An Overview of Biosecurity in Beef and Dairy Herds

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Biosecurity: A Current Definition
BAMN (Bovine Alliance on Management and Nutrition)

The programs for infectious disease control that reduce or prevent:
• the introduction of new disease onto an operation from outside sources
  - External
    - Minimize the risk of entry
• the movement of infectious agents within an operation
  - Internal
    - Minimize the risk of transmission from infected to susceptible animals

Biosecurity: "New term for an old concept"

Basic biosecurity measures:
• Cleanliness, disinfection, isolation of replacements and sick animals
• Cause and effect relationship between animal contact and disease known since the early 1900’s

*"Bad management will overwhelm the best vaccine!"*

Nuts & Bolts – Livestock Biosecurity Materials

Center for Food Security and Public Health - Iowa State University  http://www.cfsph.iastate.edu/
  - Biological Risk Management (BRM)
  - Beef resources
  - Dairy resources

NYSCHAP - New York State Cattle Health Assurance Program  http://nyschap.vet.cornell.edu/default.asp
  - First governmental entity to develop an integrated program

CIDRAP - Center for Infectious Disease Research & Policy

Basic Questions:
1. Do your clients know what infectious diseases are heading their direction?
2. Do they know how their herds are likely to get them?
3. What are they doing about these?

John’s Rule:
*What they don’t know, your clients will likely get!*
"My herd is closed!"

A herd is "closed" if it doesn't:
- Buy any genetics or livestock
- Commingle stock (grazing?)
- Buy feeds, particularly of animal origin
- Have any wildlife exposure
- Have any vermin (flies, birds, rodents, ...)
- Have any neighbors with livestock
- Have any bad fences
- Hire livestock haulers
- Take livestock to fairs or shows
- Have employees who own off-premises livestock

Really closed? Then no worries!

Potential Wrecks: A Partial List

**Common wrecks:**
- Salmonellosis
- BVD type II, PI
- Johne's Disease
- Vibriosis, Trichomoniasis

**"Holoendemic" wrecks:**
- Calf Scour Agents – Rota, Corona, Crypto, E. coli
- BRD
- Staph. aureus mastitis

**Exotic wrecks:**
- Foot and Mouth Disease
- BSE
- Consumer product wrecks:
  - E. coli O157:H7
  - Antibiotic resistance

What should be worried about?

**Selected Emerging/Re-Emerging Candidates:**
- Antibiotic resistance
- Foodborne zoonoses
- Foot and Mouth Disease
- Taiwan outbreak
- UK outbreak
- E. coli O157:H7
- Chronic Wasting Disease
- "Mad Cow" Disease
- MDR Tuberculosis

How well are we doing?

**Empirical evidence:** Not Well!
- NAHMS
- Multiple management practice surveys of randomly selected livestock producers across majority of US producers
  - Cow-calf – '93, '97
  - Feedlot – '94, '99
  - Dairy – '93, '96, '02
  - Swine – '90, '95, '00, '06

Herds Vaccinating Replacements (Dairy '02)

<table>
<thead>
<tr>
<th>Disease</th>
<th>&gt; 500 head</th>
<th>All Herds</th>
</tr>
</thead>
<tbody>
<tr>
<td>BVD</td>
<td>88%</td>
<td>71%</td>
</tr>
<tr>
<td>IBR</td>
<td>85%</td>
<td>67%</td>
</tr>
<tr>
<td>Leptospirosis</td>
<td>80%</td>
<td>65%</td>
</tr>
<tr>
<td>E. coli mastitis</td>
<td>53%</td>
<td>21%</td>
</tr>
<tr>
<td>Clostridia</td>
<td>63%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Which vaccines pay and which don't?
Johnes knowledge (self-assessed)

<table>
<thead>
<tr>
<th>NAHMS Study</th>
<th>Not heard of</th>
<th>Recognized name only</th>
<th>Knew some basics</th>
<th>Fairly knowledgeable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef ’97</td>
<td>70%</td>
<td>22%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Dairy ’96</td>
<td>10%</td>
<td>35%</td>
<td>37%</td>
<td>18%</td>
</tr>
<tr>
<td>Dairy ’02</td>
<td>1%</td>
<td>11%</td>
<td>42%</td>
<td>45%</td>
</tr>
</tbody>
</table>

Introduction Risk Factor Prevalence (1996 Dairy NAHMS)

Industry-wide introduction risk factor prevalence:
- 22% of cows were not born on the dairy
- Prevalence of introduction risk due to purchased animals
  - 44% introduced 1+ animals during the previous year
  - 26% introduced replacement heifers
    - 48% of operations with > 200 cows
  - 29% introduced lactating cows
  - 7% introduced dry cows

What is the probability they bought and paid for disease?

