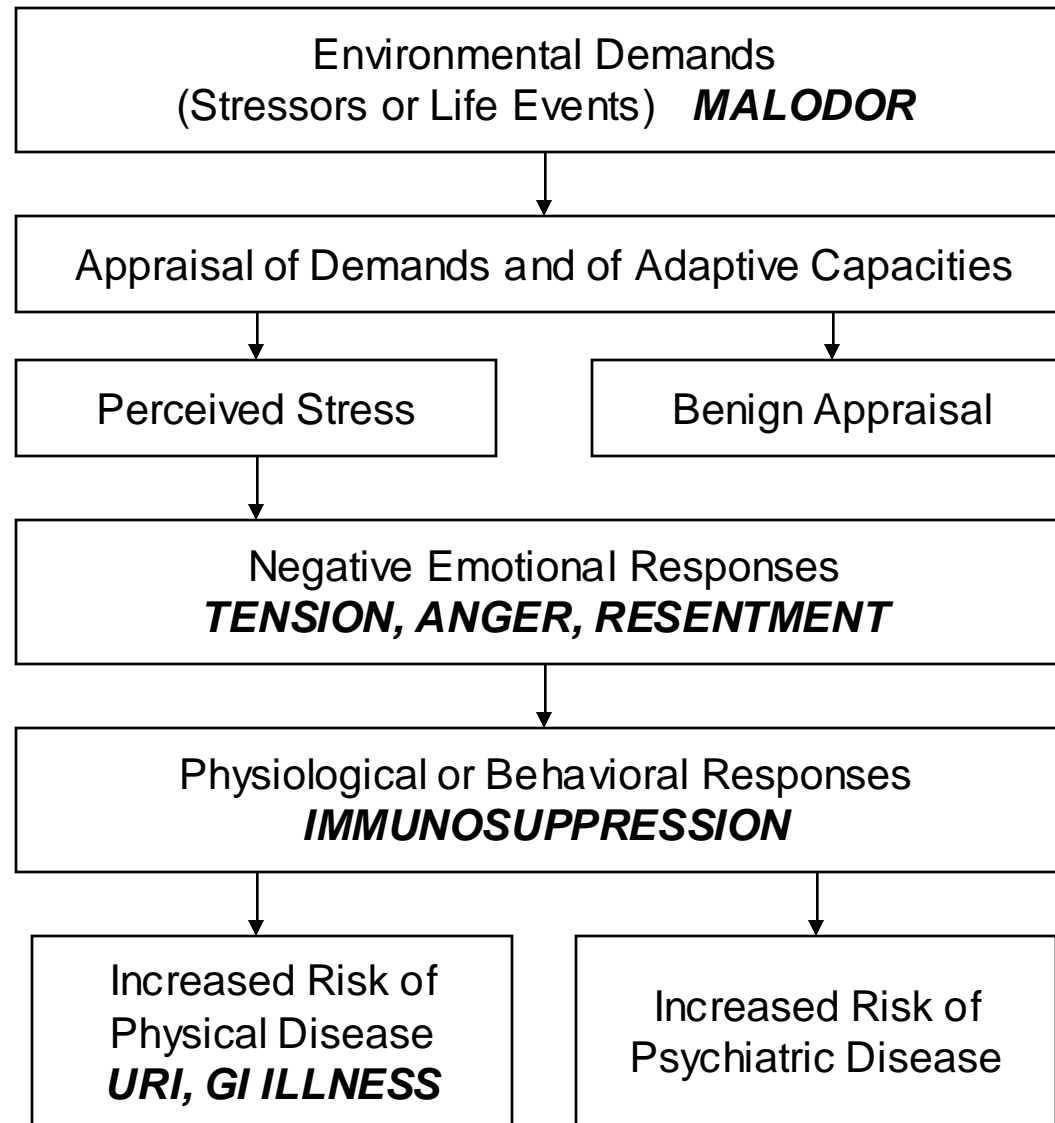# Malodor from Industrial Hog Operations, Stress, Negative Mood, and Secretory Immune Function in Nearby Residents

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Conceptual Framework and Specific Aims

