Hazard prioritisation data scarce setting: case-study of the dairy sector of Punjab, India

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Background

- Foodborne hazards pose a vast global burden on public health
- Information is needed to prioritise these hazards and inform risk management strategies
- Raw milk may be contaminated with a wide range of hazards (biological, chemical, physical)
- India world's leading milk producer, Punjab State produces most milk per capita
- No formal assessment of the potential public health risks associated with dairy consumption in Punjab or India to date



Aims & objectives

Risk ranking exercise to identify priority public health hazards associated with the consumption of cow and buffalo milk and dairy products in Punjab, India

- Identify critical control points
- Knowledge/data gaps precluding formal assessment

The results were also used as:

- Pilot exercise used to inform further research on milk safety in India
- First chapter of PhD investigating brucellosis in Punjab:
 - I. Inform design of cross-sectional survey and data-collection tools
 - II. Preliminary assessment of the relative importance of *Brucella* spp. as a foodborne hazard

Methods



Situation analysis: dairy sector

- Majority of milk produced by smallholders and flows through informal channels
- Study found farmers adopted around half recommended milk hygiene practices
- Only person/dairy handling more than 10,000 L milk needs to be registered
- Legislation for microbiological standards and MRL's for pasteurised milk and dairy products
- About 17% milk is processed into other dairy products by the consumer
- Wide range of dairy products consumed in Punjab



Hazard identification



Articles identified by the literature review:



Identified hazards: Brucella abortus, Bacillus cereus, Campylobacter spp., Coxiella burnetti, Cryptosporidium parvum, E. coli, Leptospira spp., Listeria monocytogenes, Mycobacterium bovis, Salmonella spp., Staphylococcus aureus

Absence of evidence is not the same as evidence as absence

Rapid exposure assessment: hazard presence

Example of results from literature review:

| Hazard | Presence at producer | Presence at retail | Ref | | | | | |
|------------|------------------------|---------------------------------|-----|--|--|--|--|--|
| | level | | | | | | | |
| B. cereus | | Detected in 66.6% of milk | 1 | | | | | |
| | | samples, 44.8% of burfi & | | | | | | |
| | | 44.4% milk powder | | | | | | |
| Salmonella | Evidence of presence | In 58 samples of paneer, 1 +ve | 2 | | | | | |
| spp. | in DA | for S. enteridis & 1 +ve for S. | | | | | | |
| | | typhimurium. Not isolated in | | | | | | |
| | | milk but studies are limited. | | | | | | |
| Coxiella | 2.8% of 361 individual | | 3 | | | | | |
| spp. | milk samples positive | | | | | | | |
| Pathogenic | 17.0% swabs from | - 29.0% rasgulla/rasmalai | 4-7 | | | | | |
| E. coli | buffalo udders | (sweets) produced in | | | | | | |
| | seropositive E. coli | informal sector positive. | | | | | | |
| | | - 6 out of 10 cheese samples | | | | | | |
| | | positive <i>E. coli</i> | | | | | | |
| | | - 12 (8.9%) out of 135 dairy | | | | | | |
| | | products +ve for E. coli; 2 | | | | | | |
| | | (1.5%) stx2 positive. | | | | | | |

| Hazard | Summary of literature | Ref | | | | | | | |
|------------|--|-----|--|--|--|--|--|--|--|
| Pesticides | Organochlorine pesticides: HCH, DDT, endosulfan (5.8% exceeded | 8- | | | | | | | |
| | MRL), fipronil and butachlor N-(Butoxymethyl)-2-chloro-N-(2, | | | | | | | | |
| | diethylphenyl) acetamide detected in milk samples. | | | | | | | | |
| | Bovines: 16.8% bovines positive for pesticide residues (56.1±62.1 ng/ml), mainly DDT and its metabolites and chlorpyriphos. Associated with reproductive disorders. | | | | | | | | |
| | DDT milk: 0.3% to 92% of milk samples exceeded the MRL in different studies. Mean conc. p,p" DDE ranged from 0.660 to 1.436 ng g^{-1} and p,p" DDD ranged from 0.358 to 0.210 ng g^{-1} | | | | | | | | |
| | HCH milk : 3.8% to 55% of milk samples exceeded MRL in different studies. Mean conc. ranged from 0.468 to 1.778 ng g ⁻¹ in different districts. | | | | | | | | |
| | <u>Synthetic pyrethroids:</u> chlorpyrifos (5.8% exceeded MRL), cyhalothrin, cypermethrin, fenvalerate and deltamethrin detected in milk | | | | | | | | |
| | Many can be toxic to humans, HCH is class 1 agent 'human carcinogen', DDT is class 2A agent , "probably carcinogenic to humans" and fenvalerate and deltamethrin is a class 3 agent . | | | | | | | | |