Evidence of Risk Mitigation (1996 Dairy NAHMS)

- Amount of introduction risk due to purchased animals
  - Avg. # of heifers introduced equaled 18% of herd size
  - Avg. # of cows introduced equaled 14% of herd size

- Evidence for limited mitigation of this risk:
  - Quarantine by importing dairies
    - Bred Heifers - 15% of importing dairies for 17 days average
    - Dry Cows - 18% of importing dairies for 9 days average
  - Testing by importing dairies
    - 9% required testing for Johnes’s Disease
    - 16% required testing for BVD
    - 26% required individual cow somatic cell count, 15% bulk tank count
    - 9% required individual cow culture, 6% bulk tank culture

Potential maintenance risk factors (1996 Dairy NAHMS)

<table>
<thead>
<tr>
<th>Potential Maintenance Risk Factor</th>
<th>Herd Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermin access to grains, concentrates</td>
<td>70%</td>
</tr>
<tr>
<td>Calving area used as sick cow area</td>
<td>55%</td>
</tr>
<tr>
<td>Continuous contact between pre-weaned calves and bred heifers or adult cows</td>
<td>39%</td>
</tr>
<tr>
<td>Open pond or ditch cow water source</td>
<td>37%</td>
</tr>
<tr>
<td>Udders not cleaned prior to colostrum harvest</td>
<td>32%</td>
</tr>
<tr>
<td>Calves &lt; 1 yr of age sharing feed and water sources with cows</td>
<td>25%</td>
</tr>
</tbody>
</table>

Given US herd prevalences, probably close to 100%

More Troubling Questions:
1. How do you find out what infectious diseases are heading their direction?
2. Do we have a good surveillance and alerting system?
3. Whose responsibility is it initiate communication?
   - Yours – Push information delivery?
   - Client’s – Pull information delivery?
   - Somebody else? – media, industry, governments, schools,
4. Who pays for this?
   - Vets, producers, food chain firms, taxpayers?

Problem: “Emerging” Diseases

- Emergence of “new” strains from high pressure areas
  - MR-Salmonella newport
- Lack of quick dissemination of new information about current diseases
  - BVD PI
- Lack of good surveillance / alerting systems for non-regulatory diseases
  - Hairy Foot Wart
Isolation of multiple Salmonella serovars from a dairy two years after a clinical salmonellosis outbreak
- After outbreak in the lactating herd, no clinical salmonellosis cases had occurred in the lactating herd since.
- Consistently ranked in the top 25% of area dairies in DHIA. 76% (108/142) of environmental samples
- 48% (639/1,339) of fecal samples (+)
- 78% of herd bulk milk filter samples (+)
- 78% of calf fecal samples from calves being fed waste milk (+)
- 25% of fecal samples from cows at the time of breeding (+)

Freedom from clinical salmonellosis and high herd performance do not indicate the absence of salmonellae from a premises.

EX: Salmonella – often present but silent!
- 9 (56%) of 16 herds had fecal (+) cows (60 sampled).
- Mean within-herd prevalence in (+) herds was 17% with a maximum of 37% in 2 herds.
- Serotypes Montevideo and Muenster were the most frequent and widespread.
- Subclinical colonization with Salmonella enterica is relatively common on dairy farms
- No herds reported any clinical salmonellosis cases!

