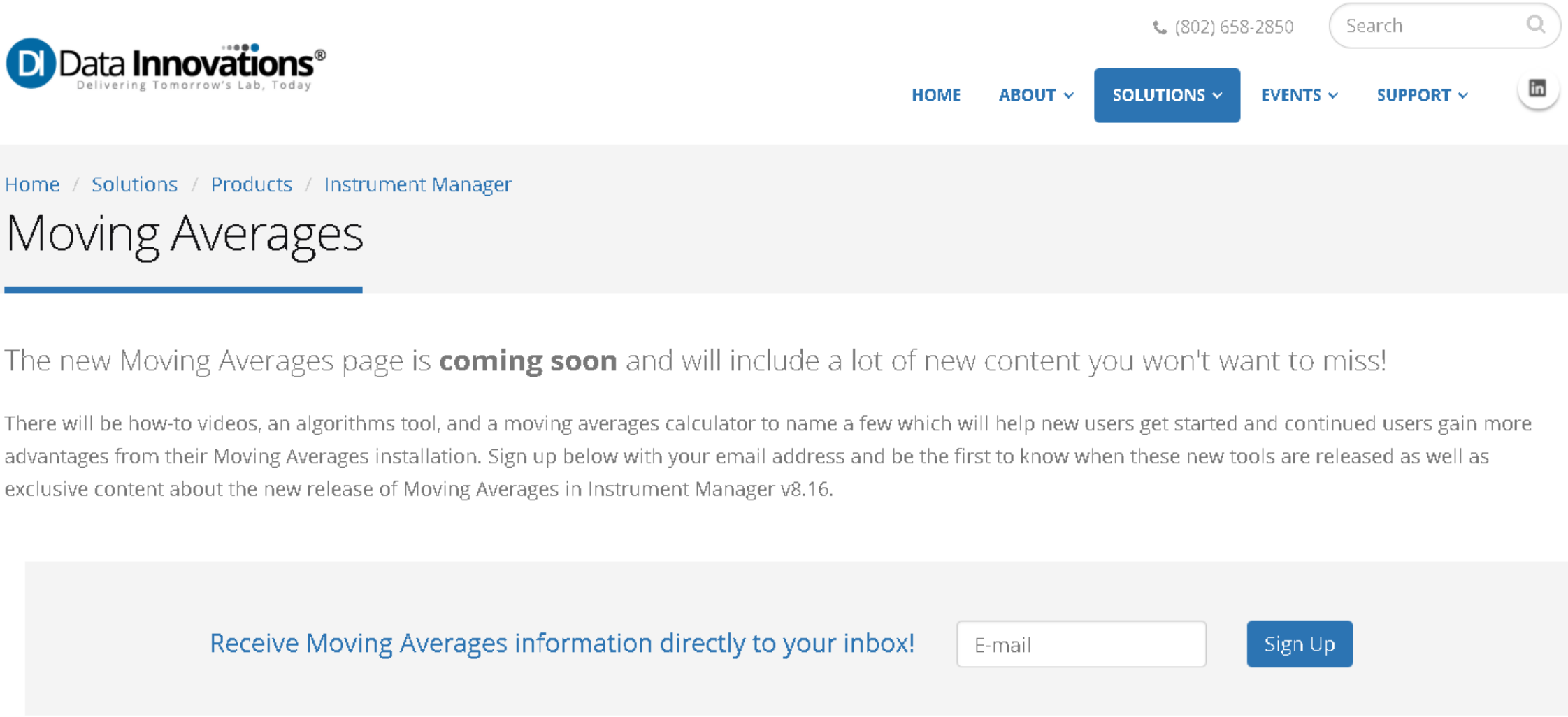

Questions?

Thank you for your time!

Moving Averages - Citations

- Changing the paradigm of laboratory quality control through implementation of real-time test results monitoring: For patients by patients, Clin Biochem (2015), Fleming JK, Katayev A *
- Design and assessment of average of normals (AON) patient data algorithms to maximize run lengths for automatic process control, Clinical Chem 42:10 (1996), Westgard, Smith, Mountain, Boss. **
- Assessment of “Average of Normals” Quality Control procedures and Guidelines for Implementation, Cembrowski, Chandler, and Westgard, The American Journal of Clinical Pathology 81:4 pp.492-497 (1984) **
- Patient result median monitoring for clinical laboratory quality control; Wilson, Roberts, Pavlov, Fontenot, Jackson (ARUP Laboratories, Clinica Chimica Acta 412 (2011) 1441–1446 ***

** Large scale use of Moving Averages for Patient Monitoring (Laboratory Corporation of America)*

*** Article for establishing N*

**** Use of Medians (ARUP) for patient results monitoring*

Moving Averages - Citations

- Evaluation of the Average of Patients Application: Application to Endocrine Assays, Douville, Cembrowski, and Strauss. Clinica Chimica Acta 167 pp.173-185 (1987)
- Use of medians and “average of normals” of patients’ data for assessment of long-term analytical stability, Lott, Smith, Mitchell, Moescheberger, Clinical Chemistry 42:6 (1996)
- The exponentially weighted moving average (EWMA) rule compared with traditionally used quality control rules, Clin Chem Lab Med (2006) by Kristian Linnet.