Being a mom is hard: The importance of managing hypocalcemia on dairy cow welfare

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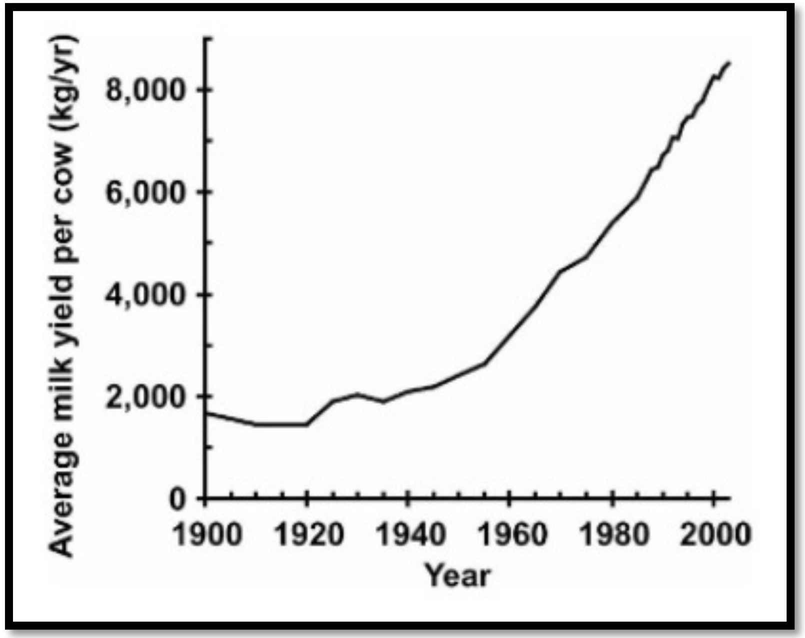
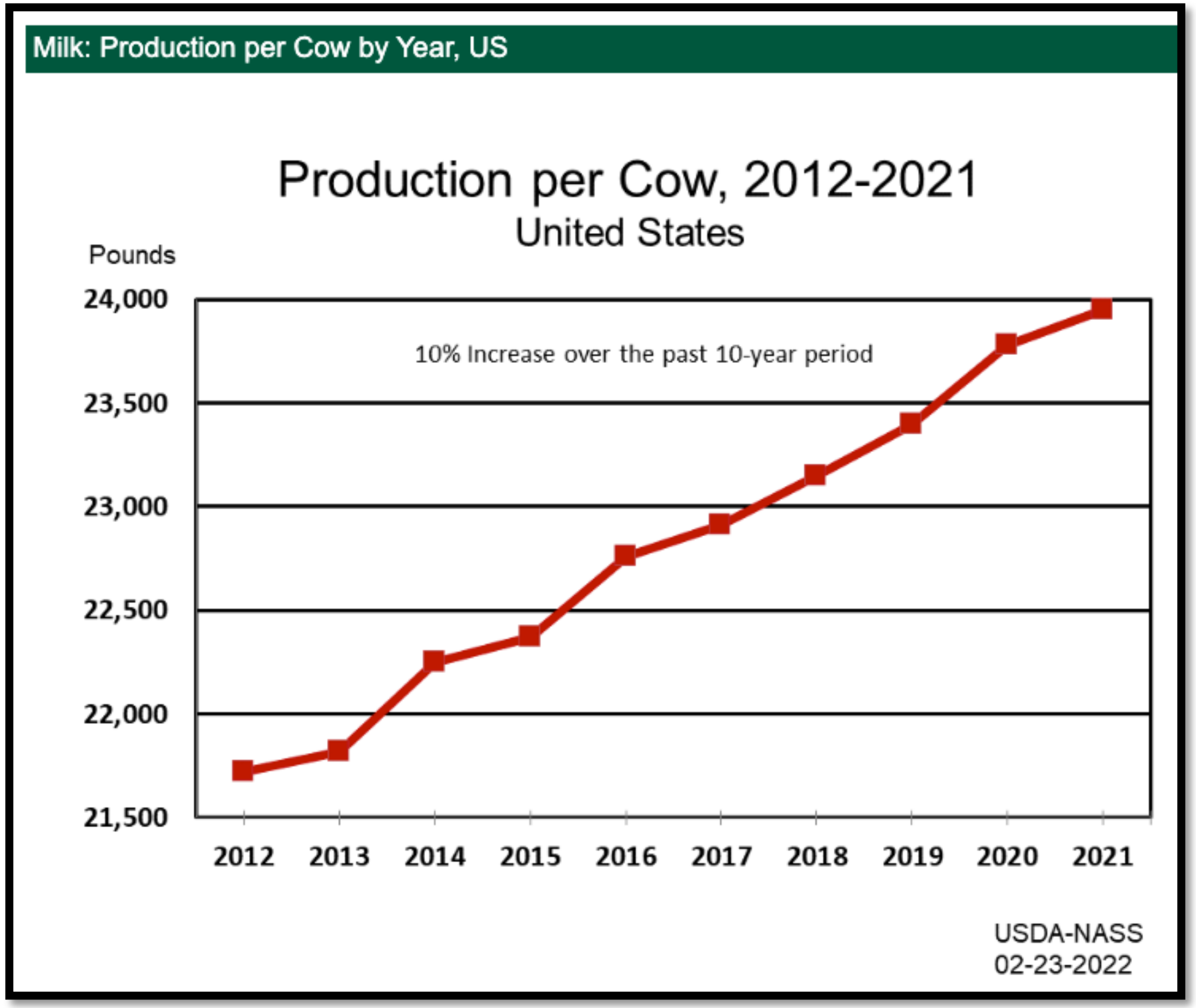
Overview

- Demands of early lactation
- Classification of hypocalcemia
- Transient, persistent, delayed hypocalcemia
- Measuring calcium
- Prepartum nutritional & postpartum prevention strategies

The average cow of today:



VandeHaar and St-Pierre, J Dairy Sci, 2006



- Many cows producing >100 lbs by end of 1st week
- Lactation initiates massive change in nutrient and macromineral demands

