Executive Summary: Health Impact Review of SHB 1299

Including Cattle Feedlots Implementing Best Management Practices Within the Statutory Exemption for Odor or Fugitive Dust Caused by Agricultural Activity
(2017-2018 Legislative Session)

It is unclear if SHB 1299 has the potential to change the levels of fugitive dust produced from cattle feedlots. There is evidence to demonstrate associations between fugitive dust, health, and health disparities. However, because the potential impact of this bill on levels of fugitive dust is unknown, directionality of downstream impacts cannot be determined.

BILL INFORMATION

Sponsors: Representatives Blake, Manweller, Pettigrew, Dent, Robinson, Chapman, Buys, Kretz, Haler, Irwin

Companion Bill: SSB 5196

Summary of Bill:

- Expands the agricultural activity exemption for fugitive dust under the Washington State Clear Air Act to include cattle feedlots that are implementing best management practices pursuant to a fugitive dust control plan.
- Specifies that the exemption for cattle feedlots applies to feedlots with 1,000 or more cattle between June 1st and October 1st and feedlots where vegetation forage growth does not cover a majority of the lot during normal growing season.
- Expands the definition of "agricultural activity" to include growing, raising, or production of cattle at cattle feedlots.
- Expands the definition of "good agricultural practices" for cattle feedlots to include the "implementation of best management practices pursuant to a fugitive dust control plan that conforms to the fugitive dust control guidelines for beef cattle feedlots, best management practices, and plan development and approval procedures that were approved by the department of ecology in December 1995 or in updates to those guidelines that are mutually agreed to by the department of ecology and by the Washington cattle feeders association on behalf of cattle feedlots."
- Creates a requirement that any notice of violation regarding odor or fugitive dust must include a detailed statement with evidence stating why the activity in question is inconsistent with good agricultural practices or that the odors or dust have a substantial adverse impact on public health.
- Establishes that if an area where a cattle feedlot is located is designated nonattainment for a national ambient air quality standard for particulate matter then additional control measure may be required.

HEALTH IMPACT REVIEW

Summary of Findings:
This Health Impact Review found the following evidence regarding the provisions in SHB 1299:

- Unclear evidence for the bill's impacts on fugitive dust levels produced by cattle feedlots in Washington. Stakeholder input is discussed in further detail in the full Health Impact Review.
- Evidence in the literature demonstrates that associations do exist between fugitive dust from cattle feedlots, health, and health disparities. This Health Impact Review outlines the evidence for each of these associations based on the understanding that the direction of the associations will be dependent on whether or not the provisions of SHB 1299 have a positive or negative impact on levels of fugitive dust produced by cattle feedlots.

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Health Impact Review of SHB 1299

Including Cattle Feedlots Implementing Best Management Practices Within the Statutory Exemption for Odor or Fugitive Dust Caused by Agricultural Activity

(2017-2018 Legislative Session)

March 20th, 2017

Staff Contact: Alexandra Montaño

Contents

Introduction and Methods

A Health Impact Review is an analysis of how a proposed legislative or budgetary change will likely impact health and health disparities in Washington state (RCW 43.20.285). For the purpose of this review 'health disparities' have been defined as the differences in disease, death, and other adverse health conditions that exist between populations (RCW 43.20.270). This document provides summaries of the evidence analyzed by State Board of Health staff during the Health Impact Review of Substitute House Bill 1299 (SHB 1299) from the 2017-2018 legislative session.

Staff analyzed the content of SHB 1299 and created a logic model depicting possible pathways leading from the provisions of the bill to health outcomes. We consulted with experts and contacted stakeholders with diverse perspectives on the bill. State Board of Health staff can be contacted for more information on which stakeholders were consulted on this review. We conducted objective reviews of the literature for each pathway using databases including PubMed and Google Scholar.

The following pages provide a detailed analysis of the bill including the logic model, summaries of evidence, and annotated references. The logic model is presented both in text and through a flowchart (Figure 1). The logic model includes information on the strength of the evidence for each relationship. The strength-of-evidence has been defined using the following criteria:

- **Not well researched:** the literature review yielded few if any studies or only yielded studies that were poorly designed or executed or had high risk of bias.
- **A fair amount of evidence:** the literature review yielded several studies supporting the association, but a large body of evidence was not established; or the review yielded a large body of evidence but findings were inconsistent with only a slightly larger percent of the studies supporting the association; or the research did not incorporate the most robust study designs or execution or had a higher than average risk of bias.
- **Strong evidence:** the literature review yielded a large body of evidence on the relationship (a vast majority of which supported the association) but the body of evidence did contain some contradictory findings or studies that did not incorporate the most robust study designs or execution or had a higher than average risk of bias; or there were too few studies to reach the rigor of 'very strong evidence'; or some combination of these.
- **Very strong evidence:** the literature review yielded a very large body of robust evidence supporting the association with few if any contradictory findings. The evidence indicates that the scientific community largely accepts the existence of the association.

This review was subject to time constraints, which influenced the scope of work for this review. The annotated references are only a representation of the evidence and provide examples of current research. In some cases only a few review articles or meta-analyses are referenced. One article may cite or provide analysis of dozens of other articles. Therefore the number of references included in the bibliography does not necessarily reflect the strength-of-evidence. In addition, some articles provide evidence for more than one research question so they are referenced multiple times.

Analysis of SHB 1299 and the Scientific Evidence

Summary of relevant background information

- Under the federal Clean Air Act, states maintain, with the approval of the Environmental Protection Agency, a State Implementation Plan that describes how clean air programs in the state will meet the federal ambient air quality standards for air pollutants.
- The Washington Clean Air Act establishes the Washington Ambient Air Quality Standards and directs the Department of Ecology and other local clean air agencies to require permits for certain activities that are sources of air pollutants. These agencies are then responsible for enforcing the requirements of the permits.
- Under the Washington Clean Air Act, odors and fugitive dust are two kinds of emissions that are regulated for maximum emissions and the standards require that sources of these emissions must implement "reasonable precautions" to prevent emissions from being released and becoming airborne.
- Exemptions for odor and fugitive dust currently exist for agricultural activities that are consistent with good agricultural practices unless they have a substantial adverse impact on public health. Agricultural activities include, for example, growing, raising, or production of berries, poultry, livestock, shellfish, grain, dairy, etc. This exemption does not apply to cattle feedlots that have 1,000 cattle or more.