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Refs: ⁴Agarwal et. al. (2012),⁸Battu et al. (1996), ⁹Battu et al. (2004), ¹⁰Bedi et al. (2015), ⁵Kumar et. al. (2014), ⁶Rajdeep et. al. (2012), ¹Sharma et al. (2003), ³Singh et al. (2019), ²Tangri et. al. (2014)

Risk amplifying and risk reducing steps

Milk is sold immediately after

Producer

Risk amplifying

Risk reduction

milking

- Adulteration may occur
 No refrigeration: milk may easily be >10°C
- Poor milking hygiene: no disinfection, protective clothing
- Water (cleaning udders/washing containers) may present additional route
- High levels of faecal contamination

Consumer

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| Risk amplifying | Risk reduction | | | | | | |
|---|---|--|--|--|--|--|--|
| Refrigeration temperatures may not always be maintained | Milk is heat-treated (even pasteurised) | | | | | | |
| Milk/dairy products may be stored in open containers | Dairy products produced in the home are usually made from boiled milk or heat-treated as part of their processing | | | | | | |
| | Milk is refrigerated (most of the time) | | | | | | |

| Retail | |
|---|--|
| Risk amplifying | Risk reduction |
| Formal Milk/dairy products are stored chilled Milk/dairy products are pasteurised Evidence of post-pasteurisation contamination Not all milk screened and not screened for specific hazards Informal Adulteration may occur here No refrigeration No screening of milk Opportunities for cross-contamination | Formal Screening for adulteration and SPC's Informal Milk sold quickly (within 4 hours) |

Results: biological hazards

| | Haza | ard cha | aracteris | sation | Hazard identification/Rapid exposure assessment | | | | | | | Consequence score | | | | |
|---------------------------|---------------|--------------|-----------|--------------|---|---|------------|-------------|----------------|------------------|------------------|--------------------|-------------------|---------------|--------|---------|
| Possible milkhorne | Mode of cont. | | | | | Expert opinion Evidence from literature | | | | | | Consumer | Consequence score | | | |
| hazarde | | | Shed | Later | Evidence mat | Expert hazard | | | | | | | Presence at | | | |
| nazaras | Environ | Faecal | in | in | milkhorno | identification | | | | | | Strength of | consumption | Dose-response | DALY's | Overall |
| | | | milk | chain | hezerd | exercise | Ranking | Uncertainty | Producer | Retail: formalR | letail: informal | evidence | level | | | |
| Aeromonas spp. | \checkmark | x | х | \checkmark | Prob | | | | | | | | | | | |
| Bacillus cereus | \checkmark | \checkmark | х | \checkmark | Est | <10% | Low | Med | | | | V. weak | Poss | 1 | 1 | 2 |
| Brucella abortus | x | x | √ | x | Est | >10% | Med | Med | * | | | Weak | U | 3 | 2 | 5 |
| Campylobacter spp. | \checkmark | \checkmark | √ | \checkmark | Est | <10% | Low | Med | | | | Weak | U | 3 | 2 | 5 |
| Clostridium botulinum | \checkmark | \checkmark | х | x | Prob | | | | | | | | | | | |
| Corynebacterium spp | \checkmark | \checkmark | √ | \checkmark | Prob | | | | | | | | | | | |
| Coxiella burnetii | х | \checkmark | √ | х | С | <10% | Low | High | | | | Weak | U | 2 | 3 | 5 |
| Cryptosporidium spp. | \checkmark | \checkmark | х | \checkmark | Prob | <10% | Low | High | * | | | V. weak | U | 3 | 1 | 4 |
| Cronobacter sakazakii | | | | \checkmark | Prob | | | | | | | | | | | |
| pathogenic <i>E. coli</i> | \checkmark | \checkmark | √ | \checkmark | Est | >10% | Med | Med | * | | | Weak | Poss | | | 6 |
| Enterococcus spp. | \checkmark | \checkmark | х | \checkmark | С | <10% | Low | Med | | | | | | | | |
| Klebsiella | \checkmark | \checkmark | √ | \checkmark | С | | | |] | | | V. weak | | | | |
| Leptospira | \checkmark | \checkmark | √ | х | С | | Low | Med | * | | | V. weak | U | 2 | 2 | 4 |
| Listeria monocytogenes | \checkmark | \checkmark | √ | \checkmark | Est | >10% | Low | Med | | | | | Poss | 2 | 4 | 6 |
| Mycobacterium avium | Y | 1 | 1 | x | C | | | | | | | V weak | 1 | | | |
| subs. paratuberculosis | ^ | v | , v | ^ | U | | | | * | | | v. weak | <u> </u> | | | |
| Mycobacterium bovis | x | x | √ | x | Est | >10% | Med | Med | * | | | V. weak | U | 2 | 3 | 5 |
| Norovirus | √ | x | X | √ | Prob | | | | | | | | | | | 4 |
| Rotavirus | √ | x | x | √ | Prob | <10% | Low | Low | | | | | | 3 | 1 | |
| Salmonella spp. | √ | √ | √ | √ | Est | | Low | Med | * | | | Weak | Poss | 3 | 2 | 5 |
| Shigella spp. | √ | √ | x | √ | Prob | | | | | | | | | | | |
| Staphyloccocus aureus | √ | √ | √ | √ | Est | >10% | Med | High | | | | Weak | L | 1 | 1 | 2 |
| Streptococcus spp | V | √ | √ | √ | Est | >10% | | | | | | | | | | |
| Toxoplasma gondii | x | √ | √ | x | С | | Neg | Low | * | | | V. weak | | | | |
| Yersinia enterocolitica | √ | х | х | √ | Prob | | Neg | Med | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| | | | | | Controversial | Not mentioned | Not asked | Not asked | A | bsence of evider | nce | 0 - absent | | 1 | 1 | 2 |
| | | | | | Probable | Mentioned <10% | Negligible | High | E | vidence of abser | nce | 1 to 2 - very weak | Unlikely | 2 | 2 | 3 |
| | | | | | Well established | Mentioned >10% | Low | Med | E | vidence of prese | nce | 3 to 4 - weak | Possible | 3 | 3 | 4 |
| | | | | | | | Medium | Low | *found in live | stock not milk | | 5+ - moderate | Likely | | 4 | 5 |
| | | | | | | | High | | | | | | | | | 6 |