- Our job: provide the environment to support needs
- Today: focus on calcium

Calcium demands of milk production

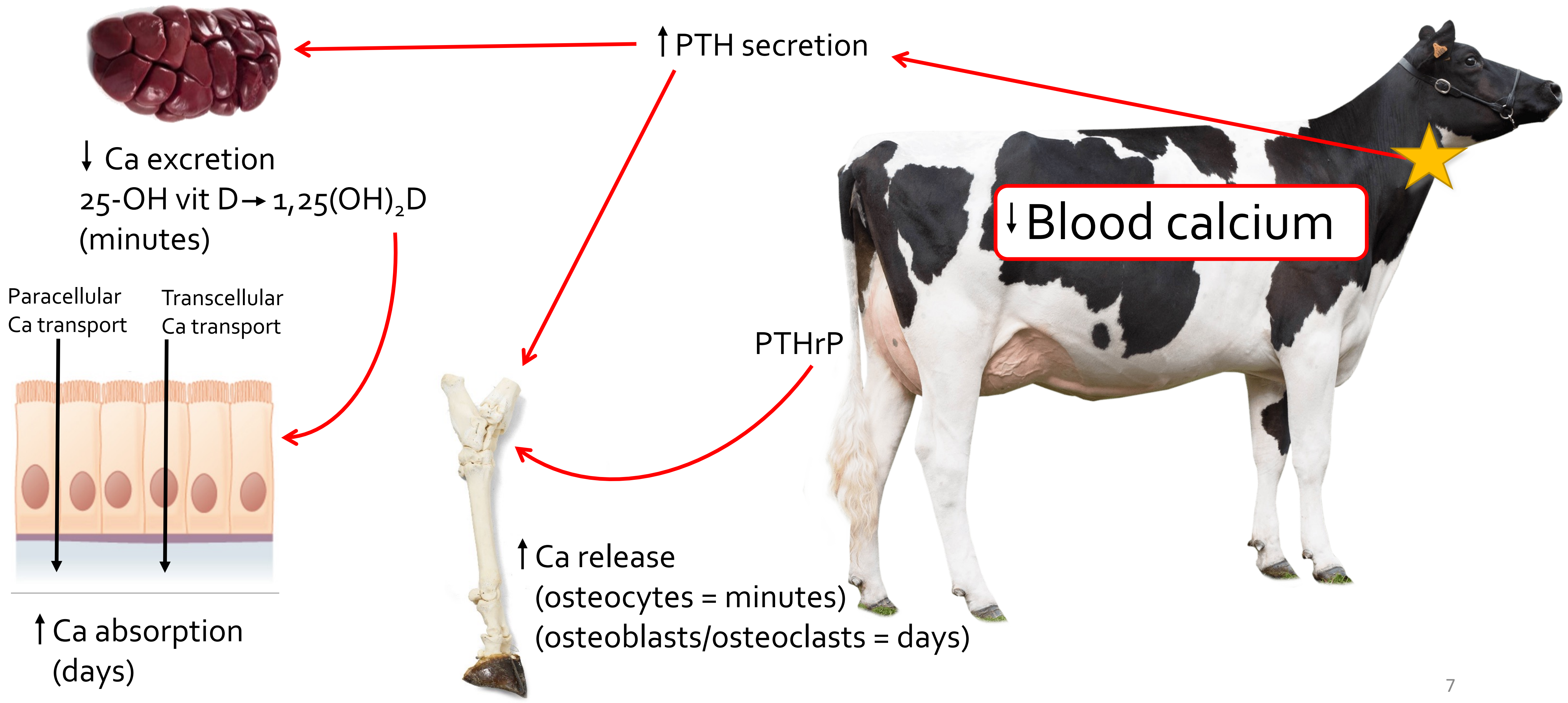
Daily maintenance = 21 g Ca

Colostrum = 23 g Ca

100 lbs milk = 56 g Ca

- Human recommended dietary allowance = 1,000 mg Ca
- 1 cup milk = 300 mg Ca

Increasing blood calcium



Calcium & welfare

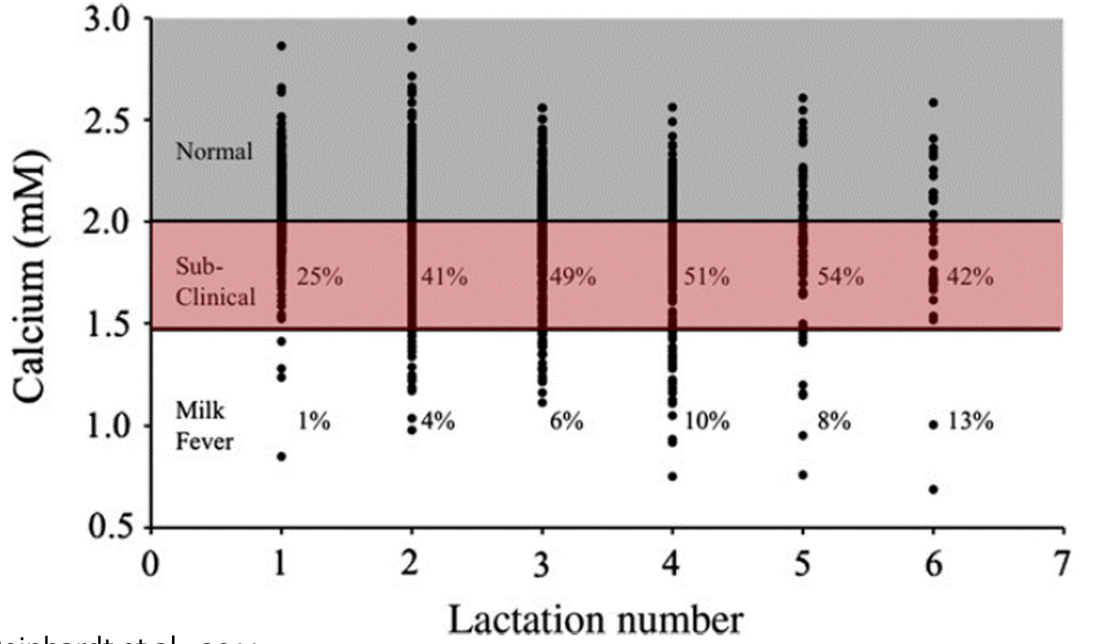
- What happens when we don't meet their needs?
  - Cows develop hypocalcemia
  - "Gateway" disease
  - Reduced milk production
  - Poorer reproduction

- How do we meet their needs?
  - Cow comfort
  - Nutrition

Chapinal et al., 2012; Martinez et al., 2012; Caixeta et al., 2017

Hypocalcemia

- Clinical disease has been well addressed, focus now on subclinical disease



Reinhardt et al., 2011

- Milk fever incidence <5% on dairies
- Subclinical hypocalcemia (SCH) incidence up to 50%

Subclinical hypocalcemia (SCH)

- Multiple studies have explored categorization of blood calcium concentrations in early lactation
  Oetzel et al., 1988; Oetzel et al., 1996; Martinez et al., 2012

- Recent studies use epidemiologic outcomes to improve characterization
  Chapinal et al., 2011; Rodriguez et al., 2017; Wilhelm et al., 2017; Neves et al., 2018; Venjakob et al., 2018

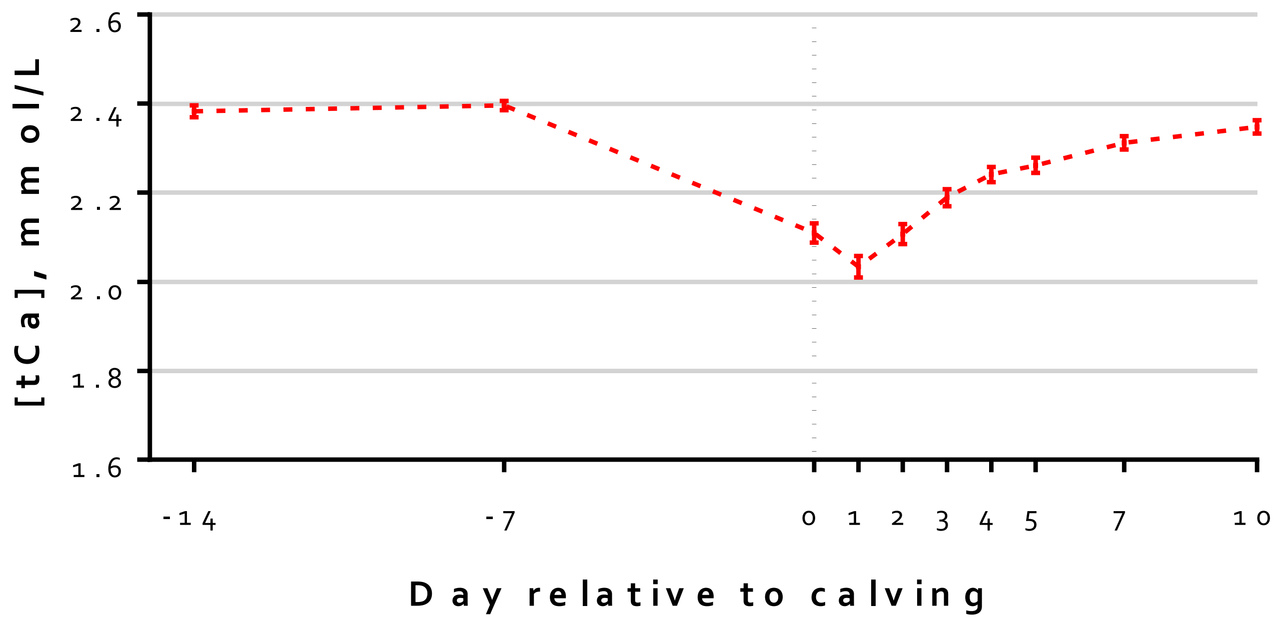
- No consensus on optimal test day or what cut point to use for classification of SCH

Identifying cows with SCH

- Are we meeting their needs for calcium regulation?
  - Incidence of milk fever
  - Incidence of other early lactation diseases
  - Peak milk
  - Testing
- Testing:
  - Herd monitoring
  - Individual cows – how and when to classify?

Classifying SCH

- When to test:
  - At calving?
  - At 24 hrs?
  - At 48 hrs?
  - Later?



- What cut-point to use:
  - Definition of "normal"
  - Based on health and production outcomes

Calcium dynamics by "cohort"

- Can we quantify the difference in calcium dynamics between cows?