Summary of SHB 1299

- Expands the agricultural activity exemption for fugitive dust under the Washington State Clear Air act to include cattle feedlots that are implementing best management practices pursuant to a fugitive dust control plan.
- Specifies that the exemption for cattle feedlots applies to feedlots with 1,000 or more cattle between June 1st and October 1st and feedlots where vegetation forage growth does not cover a majority of the lot during normal growing season.
- Expands the definition of "agricultural activity" to include growing, raising, or production of cattle at cattle feedlots.
- Expands the definition of "good agricultural practices" for cattle feedlots to include the "implementation of best management practices pursuant to a fugitive dust control plan that conforms to the fugitive dust control guidelines for beef cattle feedlots, best management practices, and plan development and approval procedures that were approved by the department of ecology in December 1995 or in updates to those guidelines that are mutually agreed to by the department of ecology and by the Washington cattle feeders association on behalf of cattle feedlots."
- Creates a requirement that any notice of violation regarding odor or fugitive dust must include a detailed statement with evidence stating why the activity in question is inconsistent with good agricultural practices or that the odors or dust have a substantial adverse impact on public health.
- Establishes that if an area where a cattle feedlot is located is designated nonattainment for a national ambient air quality standard for particulate matter then additional control measure may be required.

Health impact of SHB 1299

It is unclear if SHB 1299 has the potential to change the levels of fugitive dust produced from cattle feedlots. There is evidence to demonstrate associations between fugitive dust, health, and health disparities. However, because the potential impact of this bill on levels of fugitive dust is unknown, directionality of downstream impacts cannot be determined.

Pathways to health impacts

The potential pathways leading from the provisions of SHB 1299 are depicted in Figure 1. The likely impact of including cattle feedlots in the agricultural activity exemption for odor and fugitive dust on levels of fugitive dust is unknown. Stakeholder input on this issue is discussed in more detail on page 5 of this review. Evidence in the literature shows that associations do exist between fugitive dust, health,[1-12] and health disparities.[13-17] These associations are discussed in greater detail on page 8 and are based on the understanding that the direction of the associations will be dependent on whether or not the provisions of SHB 1299 have a positive or negative impact on levels of fugitive dust.

Magnitude of impact

Data from the Washington State Department of Health (Table 1) indicate that there are an estimated 1,185 people that live in the vicinity of a cattle feedlot with 1,000 cattle or more and are likely to be impacted by this bill. The list of cattle feedlots used for this analysis was obtained from the Department of Ecology and the Yakima Regional Clean Air Agency. The methods for these data and the subsequent estimates are explained in further detail in the annotated bibliography.[18] This number is likely an underestimate as it does not account for individuals who may work at cattle feedlots but do not necessarily live directly nearby.

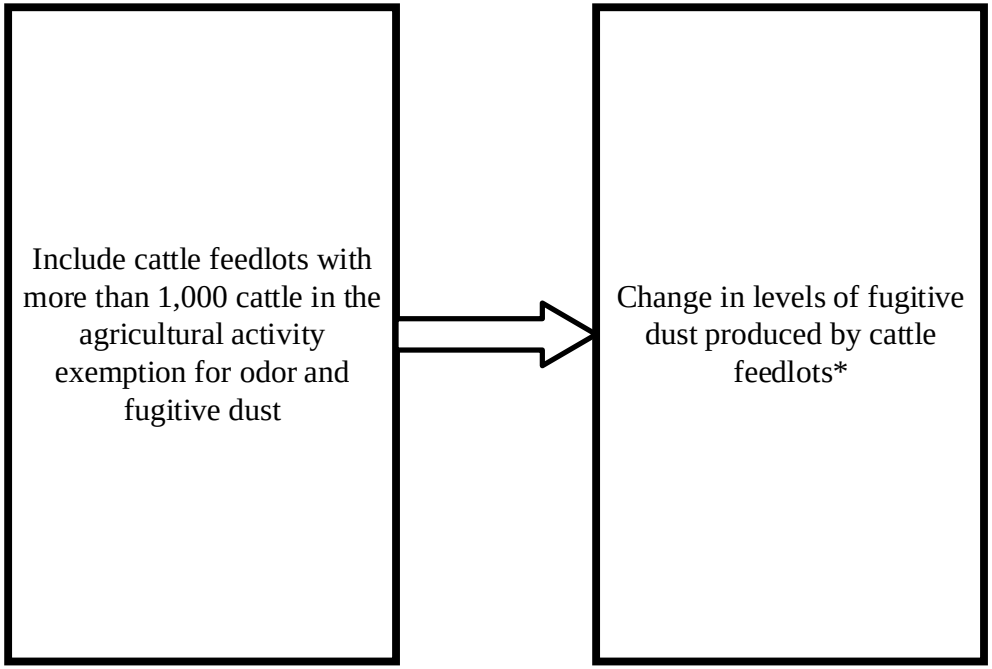
Table 1: Population Demographics by Race/Ethnicity for Populations Living Near Cattle Feedlots[1]

	Population living near cattle feedlots		Washington State	
Race/Ethnicity	*N*	*%*	*N*	*%*
White	893	75%	5,196,362	77%
Black	6	1%	240,042	4%
American Indian/Alaska Native	13	1%	103,869	2%
Asian	10	1%	481,067	7%
Native Hawaiian/Other Pacific Islander	1	0%	40,475	1%
Other Race	229	19%	349,799	5%
Two or more races	33	3%	312,926	5%
Total Housing Units	433		2,885,677	
Population <5 years of age	106	9%	526,207	8%
Hispanic	413	35%	755,790	11%
Total Population[2]	1,185		6,724,540	

[1]Cattle feedlots in Washington with 1,000 cattle or more, estimated using Census Block Groups (U.S. Census 2010 Summary File)