Animate Replication Sites in Farm Ecosystem
Cattle Intestinal Tracts: Other Intestinal Tracts:

Rodents
Flies
Feral Dogs & Cats
Birds
Domestic Pets
Wild Mammals
Humans

Salmonella is capable of replicating in ALL intestinal tracks on a farm

The House Fly Musca domestica

Mouth Parts
½ of “fly spots” are regurgitation of previous meal

Puparium (Pupal Case)

If you wouldn’t eat off of it or drink out of it, don’t expect a cow to either!
Prevention of Fetal Infection by BVD

BVD challenge of vaccinated pregnant cows

<table>
<thead>
<tr>
<th>Vaccine</th>
<th>Challenge</th>
<th>% PI Calves</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLV I</td>
<td>Type I</td>
<td>10-20%</td>
</tr>
<tr>
<td>MLV I</td>
<td>Type II</td>
<td>40-50%</td>
</tr>
<tr>
<td>MLV I &amp; II</td>
<td>Type I or II</td>
<td>???????</td>
</tr>
<tr>
<td>Killed I</td>
<td>Type I</td>
<td>40-50%</td>
</tr>
<tr>
<td>Killed I</td>
<td>Type II</td>
<td>&gt;50%?</td>
</tr>
<tr>
<td>Killed I &amp; II</td>
<td>Type I or II</td>
<td>70-80%?</td>
</tr>
</tbody>
</table>

Vaccination is NOT completely protective against all aspects of the disease!

20 year march of "Hairy Heel Wart"

- 1974 – condition first described in Italy
- 1980 – first described in eastern US (JAVMA 137:437-440)
- 1993 – reached northwestern US dairy herds

The most common introduction risk factor:
- The purchase of infected replacements

Could it have been stopped?

Callan, CSU

For success we must move beyond the single agent etiologic focus!

Germ Theory of Disease

Etiologic Diagnosis Only

These Result in Handicapped Control and Prevention Thinking!

Consumer expectation is broader!

Consumer concern:
- E. coli O157:H7
- Antibiotic Resistance
- "Manure" bugs
- Salmonella spp.
- Campylobacter spp.
- Listeria spp.
- Taenia saginata

Veterinary concern:
Producer expectation is broader!

Producer concern:
- Rotavirus strains
- Cryptosporidium spp.
- Corona virus
- Coccidia spp.
- K99 E. coli
- EHEC E. coli
- Salmonella spp.
- Breda virus, parvovirus, . . .
- Clostridium spp. . . .
- Unknown agents

Calf Scours!

Veterinary concern:
- Rotavirus strains
- Cryptosporidium spp.
- Corona virus
- Coccidia spp.
- K99 E. coli
- EHEC E. coli
- Salmonella spp.
- Breda virus, parvovirus, . . .
- Clostridium spp. . . .
- Unknown agents

Primary Question

How would your clients' herd management have to change to fight the disease once they get it?

If these are inexpensive or if they pay in other ways, why not start doing these now?

Good Management Practices: "Herd Hardening"

Principle - Enhance Herd Resistance

- Practice "Biosecurity"
  - Leaders: The "White Meat" industries, swine and poultry
- Increase the "natural resistance" of the herd to the introduction and transmission of infection within it
  - Use management practices that counter the "natural history" of infectious diseases
  - Monitor for "procedural drift"
- Be careful of assumptions; "In God we Trust, all others must verify"

Develop, Apply and Monitor BMP's

Pasteurization: Example of an Integrated Approach

Procedure:
1. Determine organisms of concern in the product
2. Determine expected contamination level and amount of reduction required
3. Determine survival characteristics of each organism under range of pasteurization conditions (e.g., product characteristics, time, temperature)
4. Determine which organisms determine the boundary conditions.
5. Establish the pasteurization conditions for the product sufficient to protect against all organisms of concern

Pasteurization: Thermal Death Curves

Calving Area: Environmental Death Curves
Problem with Quarantine:

- Only works for acute diseases in which all cases have a single, well defined period of communicability
  - The easy ones

- Doesn’t work for diseases with chronic carrier states:
  - BVD, IBR, Lepto, BLV, Johne’s, Neospora
  - Hairy Foot Wart?
  - The hard ones

The Bad News: We’ve gotten rid of most of the easy ones so it’s the hard ones that are left

Buying Disease:

Because of:

- Subclinical carrier states
- Poor performance or utilization of laboratory tests

Many disease problems are bought and paid for!