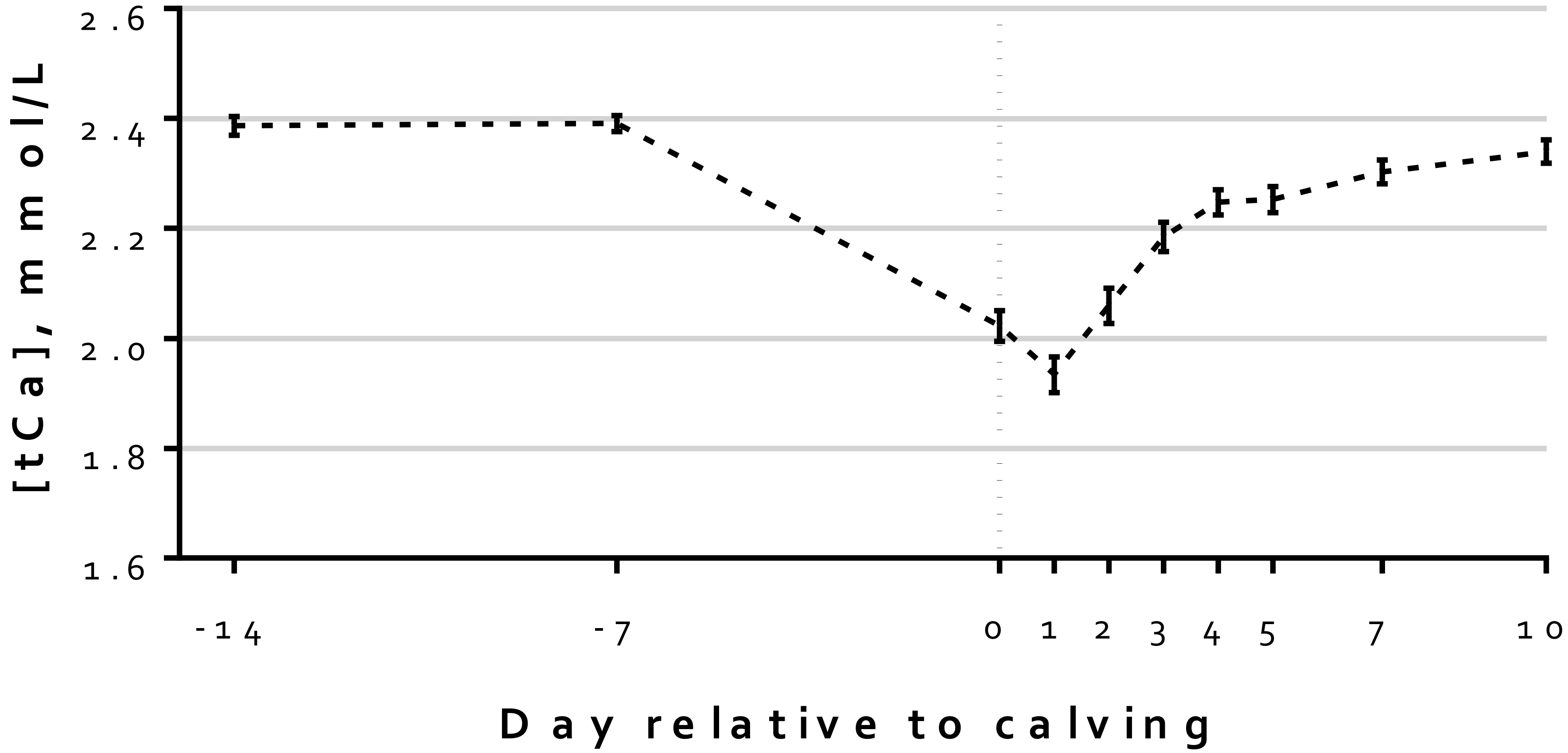
tCa: 1 mmol/L = 4 mg/dL

- Parity ≥2: cohort based on DIM 1 & 4 (1.8, 2.2 mmol/L)

Neves et al., J Dairy Sci 101:9321-9331.

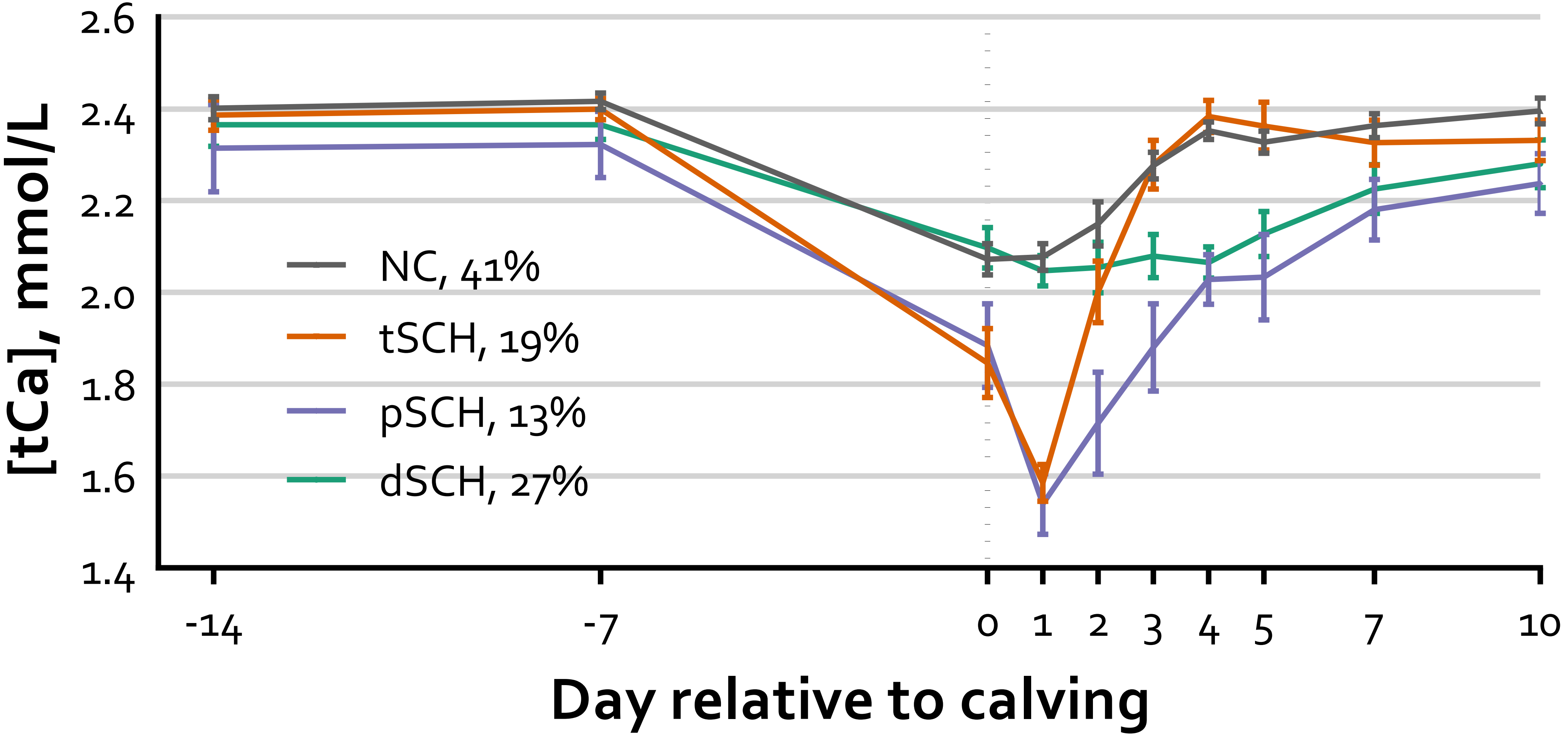
  - Normocalcemia (NC) ↑↑
  - Transient subclinical hypocalcemia (tSCH) ↓↑
  - Persistent subclinical hypocalcemia (pSCH) ↓↓
  - Delayed subclinical hypocalcemia (dSCH) ↑↓

Calcium dynamics: parity ≥2



(tCa: 1 mmol/L = 4 mg/dL)

Calcium dynamics by cohort: parity ≥2



Error bars represent ± SD.