[2]Numbers do not sum, Hispanic ethnicity is independent of race

Logic Model



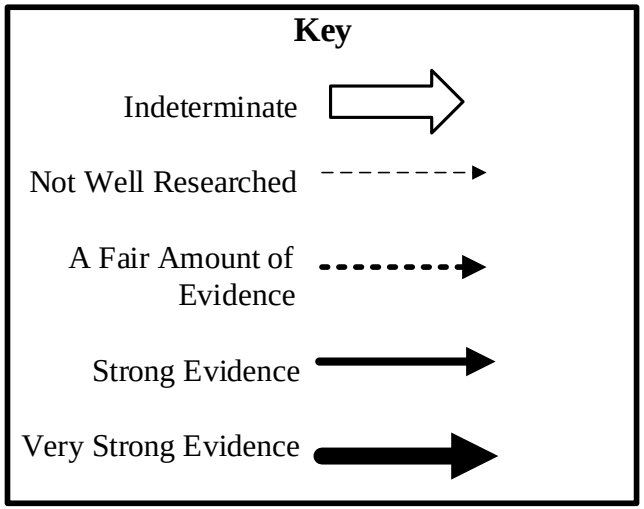


Figure 1
Including Cattle Feedlots Implementing Best Management Practices Within the Statutory Exemption for Odor or Fugitive Dust Caused by Agricultural Activity
SHB 1299

*See the full Health Impact Review for discussion about additional pathways leading from changes in levels of fugitive dust

Summaries of Findings

Will including cattle feedlots in the agricultural exemption for odor and fugitive dust change the levels of dust produced by cattle feedlots?

It is unclear if SHB 1299 has the potential to change fugitive dust levels produced by cattle feedlots in Washington. We were unable to identify any studies in the scientific literature that examined the association between agricultural activity exemptions, or similar regulations, and the impact of these exemptions on dust levels. Therefore, we consulted with a number of stakeholders with various perspectives to better understand the potential implications of this bill. There were diverse opinions about how SHB 1299 would likely impact regulation and levels of fugitive dust from cattle feedlots and a summary of these perspectives are discussed below.

Chris Hanlon-Meyer, Science and Engineering Section Manager at the Washington State Department of Ecology (ECY) Air Quality Program discussed a number of challenges that SHB 1299 would present for regulating agencies. Currently, a cattle feedlot can be cited for infractions of the Washington Clean Air Act and ECY can issue a notice of correction that can include requiring the feedlot to implement additional best management practices (Chris Hanlon-Meyer, personal communication, March 2017). If there is not compliance after a notice of correction is issued there can be penalties imposed. Data show that in 2016 the Air Quality Program was engaged in 10 complaint investigations, 4 inspections, and 10 visits for technical assistance across the feedlots that are registered with ECY and from this, staff issued 7 notices of correction but no notices of violation or notices of penalty (Chris Hanlon-Meyer, personal communication, March 2017).

Provisions in SHB 1299 require that a notice of violation issued by ECY related to odors or fugitive dust caused by agricultural activity must include a detailed statement with evidence that either demonstrates why the activity in question is inconsistent with good agricultural practices or how the odors or fugitive dust have a substantial adverse effect on public health. ECY indicated that if air quality problems were identified even though good agricultural practices were being used, evidence demonstrating a substantial adverse effect on public health would be resource intensive, time consuming and would require a very high burden of proof. In order to provide this level of evidence, a detailed Health Impact Assessment (HIA) demonstrating a causal relationship between the pollution and damage to public health would be necessary (Chris Hanlon-Meyer, personal communication, March 2017). To date, ECY has only conducted one such assessment in this topic area and the agency was unsuccessful in proving adverse public health impacts to the state Pollution Control Hearing Board; as a result ECY has not pursued this option (Chris Hanlon-Meyer, personal communication, March 2017).

Hasan Tahat, Engineering and Planning Division Supervisor with the Yakima Regional Clean Air Agency also discussed the difficulty with provisions in the bill that require a regulating agency to consult with a third-party expert in determining if the activities of a feedlot are consistent with good agricultural practices before issuing a notice of violation. Mr. Tahat expressed that finding a third-party expert is challenging in itself but there is also the issue that the expert did not see or experience what an inspector or agency representative may have at the time that the investigation was initiated (Hasan Tahat, personal communication, March 2017). Additionally, there is concern that because collecting the necessary evidence could take up to

year in some cases, dust exposure could continue to be elevated during the time of an investigation, which would only prolong the potential for further adverse health impacts (Chris Hanlon-Meyer, personal communication, March 2017).

A representative of the community organization Friends of Toppenish Creek also expressed concern about the potential for the bill to hinder ECY's ability to implement more protective standards regarding aerosols from feedlots, as well as the use of terms with unclear definitions, such as "good agricultural practices" and "best management practices", that would likely make it difficult for agencies to effectively evaluate and control air pollution from these sources.

Jack Field, Executive Director of the Washington Cattle Feeders Association indicated that including cattle feedlots that are implementing best management practices for fugitive dust in the agricultural activities exemption will incentivize cattle feeders to have a dust management plan. Cattle feeders are interested in the health of their cattle and preventing disease in their animals and in order to do that, they need to control dust through practices such as the use of overhead sprinklers, applying products to roads that reduce dust, and controlling animal density and times of corralling (Jack Field, personal communication, March 2017). SHB 1299 includes a provision that outlines that good agricultural practices include "…best management practices pursuant to a fugitive dust control plan that conforms to the fugitive dust control guidelines for beef cattle feedlots, best management practices, and plan development and approval procedures that were approved by the department of ecology in December 1995 or in updates to those guidelines that are mutually agreed to by the department of ecology and by the Washington cattle feeders association on behalf of cattle feedlots." Given this provision, Mr. Field expressed that this allows cattle feeders and the Department of Ecology to continue to build a good working relationship as they are working towards the same goals of controlling meaningful dust and protecting health (Jack Field, personal communication, March 2017).

Because we were unable to find any scientific evidence that examined the association between agricultural activity exemptions, or similar regulations, and the impact of these exemptions on dust levels, and because the stakeholder perspectives we received represented conflicting viewpoints on how levels of fugitive dust will change, we cannot conclude whether SHB 1299 will result in higher or lower levels of fugitive dust produced from cattle feedlots.