Conceptual Framework for Dissertation

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┌─────────────────────────────────────────────────────┐
│              Environmental Demands                    │
│     (Stressors or Life Events)  *MALODOR*             │
└─────────────────────────────────────────────────────┘
                          │
                          ▼
┌─────────────────────────────────────────────────────┐
│     Appraisal of Demands and of Adaptive Capacities   │
└─────────────────────────────────────────────────────┘
          │                              │
          ▼                              ▼
┌────────────────────┐        ┌────────────────────┐
│  Perceived Stress  │        │  Benign Appraisal  │
└────────────────────┘        └────────────────────┘
          │
          ▼
┌─────────────────────────────────────────────────────┐
│          Negative Emotional Responses                 │
│         *TENSION, ANGER, RESENTMENT*                  │
└─────────────────────────────────────────────────────┘
                          │
                          ▼
┌─────────────────────────────────────────────────────┐
│       Physiological or Behavioral Responses           │
│              *IMMUNOSUPPRESSION*                      │
└─────────────────────────────────────────────────────┘
          │                              │
          ▼                              ▼
┌────────────────────┐        ┌────────────────────┐
│  Increased Risk of │        │  Increased Risk of │
│  Physical Disease  │        │  Psychiatric Disease│
│  *URI, GI ILLNESS* │        │                    │
└────────────────────┘        └────────────────────┘
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Adapted from Cohen, S., R. Kessler, and L. Gordon, *Strategies for measuring stress in studies of psychiatric and physical disorders*, in *Measuring Stress: A Guide for Health and Social Scientists*. 1997, Oxford University Press: New York.

Study Hypothesis:

Malodor from industrial hog farms is an environmental stressor, which, when perceived as such, exerts an immunosuppressive effect on the secretory immune system of neighbors.

Methods

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Variables from CHEIHO Study

- Odor rating after 10 minutes outdoors
  - 9-point scale where 0=none & 8=very strong

- How do you feel now?
  - Stressed or annoyed?
  - Nervous or anxious?
  - Gloomy, blue, or unhappy?
  - Angry, grouchy, or bad-tempered?
  - Confused or unable to concentrate?
  - Same 9-point scale as above

- Saliva samples analyzed for sIgA content (μg/min)

Coping Style and Threshold Odor Sensitivity

- **Pearlin Mastery Scale** (Pearlin L and Schooler C, 1978)
  - "There is really no way I can solve some of the problems I have."
  - "I can do just about anything I really set my mind to."
  - 5 response categories: strongly agree, agree, neutral, disagree, strongly disagree

- **John Henryism Active Coping Scale** (James S, Hartnett S *et al*, 1983)
  - "When things don't go the way I want them to, that just makes me work even harder."
  - "Very seldom have I been disappointed by the results of my hard work."
  - 5 response categories: completely true, somewhat true, don't know, somewhat false, completely false

- **Threshold Odor Sensitivity**
  - Lowest concentration at which butanol odor correctly identified (ppm)

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Statistical Analyses

- Longitudinal Design
  - Repeated measures on individuals over time
  - Approximately 28 timepoints/person
  - Each person serves as his/her own control

- Mixed Models to account for clustering

- Time-dependent potential confounders
  - Time of day, study day, study week, and whether or not the participant reported any illness during data collection

- Time-independent potential modifiers
  - Time of day, gender, age, mastery score, John Henryism score, threshold odor sensitivity

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Results

Characteristics of Study Participants

- 101 total participants in CHEIHO study

- 71 participants in this sub-study
  - 83% black, 17% white
  - 69% female, 31% male
  - Median age = 55.5 years; Range = 19.2 – 84.6 years
  - 77% grew up around livestock

- 16 communities
  - 6 within 2 miles of 1-4 IHOs
  - 4 within 2 miles of 5-9 IHOs
  - 2 within 2 miles to 10+ IHOs
  - Range of average SSLW within 2 miles: 0.6 – 11 million pounds

Specific Aim #1: to determine whether exposure to odor from industrial hog operations is perceived as stressful by persons exposed to the odor in and around their homes and whether any such association is modified by age, gender, coping style, or threshold odor sensitivity.

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Specific Aim 1: Distribution of Odor Ratings

Table 2. Number (%) of Records, n, and Number of Participants, N, in Each Category of the Independent Variables.