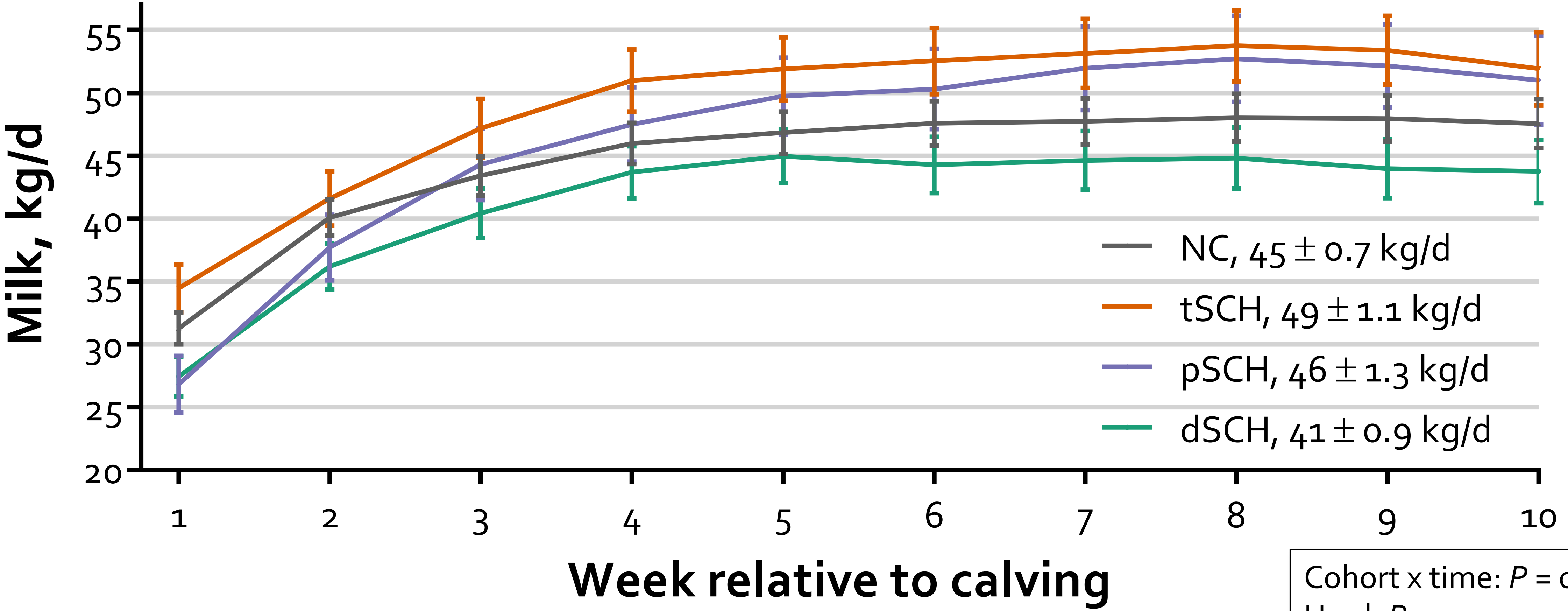
McArt and Neves., J Dairy Sci, 2020

Disease by cohort: parity ≥2

	Metritis	DA	Herd Removal
NC, n = 109	6%	2%	1%
tSCH, n = 50	4%	2%	2%
pSCH, n = 34	18%	12%	3%
dSCH, n = 70	13%	9%	13%

McArt and Neves, J Dairy Sci, 2020

Milk yield by cohort: parity ≥2



Cohort x time: *P* = 0.009
Herd: *P* = 0.22

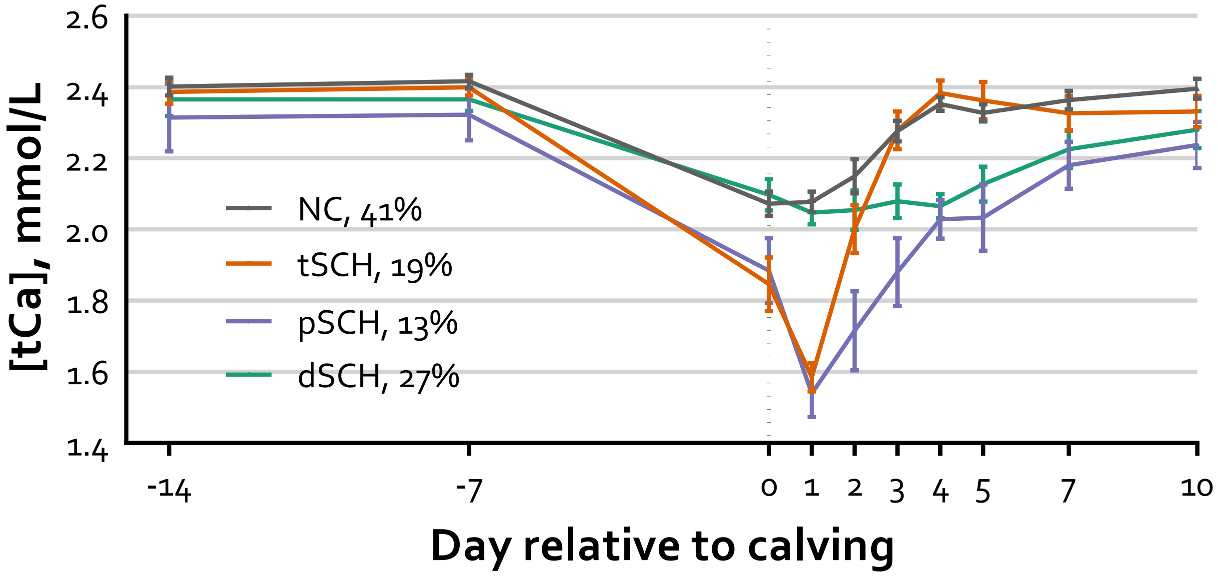
Error bars represent 95% confidence intervals.

McArt and Neves., J Dairy Sci, 2020

What did we learn?

- Conclusions:
  - Cows differ in dynamics of calcium change in early lactation
  - Differences associated with risk of adverse events and milk yield

- Why?
  - Failure of homeostatic regulation?
  - Cause or effect of disease?
  - Dry matter intake?



Association of subclinical hypocalcemia dynamics with dry matter intake, milk yield, and blood minerals during the periparturient period

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Slide courtesy: C. Seely

Materials and methods

- Multiparous Holstein cows (n = 78)
  - Leno et al. (2017a;b) and Kerwin et al. (2019)
- Housed in tie-stalls at the Cornell University Ruminant Center (Harford, NY)
- Individual DMI recorded daily from 14 d prior to parturition → 21 DIM
- Blood sampled from 1-6, & 10 DIM