Logic Model- Additional Pathways

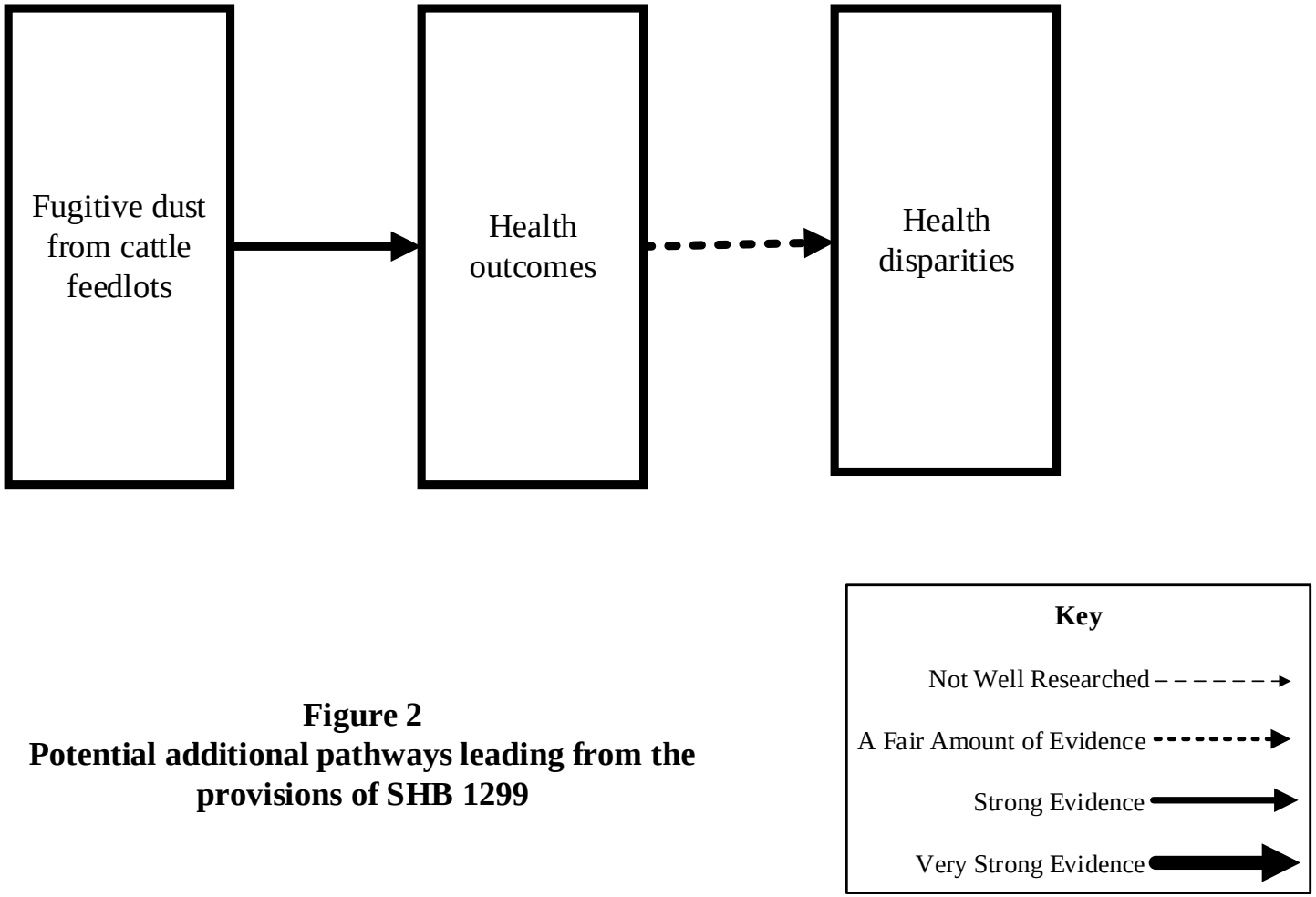


Figure 2
Potential additional pathways leading from the provisions of SHB 1299

Discussion of Additional Pathways

Overview

For this Health Impact Review, we examined the most direct pathway leading from the provisions of SHB 1299 to health and health disparities, which is through a change in the levels of fugitive dust produced by cattle feedlots. Because there was a lack of evidence to support an association, and the directionality of the association could not be determined (i.e. a positive impact or a negative impact), we were unable to conclude what the impacts would be further down the logic model. What we do know from evidence in the literature is that associations do exist between fugitive dust, health, and health disparities. The following sections outline the evidence from the literature for each of these associations. The direction of the associations will be dependent on whether or not the provisions of SHB 1299 have a positive or negative impact on levels of fugitive dust from cattle feedlots. In other words, if future research demonstrates that including cattle feedlots in the agricultural activity exemption for odor and fugitive dust results in lower dust levels, then existing evidence would further support positive impacts on health and health disparities. Conversely, if future research demonstrates that including cattle feedlots in the agricultural activity exemption for odor and fugitive dust results in higher levels of dust, then existing evidence would further support negative impacts on these outcomes.

Fugitive dust and health outcomes

There is strong evidence that exposure to fugitive dust is associated with adverse health outcomes. Evidence in the literature has demonstrated that sources of air contamination from confined animal feeding operations (CAFOs) include particulate and gaseous substances such as ammonia, hydrogen sulfide, and methane.[2,4,6,7] Respiratory disease in the agricultural community has been associated with organic dust from dried manure, allergens from animal dander, endotoxins from bacteria within the environment, microorganisms, toxic gases such as nitrogen oxides and animal confinement gases, and pesticides.[3] Common respiratory diseases seen in individuals who work in the agricultural community include hypersensitivity pneumonitis, organic toxic dust syndrome, and other asthma-like symptoms.[2,7] Many of these health outcomes have also been described among individuals living in communities near CAFOs. For example, studies have found a strong association with living near agricultural land and wheezing[8,10] The authors of these studies conclude that exacerbations of asthma symptoms may be increased with living in proximity to densely agricultural areas.[8,10] Odor annoyance from feedlots has also been associated with lower self-reported general health, increased reporting of respiratory, gastrointestinal, neurological, and stress-related symptoms.[5] Further, studies have shown that veterinary antibiotics can be measured in both upwind and downwind dust samples from cattle feedlots.[9] Among thousands of other bacteria, samples contained several species that are known to be infectious to humans including Corynebacterium, Leptospira, Clostridium, Bacteroides, and Staphylococcus, which may demonstrate the potential for antibiotics and bacteria to be transported by the wind from beef cattle feed yards to the environment.[9]