Trichomoniasis, BVD, Johne’s, Neospora, . . .

Failure to Recognize the “Iceberg”

- Most infections are subclinical
  - Typically > 10:1
- Can’t identify every infected animal
- Some animals are much more susceptible than normal
- Neonates
- Animals with other diseases

Failure is a major error in both external and internal biosecurity

Normal Appearing Cow

Situation:
- Purchased cows
- Fed alfalfa hay
- Sawdust pack replaced weekly

141G Cow 374

- Shedding over $10^6$ Salmonella CFU per gram of manure for 6 months
  - ~$10^9$ organisms shed every day
- Heavy environmental contamination detectable everywhere for 3 weeks after she was removed

- Normal animals are easily infected by $10^5$ CFU (1/10 of a small green pea-sized chunk of her manure)
- All of her pen mates became subclinically infected!
- None ever showed clinical salmonellosis

Still haven’t gotten the Salmonella out of my carpet > Zoonoses!

Failure to Respect the Enemy’s Strengths

Microbes are extraordinarily flexible and successful!

- Most co-evolved with their hosts before domestication
- Markedly increased contact opportunities occur now!
- Generation time is very short and selection pressure results are mostly hidden.
  - 1 cow generation = 35,040 bacterial generations
- Given how much humans have deliberately changed the cow host, how much have we inadvertently changed her microbes?
- Molecular biology advances show that bacteria are very adept at acquiring new genes from completely unrelated organisms
- Most bacterial adaptation occurs due to genetic exchange rather than genetic mutation!

Consequence: Microbes are opportunists that quickly evolve to evade single point controls and to take advantage of new niches presented by changing animal husbandry!
Transmission from infectious agent’s perspective

Infectious Agent's Perspective

Mammalian Body

Transmission Pathways:
- Mouth
- Nose
- Eyes
- Urine
- Feces
- Respiratory System
- Skin
- Genital Genital System
- Mammalian Portal of Entry and Exit

Environmental Survival

- Half-Life Curve
- Number of Infective Particles

Agent Environmental Survival Half-life

Agent shed into Environment

Half Life Curve

Clinical Disease
Subclinical Infection
Threshold

Environmental Survival Consequences

Infected Host Shedding Level

Number of Infective Particles

Infected Host Shedding Level

Agent shed into Environment

Time

Infection Transmission Chain

Infected Host

Sheds Agent in oral & nasal secretions, urine, faces

Contaminated Environment

Hands, Thermometers, Equipment, Feed, Water, Boots, . . .

Agent survives at Infectious Dose

Susceptible Host

Becomes

"Hardening" Strategies

Results for an Infectious Dose

- Increase Host Resistance
- Reduce Infectious Dose

No of People

Infectious Dose

Uninfected

Host Resistance

Clinical

Low

High

Infection Transmission Chain

Infected Host

Sheds Agent

Environment

(Hands, Housing, Food, Water...)

- Remove contaminated materials
- Increase agent death rate

Agent survives at Infectious Dose

Susceptible Host

Isolate

Reduce shedding level

Increase Resistance

Isolate to minimize infectious dose
Crucial Information Needs

We don't have much of the information that we need to develop integrated control and prevention approaches!

- Example: Agent survival curves under range of typical farm environmental conditions.


- "...to identify rational biosecurity programs, research is needed to provide estimates of the risk of introducing disease into a herd, the economic effects of introducing disease and the effectiveness of management strategies to reduce this risk."

- "...at this point, we lack adequate data to know which, if any, biosecurity practices are worthwhile."

Classic text for diseases affecting humans:

Several concise pages for each disease that cover:
1. Identification
2. Infectious agent
3. Occurrence
4. Reservoir
5. Mode of transmission
6. Incubation period
7. Period of communicability
8. Susceptibility and resistance
9. Methods of control
   A. Preventive measures
   B. Control of patient, contacts and environment
   C. Epidemic measures
   D. Disaster implications
   E. International measures

We need this for veterinary medicine.

"Spheres of Influence" (Covey)

What can we change?

Within Herd "Hardening"

Foreign Animal Disease

What we can do the most about

Animal Importation

Driven by Economics

Know the herd of origin disease statuses!