Materials and methods: SCH classification

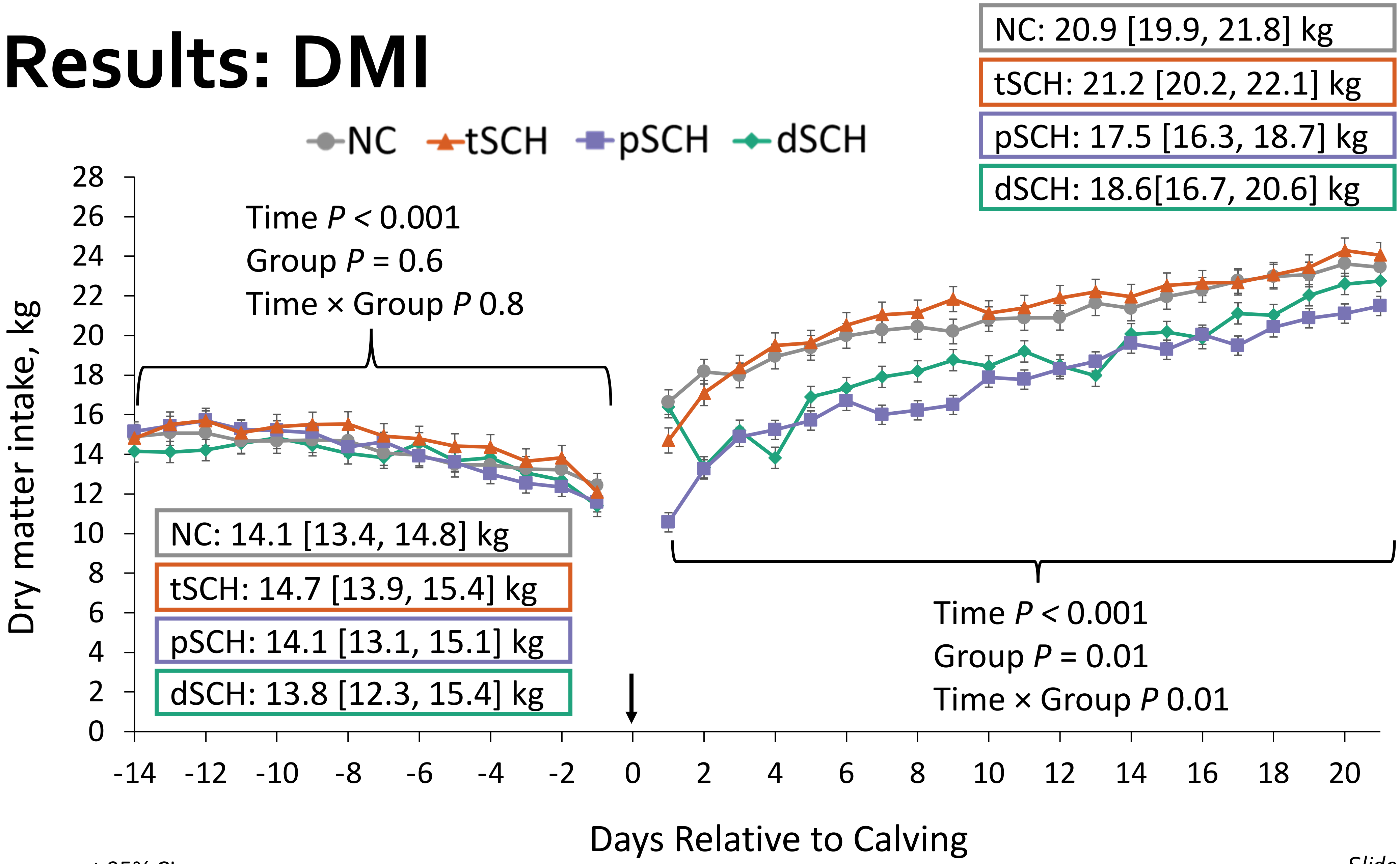
1 DIM mean tCa = 1.95 mmol/L

4 DIM mean tCa = 2.20 mmol/L

Normocalcemic (NC; n = 28)	1 DIM [Ca] ↑ 4 DIM [Ca] ↑
Transient SCH (tSCH; n = 27)	1 DIM [Ca] ↓ 4 DIM [Ca] ↑
Persistent SCH (pSCH; n = 17)	1 DIM [Ca] ↓ 4 DIM [Ca] ↓
Delayed SCH (dSCH; n = 6)	1 DIM [Ca] ↑ 4 DIM [Ca] ↓

Slide courtesy: C. Seely

Results: DMI



*error bars represent 95% CI

Slide courtesy: C. Seely

Calcium dynamics – they matter!

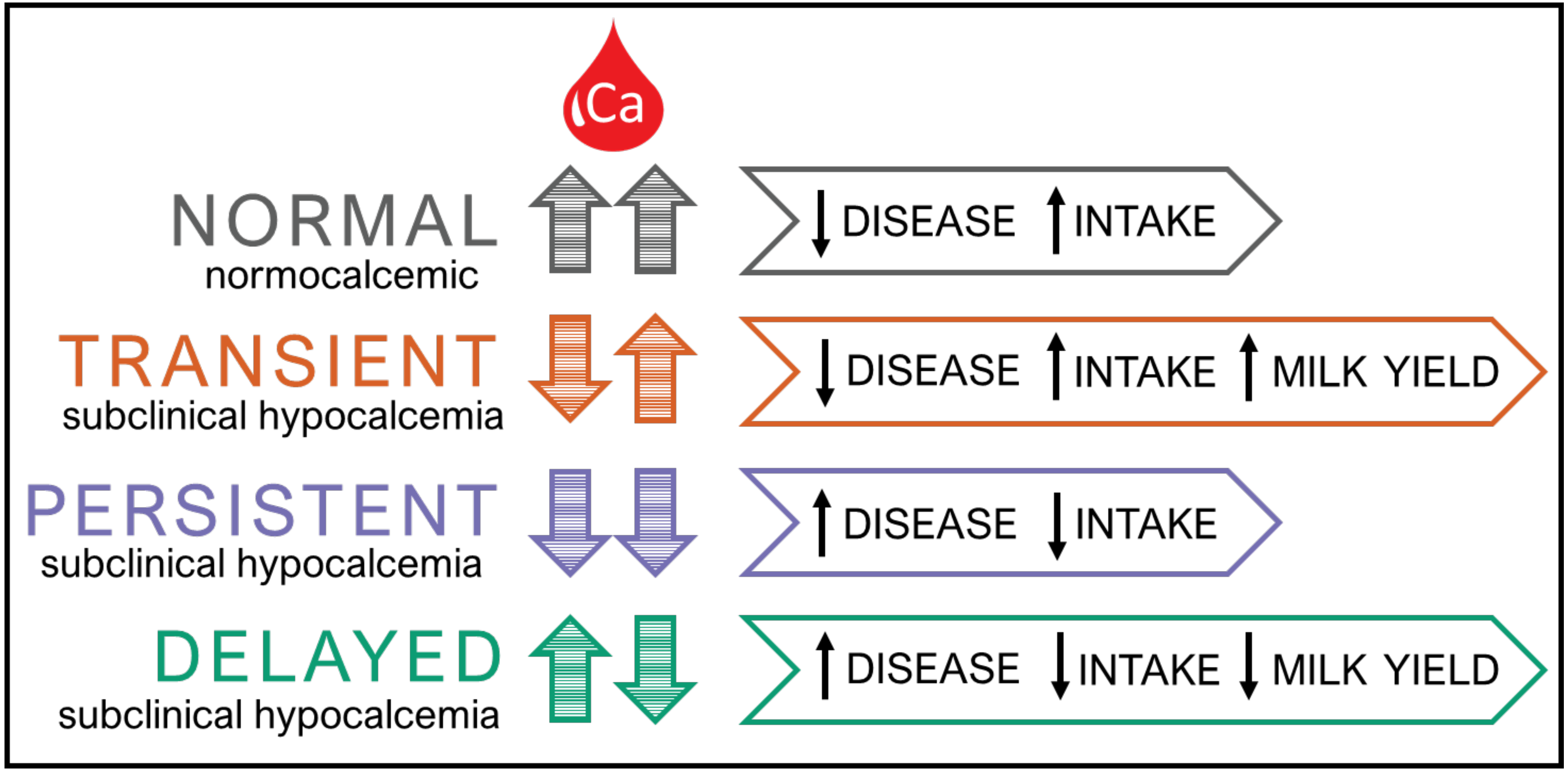


Figure: The dynamics of blood Ca measured on days 1 and 4 in milk and the outcomes associated with different classifications of subclinical hypocalcemia. Courtesy: C. Seely

Implications for the real world …

- We need to stop diagnosing SCH at calving or 1 DIM.
- What is a practical testing strategy in commercial herds?
  - Measure cows a 1 and 4 DIM?
  - Just measure at 4 DIM?
- We need more work on this on a large number of herds.
- Likely a difference between monitoring and test-to-treat methods.

Determining calcium status

Direct measurement of calcium

- Calcium is found in 3 forms in blood:
  - Free or ionized (50-60%)
  - Bound to proteins (30%)
  - Complexed (10%)

- 2 options:
  - Ionized calcium (iCa)
  - Total calcium (tCa)

Ionized calcium

- iCa thought to have greater biological relevance than tCa
- Ion-selective electrode technology is largely employed for clinical use (blood-gas analyzers)
- Measurement of iCa is expensive, special handling procedures
  - Heparin salts bind calcium
  - Use of electrolyte-balanced syringes
  - Exposure to air changes blood pH

Ionized calcium – methods of analysis

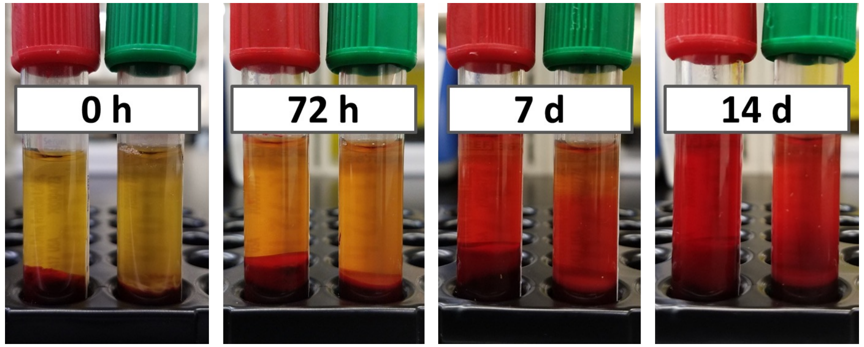
- Cowside = not practical

- Machines targeted for on-farm use:
  - iSTAT, VetScan, Nova Stat
  - $10,000-$15,000 + sample costs
- Fast, accurate, and <u>inexpensive</u> tools that measure iCa do not currently exist

Total calcium

- Collect in red or green top tubes

- Very stable
  - No difference after 14 d at 20°C (Bach et al., JDS, 2020)
  - No effect of hemolysis on tCa – not true for all metabolites



- Methods of analysis:
  - Benchtop analyzer in laboratory @ $5-15/sample

How should you use on-farm testing?