Although potentially less generalizable, studies related to air quality and dust around dairies have shown that outdoor particulate matter (PM), ammonia, and cow allergen concentrations were all higher both indoors and outdoors at homes that were closest to dairy operations.[8,11,12] Cow allergen is a component of airborne particles that are associated with dander, hair, sweat, and urine from cattle.[11] A number of studies of homes in Yakima, Washington located at various

distances from large dairies have shown that, "[c]ow allergen was detected in 79%, 57%, and 23% of proximal, intermediate, and distal homes, respectively...Similar to outdoor dust results, indoor cow allergen was observed with 80%, 86%, and 46% of dust samples having detectable cow allergen in proximal, intermediate, and distal homes."[11] The authors discuss that although the health impacts of chronic exposure to cow allergen have not been well studied, there is potential for residents exposed to this allergen to become sensitized and have allergic symptoms.[11,12] These allergic symptoms can be further exacerbated for individuals with asthma and may trigger respiratory symptoms that require the use of medication and health care services.[12] Endotoxin in settled dust from dairies, which was found in 100% of outdoor dust samples in one study, has also been associated with asthma and wheeze.[11] Finally, another study demonstrated that around 65% of the Staphylococcus aureus isolates tested from air samples surrounding a dairy were resistant to ampicillin and 34% were resistant to the two classes of antibiotics tested (i.e. resistant to either ampicillin or penicillin and ceflacor). The authors conclude that antibiotic resistance is a public health concern and the resistant microbial specimens found in environments around CAFOs may adversely impact surrounding communities.[1]

Health outcomes and health disparities

There is a fair amount of evidence that exposure to fugitive dust could exacerbate health disparities for low income individuals. Data from Washington State indicate that counties in eastern Washington were more likely to have higher poverty rates than counties in western Washington. Specifically relevant for this review, four of the five counties where cattle feedlots are located (Adams, Franklin, Grant, and Yakima counties) have higher rates of poverty than the state average.[14] Literature has demonstrated that a strong association exists between household income and adults reporting current asthma in that as income increases, the percentage of adults who report currently having asthma decreases.[13,15-17] This association is true in Washington and remains robust after adjusting for gender, education, race and Hispanic origin.[13]

In summary, it is unclear how SHB 1299 would impact fugitive dust levels from cattle feedlots. However, if future evidence reveals that including cattle feedlots in the agricultural activity exemption for odor and fugitive dust results in higher dust levels, then SHB 1299 would have the potential to worsen health outcomes and exacerbate health disparities for low-income populations. Conversely, if future evidence reveals that including cattle feedlots in the agricultural activity exemption results in lower dust levels, then SHB 1299 would have the potential to improve health and reduce health disparities for low-income populations.

Annotated References

1. **Alvarado Carla S. , Gibbs Shawn G., Gandara Angelina, et al. The potential for community exposures to pathogens from an urban dairy. *Journal of Environmental Health.* 2012;74(7):22-28.**

In this study, Alvarado et al. collected samples from a dairy cattle confined animal feeding operation (CAFO) with close to 5,000 cattle located in northern Mexico about 10 miles from the U.S.-Mexico border. The aim of the study was to evaluate the variation and transport of fungal and bacterial concentrations in the air and to establish the concentration and incidence of antibiotic-resistant isolates of Staphylococcus aureus. There were three sampling locations including on-site, upwind, and downwind of the diary. The one-site location was on a road at the center of the cattle feeding area with cattle on either side of the road. The upwind location was at the furthest upwind point of the property line, over 100 meters from the cattle, while the downwind location was at the furthest downwind spot, about 50 meters from a calving area. The authors collected bioaerosol samples in duplicate after a minimum of three days with no rain during April, August, and November of 2006 and tested them for culturable airborne fungal organisms and bacteria. For fungal organisms, there were more organisms recovered from fine particles than from coarse particles and the concentration of culturable organisms was greatest at the on-site sampling location and lowest at the upwind location. The same relationship was true for culturable bacterial bioaerosols. Around 65% of the Staphylococcus aureus isolates tested were resistant to ampicillin and 34% were resistant to the two classes of antibiotics tested (i.e. resistant to either ampicillin or penicillin and ceflacor). The authors conclude that antibiotic resistance is a public health concern and the resistant microbial specimens found in environments around CAFOs may adversely impact surrounding communities.

2. **Basinas I., Sigsgaard T., Kromhout H., et al. A comprehensive review of levels and determinants of personal exposure to dust and endotoxin in livestock farming. *Journal of exposure science & environmental epidemiology.* Mar-Apr 2015;25(2):123-137.**

Basinas, Sigsgaard, Kromhout et al. conducted a comprehensive review of all literature from 1980-2012 relating to respiratory health in livestock farmers. The authors specifically searched for articles that studied the impacts of organic dust and endotoxin exposure. The authors began by providing an overview of the current literature surrounding respiratory health effects of organic dust. They found that exposure to organic dust can stimulated inflammatory processes in the immune system and can cause sensitization and allergic asthma. Overall, they found varying occupational threshold limits exist for exposure to dust, such as in Denmark (3 mg/m3), in Norway and Sweden (5mg/m3), and in the United States (10 mg/m3). The authors were able to find 41 studies on pig, poultry, or cattle farmers and exposure to agricultural exposures; 39 of which included measurements of dust and/or respiratory capacity. They found a large variation in concentrations of dust and endotoxin on livestock farms. The authors found 21 studies on the determinants of organic dust and endotoxin exposure in livestock farming. These studies show that exposure depends on the type or stage of production, the season, and variation in ventilation systems. The authors found that over the body of this literature there had been no downward trend of exposure, suggesting that proper prevention strategies have not been put into place. The use of technology and design can drastically reduce exposure, but farmers need education and incentive to implement such preventative measures.