Risk ranking: biological hazards



- Priority biological hazards appear to be pathogens where post-processing contamination is possible
- Limited evidence: no hazards can be classified as negligible at this stage
- *E. coli* and *L. monocytogenes* may pose the biggest risk to consumers with further investigation of *Campylobacter* spp. and *Salmonella* spp. warranted

Pathogens in black were classified as having "very weak evidence". Pathogens in white were classified as "weak evidence".

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Risk ranking: chemical hazards

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| | Haz charac | ard terisatio | | | | | | | | | |
|------------------------|---------------|------------------|----------------|--------------------|--------|--|--|---------------|------------------------|--------------------------------|-----------------|
| Hazard | Mode of cont. | | Expert opinion | | | | Evidence | e from litera | Consequence assessment | | |
| | Enviro | Shed | Expert list | Ranking Uncertaint | | Producer | oducer Retail: form Retail: infor Strength of ev | | | Overall | |
| Antimicrobial residues | x | \checkmark | >10% | С | Low | LP | | | v. weak | Uncertain | |
| Chemical adulteration | \checkmark | х | >10% | С | Low | | Р | Р | weak | Negative consequences | |
| Heavy metals | x | \checkmark | >10% | U | High | | | | | | |
| Hormones | x | \checkmark | <10% | U/C | Medium | | | | | Uncertain | |
| Mycotoxins/aflatoxins | x | \checkmark | >10% | U | Low | | РР | | weak | Carcinogenic | |
| Pesticides | x | \checkmark | >10% | С | Medium | Р | РРР | | mod | Carcinogenic | |
| Urea | V | x | >10% | С | Medium | | A | LP | v. weak | Uncertain | |
| | | | Not mentioned | Negligible | High | Ab | sence of evide | ence | 0 - absent | Negligible | |
| | | | Mentioned <10% | Unlikely | Medium | Evidence of absence 1 to 2 - very wea | | | | Not well established | |
| | | | Mentioned >10% | Common | Low | Evidence of low presence 3 to 4 - weak | | | | Negative consequences | |
| | | | | | | Evi | dence of prese | ence | 5+ - moderate | Carcinogenic | |
| | | | | | | | | | | IARC classification | Group |
| | | | | | | | | | | Aflatoxins, formaldehyde, HCH | 1 |
| | | | | | | | | | | DDT | 2a |
| | | | | | | | | | | Deltamethrin, Fenvalerate | 3 |
| | | | | | | | | | | Some heavy metals are also cla | assified as gro |

- Chemical hazards are unlikely to be inactivated by pasteurisation or consumer processing
- Evidence of presence of chemical adulterates, aflatoxins and pesticides and low evidence of presence of antimicrobial residues Pesticides have strongest evidence – DDT and HCH have now been banned for use in agriculture

Conclusions

- A wide range of pathogens may be present at the point of sale.
- Due to processing and consumption practices for dairy products, higher risk of exposure to chemical hazards, compared to biological, at the point of consumption
- Adulterates, aflatoxins and pesticides were identified as priority chemical hazards
- Combining rapid exposure assessment with consequences, *E. coli, Listeria* spp., *Campylobacter* spp. and *Salmonella* spp. were identified as priority biological hazards
- Steps in the risk pathway which may influence hazard presence and key-knowledge/data gaps were identified
- This assessment was used to inform future work...

Next steps: Milk Safety in Andhra Pradesh



- Comprehensive producer & retail surveys
- Qualitative data collection
- Quantitative risk assessment
- Systems Dynamics modelling



https://anh-academy.org/modelling-exposure-biological-hazards-dairy-chains-andhra-pradeshinform-food-safety-policy