- No current practical, on-farm testing methods
  - Exception: iStat type units
  - Exception: farms willing to purchase benchtop units
- Farm collects blood from down cows <u>before</u> treatment
  - Store in a working fridge!
  - Save and test if no response to treatment
- Routine monitoring: herds take blood from cows 4 DIM
  - Store in a working fridge!
  - Submit to lab all at once after appropriate sample size

Prepartum nutrition strategies to reduce hypocalcemia

Prepartum nutritional strategies:

- Optimize feed intake
  - Stocking density
  - Pen moves
  - Heat abatement
- Feeding a low Ca diet
  - Ca < 20 g/d absorbed (practically difficult in New York)
  - Calcium binder
- Feeding a low P diet
- Feeding a negative dietary cation anion difference diet

Calcium binders

- Sodium aluminum silicate (Zeolite A)
  - Can bind dietary Ca, P, Mg
  - Show to increase active form of vitamin D prepartum
  - Studies done in USA and New Zealand
    - Targeted 500 g/d as fed
- Decreased prevalence of hypocalcemia
- No change in postpartum milk yield

Feeding of low P: recent studies

J. Dairy Sci. 104:11646–11659
https://doi.org/10.3168/jds.2021-20488

Effects of dietary phosphorus concentration during the transition period on plasma calcium concentrations, feed intake, and milk production in dairy cows

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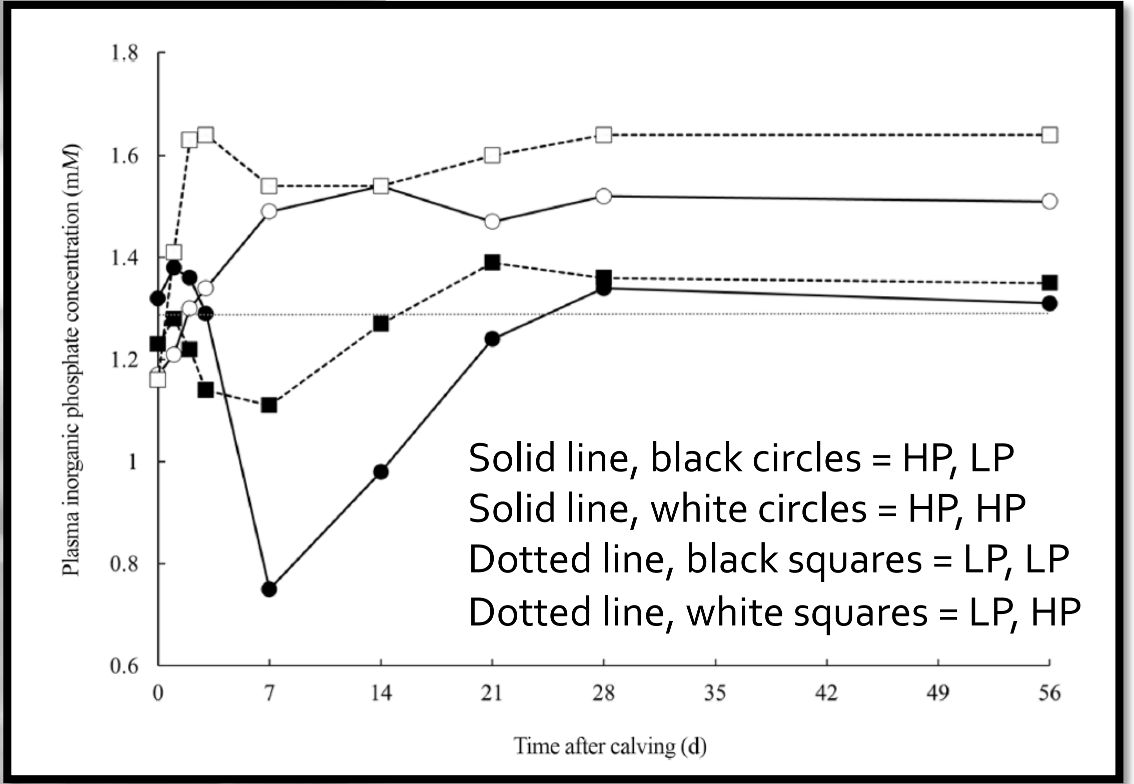
- 60 multiparous Holstein Friesians
  - Dry (6 wk): high P = 3.6 g P/kg, low P = 2.2 g P/kg
  - Lactating (8 wk): high P = 3.8 g P/kg, low P = 2.9 g P/kg
  - Blood sampled: 0, 1, 2, 3, 7, 14, 21, 28, and 56 DIM

Feeding of low P: recent studies



Experimental diet		Sampling day after calving: 0	1	2	3	7	14	21	28	56
Calcium										
Dry-HP	Lac-HP	1.81	1.74	2.02	2.20	2.30	2.34	2.33	2.33	2.29
	Lac-LP	1.85	1.89	2.12	2.38	2.34	2.42	2.40	2.28	2.47
Dry-LP	Lac-HP	1.93	1.88	2.07	2.39	2.28	2.40	2.45	2.40	2.44
	Lac-LP	2.05	2.16	2.25	2.37	2.39	2.38	2.44	2.44	2.44

Keanthao et al., JDS, 2021

Feeding of low P: recent studies

J. Dairy Sci. 105:748–760
https://doi.org/10.3168/jds.2021-20726

Effects of restricted dietary phosphorus supply to dry cows on periparturient calcium status