3. **Cole N.A, Todd R., Auvermann B., et al.** ***Auditing and Assessing Air Quality in Concentrated Feeding Operations.*** **USDA Agricultural Research Service;2008.**

Cole, Todd, Auvermann et al. created a report regarding best practices of auditing air quality issues caused by Animal Feeding Operations (AFOs). The federal government regulates air quality through the Clean Air Act of 1970, established by the Environmental Protection Agency (EPA); however, local government does have some authority over air quality issues including nuisance complaints. While many pollutants are regulated by this act, ammonia and hydrogen sulfide emissions—the primary contributors to odor—are not currently regulated by the EPA. For the purposes of background, the report describes a number of air quality components of livestock operations including ammonia, particles, dust, pathogens, and endotoxins. The authors discuss that these components, as well as others, may have negative impacts on human health. In the late 1900s the EPA, poultry industry, swine industry, and dairy industry developed the Animal Feeding Operations Air Compliance Agreement. This agreement required that these industries fund a 2-year research project measuring air quality surrounding AFOs, including ammonia, hydrogen sulfide, particulate matter, and volatile organic molecules (VOC). The European Union already regulates the above-listed compounds due to their adverse effects on health and the environment. The EPA conducts environmental audits to verify compliance to environmental regulations, evaluate the effectiveness of environmental management systems, and to assess risks from regulated and unregulated materials and practices. The EPA has incentivized opportunities for regulated entities to "police" themselves to promote voluntary participation in environmental audits. While local government would like the EPA to regulate ammonia, hydrogen sulfide, particulate matter, VOC, and pathogens coming from AFOs, it has proven to be a challenging and expensive endeavor. The authors discuss several methods for measuring pollutants and conducting an environmental audit. They conclude that in the future there will be a drastic need for well-trained auditors due to increasing environmental air quality concerns.

4. **Heederik D., Sigsgaard T., Thorne P. S., et al. Health effects of airborne exposures from concentrated animal feeding operations.** ***Environmental health perspectives.*** **Feb 2007;115(2):298-302.**

Heederick, Sigsgaard, Thorne et al. conducted a systematic review of the health effects of airborne exposures from concentrated animal feeding operations (CAFOs). The authors were able to find several studies that are definitive about the association between CAFOs and toxic gases, vapors, particulate matter, and organic compounds. Many studies suggest that working within a CAFO can have detrimental health effects. The authors had a difficult time finding articles to determine the health effects of exposure to odors created by CAFOs. Based on their search, they recommend that future research focus on determining the health effects of exposure to CAFO by-products on the people who live in the surrounding neighborhoods.

5. **Hooiveld M., van Dijk C., van der Sman-de Beer F., et al. Odour annoyance in the neighbourhood of livestock farming - perceived health and health care seeking behaviour.** ***Annals of Agricultural and Environmental Medicine.*** **2015;22(1):55-61.**

Hooiveld, van Dijk, van der Sman-de Beer et al. conducted a cross-sectional study of residents in the Netherlands who lived near animal feeding operations (AFOs) in June 2010. The main goal

of the study was to determine if there was an association between proximity to AFOs and health care seeking behavior. A sample of 758 patients with asthma and 1,519 patients with low-back pain without radiation were randomly selected from the adult population of 20 general practices. Patients received a questionnaire from their general practitioner addressing demographics, environmental living conditions, health habits, self-reported symptoms, and farm childhood. A total of 317 asthma patients and 662 low-back pain patients returned the surveys after two weeks; however, those who reported that they live or work on a farm or those who had missing data were excluded, leaving 753 subjects for analysis. Nearly 63% of participants surveyed were female. Nearly a quarter of them had grown up on a farm and one-third reported odor annoyance in the neighborhood. Participants frequently reported living within 500m of pigs, poultry, or cattle. Odds ratios of odor annoyance were calculated at 2.3 for proximity to pigs, 2.95 for proximity to poultry, and 2.32 for proximity to cattle. Odor annoyance was associated with lower general health (OR 0.73), increased reporting of respiratory (RR 1.22), gastrointestinal (RR 1.4), neurological, and stress-related symptoms (in low-back pain only, RR 1.4). Policy makers should consider odor annoyance, rather than just odor, when creating environmental health regulations.

6. **Hribar Carrie.** ***Understanding Concentrated Animal Feeding Operations and Their Impact on Communities.*** **Ohio: National Association of Local Boards of Health;2010.**

Hribar and the National Association of Local Boards of Health (NALBOH) created a report about Animal Feeding Operations and how Local Boards of Health can protect their communities from the possibility of health effects. The authors summarize potential environmental health effects of the abundance of manure produced by Concentrated Animal Feeding Operations (CAFO), which is estimated to be between 3-20 times more waste than humans in the U.S. produce. Groundwater and surface water can both be contaminated by runoff from land applications of manure; which can increase the concentration of pathogenic organisms, nitrates, and synthetic hormones in these water sources. Sources of air contamination from CAFOs include particulate and gaseous substances such as ammonia, hydrogen sulfide, and methane. The authors summarize the evidence that living near a factory farm can increase the risk of asthma in neighboring communities. Other environmental health concerns created by CAFOs include increased greenhouse gases, odors, insect vectors, pathogens, and antibiotics in the surrounding communities. The report reviews three case studies in which local boards of health were able to protect local communities from the above-mentioned environmental health concerns.

7. **Kirkhorn S. R., Garry V. F. Agricultural lung diseases.** ***Environmental health perspectives.*** **2000;108(4):705-712.**

Kirkhorn and Garry conducted a systematic review of literature associating working in an agricultural setting to respiratory diseases. In 1997, it was estimated that up to 5 million people worked in the U.S. agricultural setting. While the agriculture field is drastically changing, there continues to be no oversight from the Occupational Safety and Health Administration (OSHA) for farms with fewer than 11 employees. Respiratory disease in the agricultural community has been associated with inorganic dust such as sand, organic dust from dried manure, allergens from animal dander, endotoxins from bacteria within the environment, microorganisms, toxic gases such as nitrogen oxides and animal confinement gases, and pesticides. Common respiratory diseases seen in the agricultural community include hypersensitivity pneumonitis, organic toxin

dust syndrome, and other asthma-like symptoms. It is important to ensure that small farms (fewer than 11 employees) are considered under OSHA regulations. Further occupational safeguards are necessary to protect agricultural workers.