Threats – Increasing with Globalization

- Illicit trade in food products and wild animals
  - Bushmeat
  - Exotic Pets
- Increasing international air travel
  - Human GI tracts
  - Importation of cultural foods

Global Traffic

International flights:
- People (2004):
  - 645,499,000 US domestic passenger enplanings
  - 66,752,000 US international passenger enplanings
  - 1 in 10 passengers is international!
- Transport of infected freight
  - Illicit wild animal trade
  - Illicit foodstuff – "bushmeat"
- Migratory birds

http://www.bts.gov/programs/airline_information/indicators/top.htm

Major Air Traffic Flows Between Regions, 2000 (% of IATA Scheduled Passengers)
Passenger luggage of 14 Africa to London flights contained 5 ½ tonnes of meat and fish (HJ Pharo, MAF, NZ)

Highly Pathogenic H5N1 Influenza Virus in Smuggled Thai Eagles, Belgium (Emerg Infect Dis 11(5), 2005)
- Thai resident took flights from Bangkok to Brussels, with a stopover in Vienna
- Placed luggage in an overhead compartment during both flights
- Declared that he "bought the eagles on a major Bangkok market, as a present for [his] brother living in Belgium"
- A few days later, a Belgian falconer declared he had ordered the eagles and offered £7,500 Euros for each bird

Crested Hawk-Eagles confiscated at Brussels International Airport in hand luggage

Huge illicit trade in wild animals

Overlapping Wild Aquatic Bird Flyways

Evidence suggests a pandemic would move worldwide in 8 months

Threats – Increasing Human Population
- Increasing human population density
- Increasing livestock density
- Contact with new ecosystems in search for food sources
  - Ebola
  - SARS

Since 1980 a new human disease has emerged every 8 months!

Global Human Population Density

Dense Human Populations Increase Disease Transmission

Global Livestock Population Distribution

Livestock Population Density Mirrors Human Population Density
**Human Population Growth Rates**

[Map showing world population growth rates]

**Global Foot and Mouth Distribution**

[Map showing sporadic and endemic distribution]

**Crisis: Global disease control problems**

- **Highly Pathogenic Avian Influenza**
  - The crisis
  - Why?
    - Insufficient overall capacity (Veterinary Services, Infarction Systems, Diagnostic Tools, Human resources)
    - Lack of legislation and countries not meeting their international obligations to report
    - Lack of biosecurity at the farm, market, international borders ...

(Modeled from FAO slide presentation)

**Why is this problem occurring now?**

- Farming Structure:
  - Small Holder Farming: Mixing of aquatic avians and chickens, swine (?)
  - Cross-species exposure by direct contact, feeding of manure, offal, and carcasses
- "Wet" Marketing of Live and Fresh Killed Poultry:
  - Little regulation
  - Cross-species exposure

**High Poultry Densities**

Poultry are an ideal small farmer animal
- Easy to house, feed, transport compared to larger species
- Don't have cultural implications of other meat species
- Ducks control weeds and insects on irrigated lands

40% of global poultry production

**Indonesia: Example of Industry Growth**

<table>
<thead>
<tr>
<th>Year</th>
<th>India</th>
<th>Broilers</th>
<th>Ducks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>1,080</td>
<td>(0)</td>
<td>(0)</td>
</tr>
<tr>
<td>1991</td>
<td>1,208</td>
<td>(0)</td>
<td>(0)</td>
</tr>
<tr>
<td>1992</td>
<td>1,400</td>
<td>(0)</td>
<td>(0)</td>
</tr>
</tbody>
</table>

20-fold expansion in 30 years
Crisis: Components

Highly Pathogenic Avian Influenza

Why?

- Insufficient overall capacity (Veterinary Services, Information Systems, Diagnostic Tools, Human resources)
- Lack of legislation and countries not meeting their international obligations to report
- Lack of biosecurity at the farm, market, international borders ... level.

Crisis: (FAO: Food And Agriculture Organization)

Highly Pathogenic Avian Influenza

Why?