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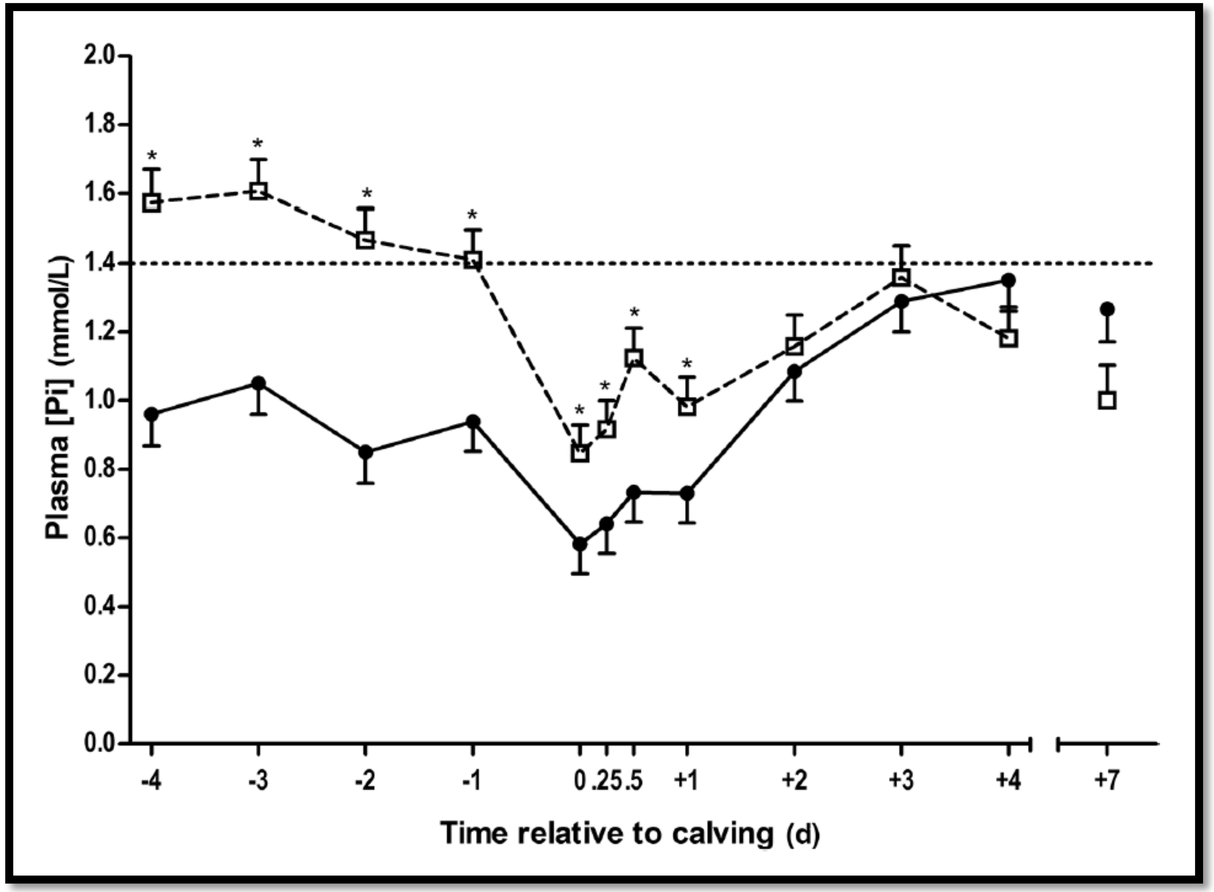
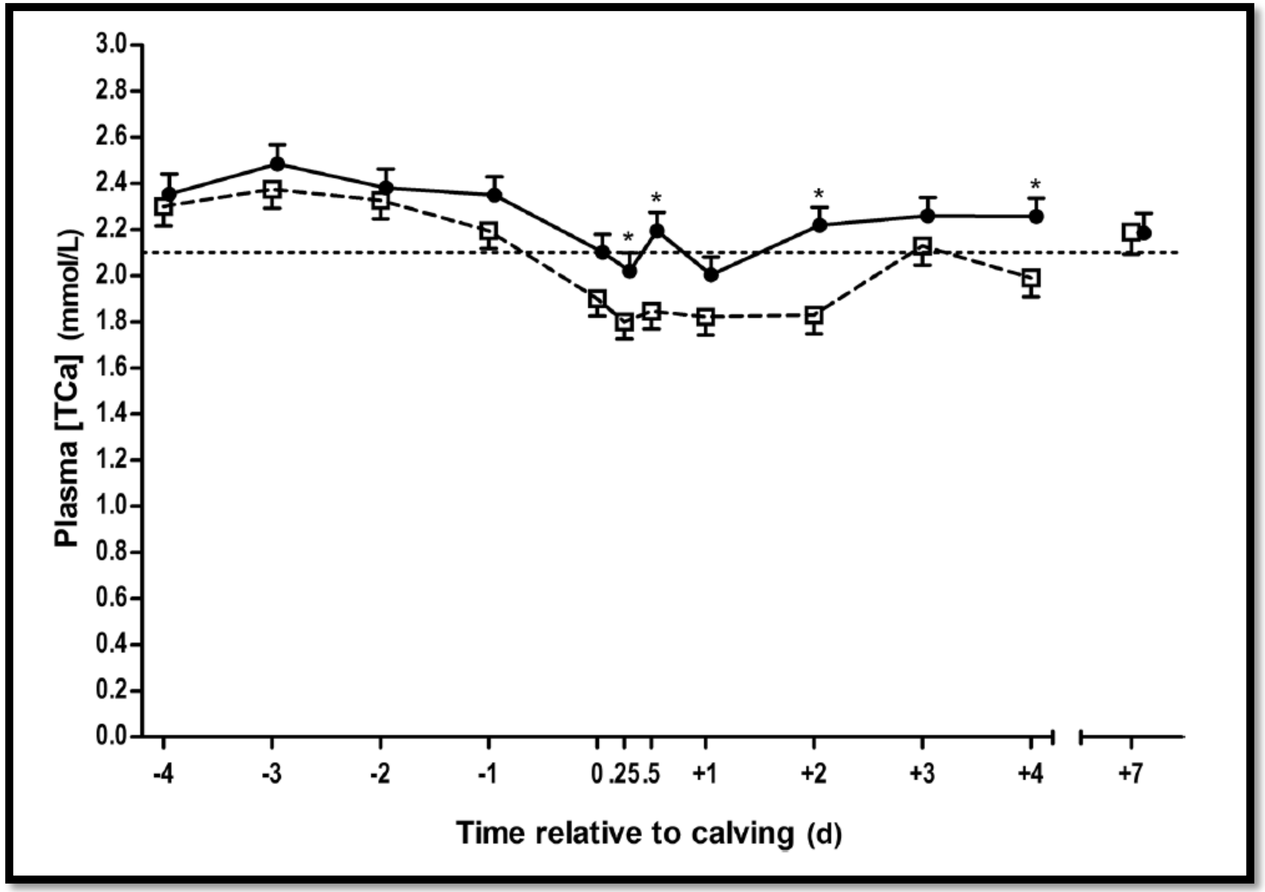
- 30 multiparous Holstein Friesians
  - Dry (4 wk): low P = 0.16% DM, adequate P = 0.30% DM
  - Lactating: adequate P = 0.46% DM
  - Blood sampled: 0, 0.25, 0.5, 1, 2, 3, 4, and 7 DIM