8. **Loftus C., Yost M., Sampson P., et al. Regional PM2.5 and asthma morbidity in an agricultural community: a panel study. *Environmental research.* Jan 2015;136:505-512.**

Loftus, Yost, Arias et al. conducted a longitudinal cohort study out of the Yakima Valley in Washington State to investigate associations between exposure to particulate matter from agricultural practices and pediatric asthma exasperations. The Aggravating Factor of Asthma in a Rural Environment (AFARE) study recruited English and Spanish-speaking community members from Yakima Valley Farm Worker Clinics (YVFWC) and through local radio stations. Participants were chosen based on age, health status (besides asthma), enrollment in the YVFWC Asthma Program, intention to stay in the area for two years, and residence within a 200-mile diameter of the densely agricultural land in Yakima Valley. Fifty-four participants were enrolled. Participants and their caretakers were surveyed via phone at regular two-week intervals. Twice daily, participants measured lung function using peak flow meters with digital memory at their homes. Particulate matter measuring less than 2.5 micrometers (PM2.5) was measured using nephelometry at a central site air monitor in a neighboring town. Two local weather stations in local communities were used to measure temperature, relative humidity, and precipitation. After analysis, the authors found a strong association with living near agricultural land and wheezing (OR 1.31, 95% CI 1.18-1.45). Nighttime walking and limitation of activities were also significant, OR 1.21 and 1.13, respectively. There were significant changes in FEV1 when the concentrations of PM2.5 were high. The authors conclude that exacerbations of asthma symptoms may be increased with living in proximity to densely agricultural areas.

9. **McEachran A. D., Blackwell B. R., Hanson J. D., et al. Antibiotics, bacteria, and antibiotic resistance genes: aerial transport from cattle feed yards via particulate matter. *Environmental health perspectives.* Apr 2015;123(4):337-343.**

McEachran, Blackwell, Hanson et al collected samples of particulate matter both upwind and downwind from 10 beef cattle feed yards in the Southern High Plains, Texas to measure the extent to which antibiotics, bacteria, and antibiotic-resistant genes were in the surrounding air. Digital portable high-volume air samplers were installed at a standard 2-3m above the ground and 10-20m upwind and downwind of the feed yard boundaries. All measurements were taken between August-December 2012 on days where the weather conditions were similar in all feed yards. Researchers used high-performance liquid chromatography with tandem mass spectrometry and electrospray ionization to measure antibiotics in the samples. They used a PowerSoil DNA Isolation Kit and real-time PCR assays to detect the presence on antibiotic resistant genes. Lastly, they conducted a microbial diversity analysis to determine the presence of bacteria in the samples. After analysis, researchers found that the mass of particulate matter downwind of feed yards was significantly different than samples collected upwind of feed yards (P=0.002). Several veterinary antibiotics were measured in both the upwind and downwind samples. Among thousands of other bacteria, there were several species that are known to be infectious to humans including Corynebacterium, Leptospira, Clostridium, Bacteroides, and Staphylococcus. An abundance of six targeted tetracycline resistance genes were found in a

significant number of samples ($p<0.002$). This study demonstrated the potential for antibiotics and bacteria to be transported by the wind from beef cattle feed yards to the environment.

10. **Radon K., Schulze A., Ehrenstein V., et al. Environmental exposure to confined animal feeding operations and respiratory health of neighboring residents. *Epidemiology.* May 2007;18(3):300-308.**

Radon, Schulze, van Stien et al. conducted a cross-sectional survey of German adults living in four towns with a high density of confined animal feeding operations (CAFOs) to investigate association between self-reported odor annoyance and respiratory disease. All adults aged 18-44 with German citizenship who lived in these 4 rural towns were included in the study (n=10,252). Participants were randomized into a questionnaire-only group and a questionnaire plus clinical examination group. Those who had occupational farm contact were excluded from the study. The questionnaire included sociodemographic data, self-reported respiratory symptoms, self-reported farm-animal contact during childhood and at time of the survey, and self-reported odor and noise annoyance. The clinical examination included blood sampling and pulmonary function testing. After analysis, the odds of reporting respiratory health symptoms increased with increased odor annoyance. The odds for wheezing without a cold was increased for participants whose homes were within 500m from more than 12 animal houses. These participants also had lower FEV1 values than any other group. The group with the highest FEV1 and lowest odor annoyance were those living within 500m of fewer than 5 animal houses. The authors suggest that living near a high density of CAFOs may adversely affect respiratory health.

11. **Williams D. A., McCormack M. C., Matsui E. C., et al. Cow allergen (Bos d2) and endotoxin concentrations are higher in the settled dust of homes proximate to industrial-scale dairy operations. *Journal of exposure science & environmental epidemiology.* Jan-Feb 2016;26(1):42-47.**

Williams et al. aimed to investigate the distribution of dairy-related animal waste contaminants found in settled dust both inside and outside of homes that are at various distances to dairy facilities as a way to characterize potentially shorter-term airborne exposure to contaminants. The study used samples from inside and outside 40 homes in Yakima, Washington that included 20 houses characterized as proximal to dairy facilities (i.e. within 0.25 mile), 7 characterized as intermediate (i.e. greater than 2.5-3 miles), and 13 characterized as distal (i.e. greater than 3 miles). Homes that had a resident who was a dairy worker, smoker, or had cows on the property were excluded from participating. Outdoor settled dust samples were collected from a location off the ground that would typically accumulate airborne dust. Indoor samples were collected from three locations including a bed and carpeting around the bed in a bedroom, an upholstered piece of furniture, and a hard surface off the floor such as a window sill or shelving unit. All samples were tested for cow allergen (Bos d 2), endotoxin, mouse allergen, and dust mite allergen. Results indicate that all tested pollutants were found at higher concentrations in both indoor and outdoor dust of homes that were proximal to dairy facilities and were the lowest in distal homes. Cow allergen was specifically chosen to be tested for in this study because the presence of cow allergen in indoor and outdoor dust represents likely contamination from resuspended waste materials from dairy operations. The authors describe that, "Cow allergen was detected in 79%, 57%, and 23% of proximal, intermediate, and distal homes, respectively...Similar to outdoor dust results, indoor cow allergen was observed with 80%, 86%,

and 46% of dust samples having detectable cow allergen in proximal, intermediate, and distal homes, respectively." The authors further discuss that other studies have shown that exposure to cow allergen can be a risk for allergic sensitization, a trigger for asthma, and can induce respiratory inflammation. Endotoxin in settled dust, which was found in 100% of outdoor dust samples, has also been associated with asthma and wheeze.