- Insufficient overall capacity (Veterinary Services, Information Systems, Diagnostic Tools, Human resources)
- Lack of legislation and countries not meeting their international obligations to report
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Laos – Difficulty of FAD Control

CIA World Fact Book:

- Mostly rugged mountains; some plains and plateaus, 3.8% arable land
- Primitive infrastructure; no railroads, rudimentary road system, limited telecommunications
- Few urban areas have electricity
- Subsistence agriculture accounts for 1/2 of GDP and provides 80% of employment
- $1,700 per capita GDP (185th out of 232 countries)

Could Laos eradicate this avian influenza even if it could afford the eradication program costs?

The Politics of Bird Flu in Thailand


4th largest poultry exporter, exporting 90% of production, 1.2 billion dollars, to the EU and Japan

- "The government handling of the bird flu is a saga of cover-ups, incompetence, lies and extremely questionable decisions:
- Long delay before admitting the existence of the bird flu in animals and in humans,
- the selective measures taken to stop the epidemic spread and,
- most spectacularly, the massive campaigns to convince Thai citizens that eating chicken was nothing less than a patriotic act."

The poultry industry is a major source of foreign exchange and tightly linked to the Thai government.
• A University veterinarian found the H5N1 virus in chicken carcasses from Nakhon Sawan in November and informed Livestock Department chief.
• No action was taken.
• In December an organic farmer near Bangkok brought carcasses to the Department and was told they were dying “without any medical cause”.
• The government admitted the presence of the disease on January 23, 2004.
• Many sources confirm that the industry and the government knew that the epidemic was raging as far back as November 2003

Export Shutdown of 90% of production
Huge Economic Impact!

• From November to January 23, workers at Centaco factory in Rangsit (near Bangkok) were asked to work much more overtime than usual.
  • “Before November, we were processing about 90,000 chickens a day. But from November to January 23, we had to kill about 130,000 chickens every day.”
• They saw many diseased chickens arriving in the factory and were ordered to process them, even if they had already died from the illness.
  • “We didn’t know what the disease was, but we understood that the management was rushing to process the chicken before getting any veterinary inspection.”

The government and the industry did respond to the University veterinarian’s report

National magazine accused the government of keeping the crisis secret to protect the interests of large poultry firms.
• Instead of quarantining the areas where bird flu was first detected, officials collected money from the private poultry companies and handed it out to the farmers with infected birds (40 baht, about 1 US$ per chicken).
• Farmers said that they were receiving this small compensation in exchange for keeping their mouth shut.
• Later, in the restocking scheme, industry leaders were selling laying chickens at 120 baht each.

Example of the international political problems associated with controlling a major livestock disease

Crisis: (FAO: Food And Agriculture Organization)

Highly Pathogenic Avian Influenza

The crisis

- Insufficient overall capacity (Veterinary Services, Information Systems, Diagnostic Tools, Human resources)
- Lack of legislation and countries not meeting their international obligations to report
- Lack of biosecurity at the farm, market, international border level.

PORTENDS A BAD TREND?

Can LDC producers understand the "how" and the "why" of control and prevention measures sufficiently to do them effectively?

Indonesian livestock producer education

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate</td>
<td>1340545</td>
<td>31.4</td>
</tr>
<tr>
<td>Not completed primary school</td>
<td>133111</td>
<td>34.6</td>
</tr>
<tr>
<td>Primary school</td>
<td>1874353</td>
<td>34.7</td>
</tr>
<tr>
<td>Senior high</td>
<td>305401</td>
<td>5.7</td>
</tr>
<tr>
<td>University</td>
<td>22469</td>
<td>0.2</td>
</tr>
</tbody>
</table>

• 90% have a primary school education or less
• Not likely familiar with the “Germ theory” of disease
• Likely have very strong cultural explanations of disease occurrence

Can LDC producers understand the “how” and the “why” of control and prevention measures sufficiently to do them effectively?

Portends a Bad Trend? I’m afraid so

Johnathan Mann (1994) wrote:

The history of our time will be marked by:
• Recurrent eruptions of new diseases
• Epidemics of diseases in new areas
• Diseases that become important because of new technologies
• Diseases that spring from insects and animals to humans through man-made disruptions in local habitats

My Brunswick “Crystal” Ball
But in the End:

First lookout for "bought and paid for" diseases!

Your client may never get rid of them.