Feeding of low P: recent studies





Solid lines = 0.16% DM P
Dashed lines = 0.30% DM P

Wachter et al., JDS, 2022

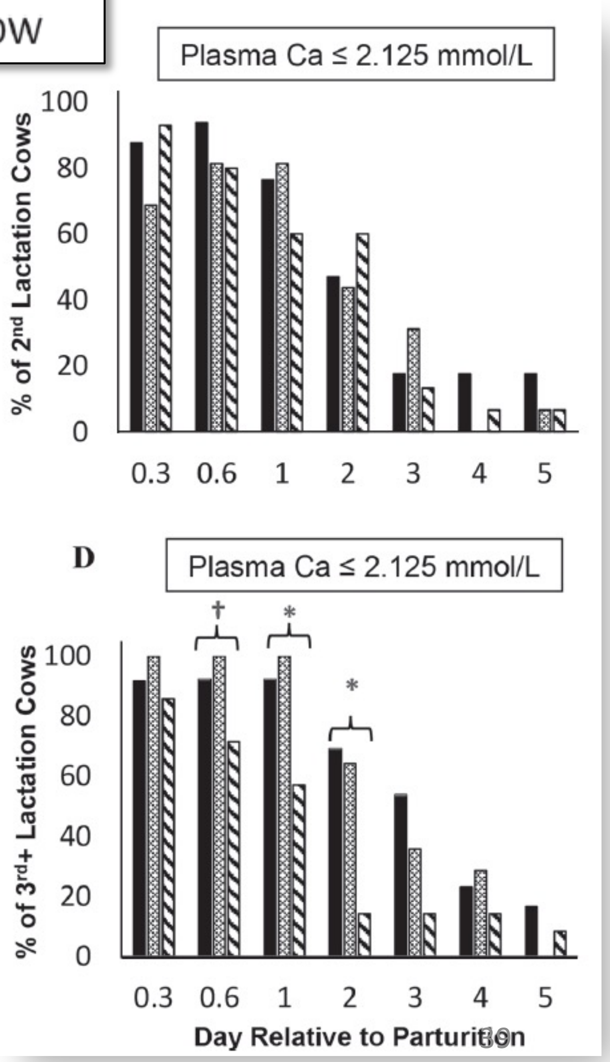
Prepartum DCAD

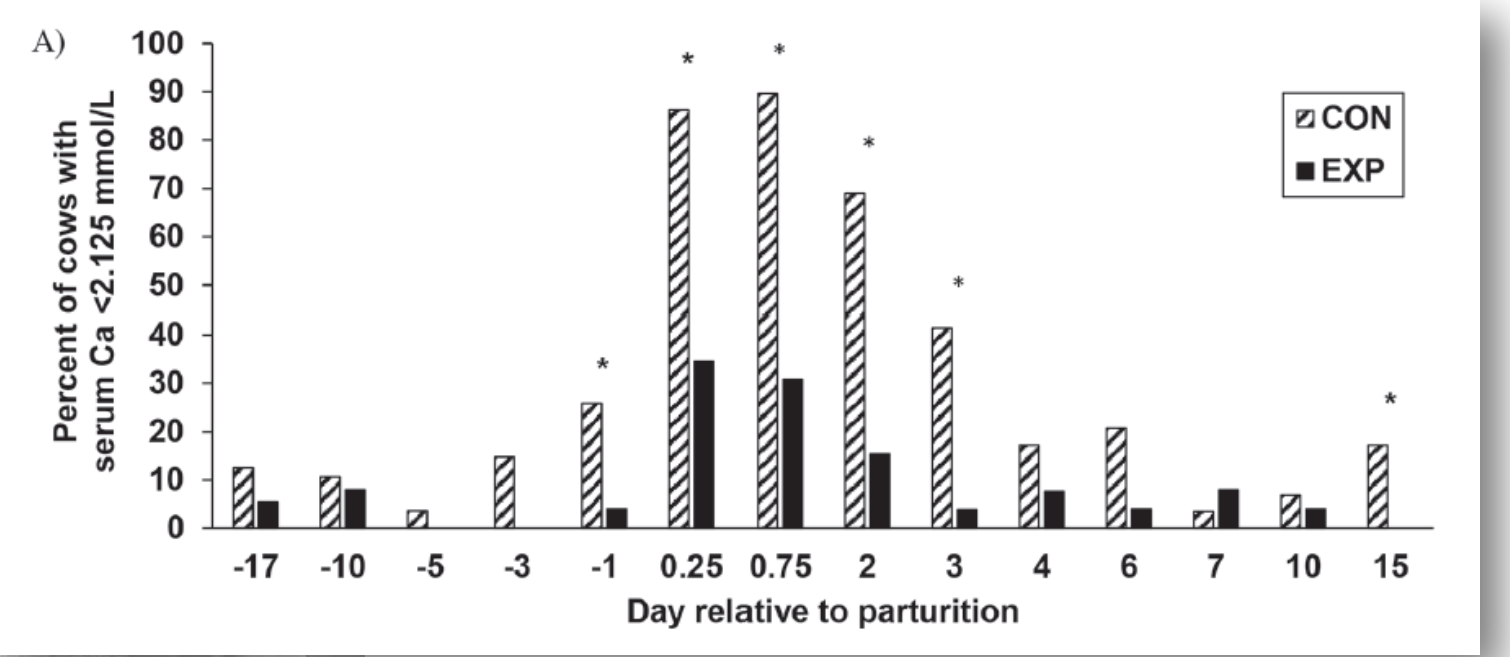
- Meta-analysis: Santos et al., *JDS*, 2019

- Reduction from +20 to -10 mEq/100 g DM:
    - Increase blood total calcium at calving (~0.2 mmol/L)
    - Increase postpartum dry matter intake (1.0 kg/day)
    - Increase milk yield in multiparous cows (1.7 kg/d)
    - Marked reduction in risk of milk fever (from 12 to 3%)
    - Reduced risk of retained placenta and metritis

Prevalence of hypocalcemia after prevention strategies:

Leno et al., 2017
Prepartum negative DCAD
CON MED LOW





Kerwin et al., 2019
Prepartum zeolite

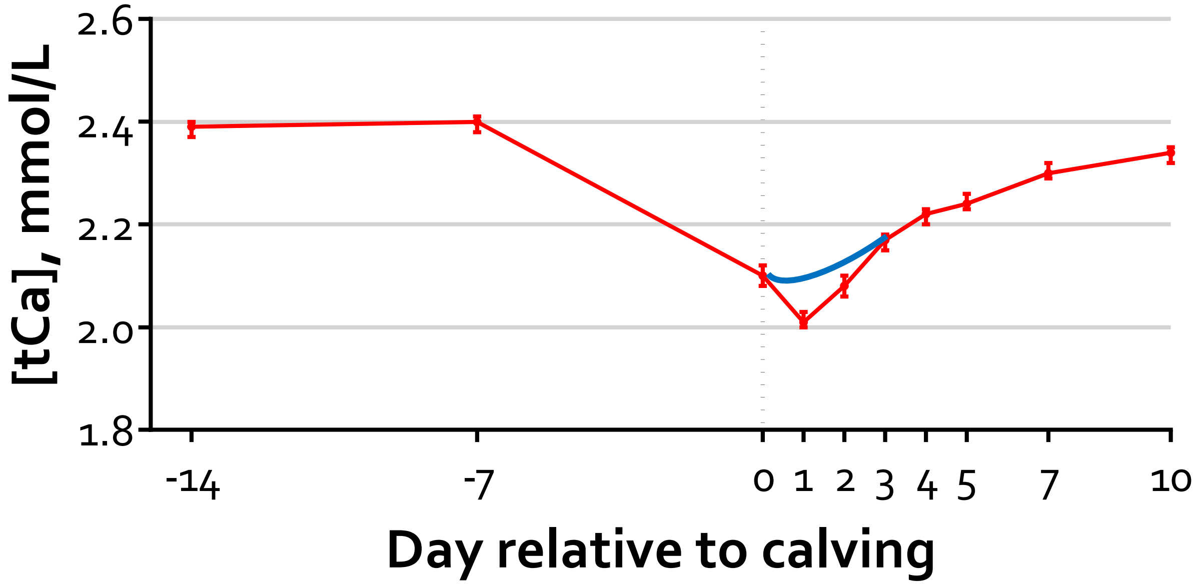
What can we do after calving to prevent hypocalcemia?

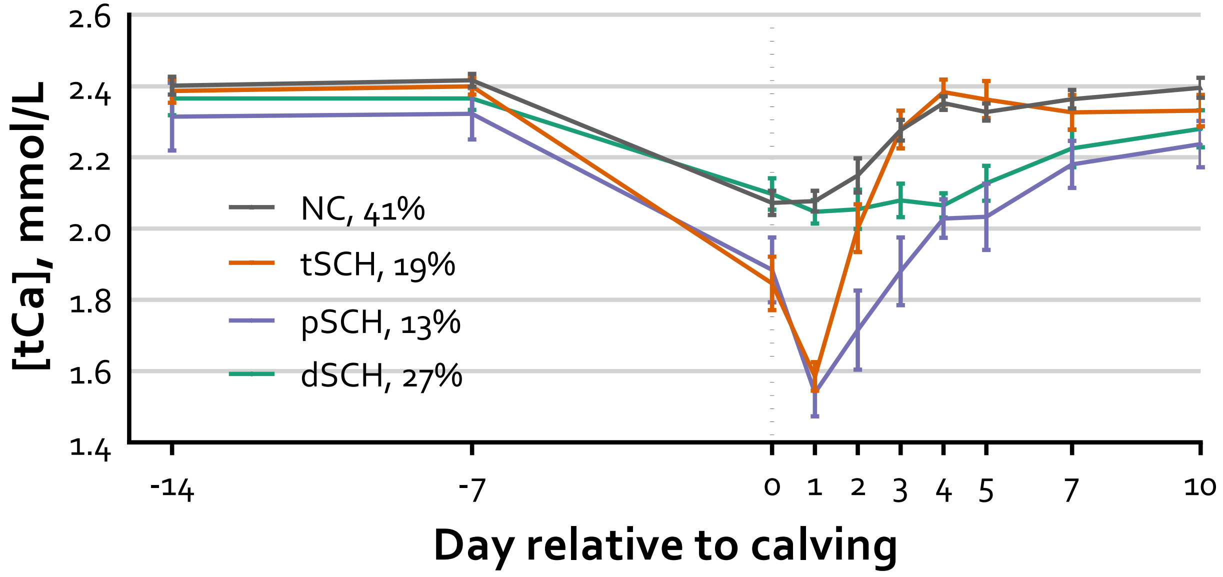
Postpartum prevention

- How do we meet their needs?
  - Cow comfort
  - Nutrition
  - Calcium supplementation
- Options for supplementation:
  - Injectable
  - Oral
- Not enough time to discuss in depth

Postpartum calcium supplementation

- Idea: supply additional calcium to reduce deficit





- Not all cows need supplementation

Postpartum calcium supplementation

- Does calcium supplementation impede welfare for some cows?
- Does type of calcium supplementation matter as far as potential harm?
- By trying to do the right thing, do we interfere with homeostatic mechanisms?
- Transition cow welfare: comfort & nutrition!

Summary

- Hypocalcemia is a prevalent "gateway" disease
- Focus on comfort & nutrition
- Our job is to meet their needs

- Future opportunities:
  - Management factors associated with transient/normocalcemia
  - Milk tells us a lot about individual cow and herd-level health

Questions?

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