12. **Williams D. L., Breysse P. N., McCormack M. C., et al. Airborne cow allergen, ammonia and particulate matter at homes vary with distance to industrial scale dairy operations: an exposure assessment.** ***Environmental health : a global access science source.*** **Aug 12 2011;10:72.**

Williams et al. aimed to understand the impact of dairy operations on nearby communities by evaluating airborne contaminants such as particulate matter (PM), ammonia, and cow allergen (Bos d 2) inside and outside homes. The authors used a sample of 40 homes in Yakima, Washington with 20 homes being defined as proximal to a dairy operation (i.e. within 0.25 of a mile) and 20 homes being defined as distal (3 miles or more from a dairy facility). Homes were excluded if a resident of the home was either a smoker or worked in a dairy or orchard where manure was spread, or if the residents owned cows on their property. Environmental testing was done by taking air samples from inside and outside each home and tested for air pollutants including ammonia, PM, or Bos d 2. Data show that outdoor PM, ammonia, and cow allergen concentrations were all higher both indoors and outdoors at homes that were closest to dairy operations. The authors discuss that although the health impacts of chronic exposure to cow allergen have not been well studied, there is potential for residents exposed to this allergen to become sensitized and have allergic symptoms. These allergic symptoms can be further exacerbated for individuals with asthma and may trigger respiratory symptoms that require the use of medication and health care services.

13. **McDermot Dennis.** ***Health of Washington State: Asthma.*** **Washington State Department of Health;2015.**

In this report, McDermot summarizes data from Washington that relates to asthma. The state average for adult asthma is close to 10% and there are no counties in the state that have a statistically significant lower asthma rate. There is a relationship between asthma and education however the relationship does not persist after adjusting for gender, income, race and Hispanic origin. In terms of race and Hispanic origin, American Indian/Alaska Native is the group with the highest rates of asthma while Asian and Hispanic have the lowest rates. Finally, there is a strong association between household income and adults reporting current asthma in that as income increased, the percentage of adults who reported currently having asthma decreased. This association remained after adjusting for gender, education, race and Hispanic origin.

14. **Sabel Jennifer, McDermot Dennis.** ***Health of Washington State Report: Socioeconomic Position in Washington.*** **Washington State Department of Health;2016.**

Sabel and McDermot present data about socioeconomic position in Washington State including differences within the state as well as statewide differences compared to national data. Data indicate that compared to the United States as a whole, fewer Washington residents are living in poverty although poverty in the state increased slowly from 2005-2014. However, these economic resources are not evenly distributed among all Washington residents. Females in

Washington were more likely to be living in poverty than males and were also more likely to have lower wages. Further, American Indian and Alaska Native, Hispanic, and black residents had higher percentages of living in poverty and lower median household incomes compared to other groups. Data also indicate that counties in eastern Washington were more likely to have high poverty rates and high rates of unemployment than counties in western Washington. Specifically related to this review, four of the five counties where cattle feedlots are located have higher rates of poverty than the state average.

15. **Chen Yue, Tang Mei, Krewski Daniel. Relationship between asthma prevalence and income among Canadians.** ***Journal of the American Medical Association.*** **2001.**

Chen, Tang, and Krewski wrote a research letter to the American Medical Association discussing their recent research on Canadian asthma prevalence and income-disparities. Their research was based on cross-sectional survey data from the National Population Health Survey (NPHS) in the period 1996 through 1997. A total of 173,032 people over the age of 12 responded. On average, 5.7% of men and 7.9% of women reported having asthma. The likelihood of having asthma was highest for those between the ages of 19 to 24 years (10.5%). Even after adjusting for all confounding factors, the prevalence of asthma increased with decreasing household income in both men and women. The authors suggest that this could be caused by poor housing environment and increased exposure to cigarette smoke.

16. **Maulden Jennifer, Phillips Martha.** ***The State of Asthma in Arkansas.*** **Arkansas Minority Health Commission;2013.**

Maulden and Phillips examined the prevalence of asthma in adults and children living in Arkansas during 2002 to 2010. Using Arkansas state data from the Behavioral Risk Factor Surveillance System (BRFSS) the authors found that the prevalence of asthma varied in different populations. Asthma was more prevalent among females and those who were obese. Individuals with a lower income level had increased prevalence of asthma. While prevalence of asthma was similar in African Americans and Whites, African Americans were over two times more likely to die from an asthma-related event.

17. **Wolstein Joelle, Meng Ying-Ying, Babey Susan H.** ***Income Disparities in Asthma Burden and Care in California.*** **UCLA Center for Health Policy Research;2010.**

Wolstein, Meng, and Babey used the 2007 California Health Interview Survey to determine asthma prevalence by county and demographics in California. The authors found that prevalence of asthma varied considerably by county, ranging from 6% in San Francisco County to 12.9% in Fresno County. In counties where the majority of residents were below 200% of the Federal Poverty Level, likelihood of having asthma was significantly higher. Low-income children were more than twice as likely to miss school from asthma-related events as higher income children (2.8 vs. 1.3 days). A possible reason for income disparity is that low-income children and adults are three times more likely to be exposed to second-hand smoke than those with higher-incomes.

18. ***Population Demographics by Race/Ethnicity for Populations Living Near Cattle Feedlots.*** **Washington State Department of Health;2017.**

To generate the data used in Table 1, the Washington State Department of Health's (DOH) Environmental Epidemiology unit utilized a list of cattle feedlots with more than 1,000 cattle provided by the Department of Ecology and the Yakima Regional Clean Air Agency to create a map of the potentially impacted feedlots in the state. The addresses of the 12 cattle feedlots were geocoded in Google Earth Pro and then exported to ESRI's ArcGIS program. Satellite imagery and tax parcel data were used to identify any adjacent parcels used for feedlot operations. A 300 meter buffer was drawn around the selected parcels to account for particulate matter (PM) drift based on PM dispersion modeling used for roadways. Census blocks were then selected if they were covered by the parcel and/or buffer. Selected census blocks were matched to 2010 census data and selected demographic measures from the census were summarized using StataIC 13 and presented in Table 1.