Level	Odor Rating After 10 Minutes Outdoors			Hourly Odor Ratings		
	n	%	N	n	%	N
0	791	42.0	60	14194	81.9	71
1	351	18.6	59	902	5.2	62
2	220	11.7	56	666	3.8	58
3	179	9.5	57	456	2.6	53
4	120	6.4	45	363	2.1	53
5	70	3.7	39	218	1.3	48
6	106	5.6	39	269	1.6	44
7	22	1.2	11	122	0.7	30
8	240	1.3	12	136	0.8	29
Total	*1883*	*100.0*	*71*	*17326*	*100.0*	*71*

Specific Aim 1: Distribution of Stress and Mood Ratings

Level	Stressed or Annoyed?			Nervous or Anxious?			Gloomy, Blue, or Unhappy?			Angry, Grouchy or Bad-tempered?			Confused or Unable to Concentrate?		
	n	%	N	n	%	N	n	%	N	n	%	N	n	%	N
0	1416	75.2	68	1551	82.4	70	1597	84.8	69	1720	91.3	70	1752	93.0	70
1	263	14.0	51	203	10.8	34	168	8.9	36	95	5.1	33	93	4.9	22
2	89	4.7	37	77	4.1	22	35	1.9	14	19	1.0	9	18	1.0	7
3	50	2.7	22	34	1.8	12	43	2.3	14	9	0.5	7	10	0.5	5
4	14	0.7	10	10	0.5	2	12	0.6	6	5	0.3	4	7	0.4	3
5	18	1.0	12	5	0.3	5	9	0.5	5	13	0.7	8	2	0.1	2
6	19	1.0	10	1	0.1	1	8	0.4	5	10	0.5	4	1	0.1	1
7	6	0.3	4	1	0.1	1	6	0.3	3	4	0.2	2	0	0.0	0
8	8	0.4	5	1	0.1	1	5	0.3	3	8	0.4	3	0	0.0	0
Total	1883	100.0	71	1883	100.0	71	1883	100.0	71	1883	100.0	71	1883	100.0	71

Specific Aim 1: Results from Nonlinear Mixed Models

Table 3.4. Ratios of the Odds of Reporting Stress/Mood for a Single Unit Increase in Reported Odor, from Nonlinear Mixed Models with Stress/Mood as Binary Variables[a]

	Odds Ratio	95% CI
Stressed or annoyed?	1.72	1.42 – 2.08
Nervous or anxious?	1.67	1.25 – 2.22
Gloomy, blue, or unhappy?	1.58	1.06 – 2.36
Angry, grouchy, or bad-tempered?	1.38	1.10 – 1.73
Confused or unable to concentrate?	1.50	1.03 – 2.18

[a] With the intercept and odor rating (0-8) included as random effects

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Specific Aim 1: Results
from Linear Mixed Models

Table 3.5. Associations Between Reported Odor and Stress from Linear Mixed Models, Stratified by Modifiers[a]

	β	SE	95% CI
Odor rating			
All records	0.16	0.03	0.10 – 0.22
Morning	0.19	0.03	0.12 – 0.25
Evening	0.14	0.03	0.07 – 0.20
Age ≤ 55.5 years	0.11	0.05	0.02 – 0.20
Age > 55.5 years	0.21	0.04	0.12 – 0.29
Low John Henryism	0.08	0.05	-0.01 – 0.18
High John Henryism	0.22	0.04	0.14 – 0.30

[a] With the intercept and odor rating (0-8) included as random effects

Specific Aim #2: to determine whether stress reported after exposure to hog odor is associated with decreased secretion of salivary secretory IgA and whether any such association is modified by age, gender, or coping style

Specific Aim #3: to determine whether exposure to moderate to high reported levels of odor is associated with decreased secretion of salivary secretory IgA and whether any such association is modified by age, gender, coping style, or threshold odor sensitivity.

Specific Aim 2: Results of Mixed Models

Table 4.5. Associations Between sIgA Secretion Rate and Reported Stress/Mood, with Reported Stress Stratified by Modifiers[a]

	β	SE	95% CI
(a) Stressed or annoyed? (0-4, 5-8)	-0.12	0.10	(-0.31 – 0.07)
Morning	0.06	0.14	(-0.21 – 0.33)
Evening	-0.29	0.13	(-0.55 – -0.032)
≤ 55.5 years	0.08	0.15	(-0.22 – 0.38)
> 55.5 years	-0.25	0.12	(-0.49 – -0.01)
Low mastery	-0.17	0.13	(-0.43 – 0.10)
High mastery	-0.07	0.14	(-0.34 – 0.19)
Low John Henryism	-0.23	0.17	(-0.56 – 0.11)
High John Henryism	-0.07	0.12	(-0.30 – 0.16)
(b) Nervous or anxious? (0-4, 5-8)	-0.23	0.21	(-0.65 – 0.18)
(c) Gloomy, blue, or unhappy? (0-4, 5-8)	-0.13	0.13	(-0.37 – 0.12)
(d) Angry, grouchy, or bad-tempered? (0-4, 5-8)	-0.25	0.12	(-0.49 – -0.003)
(e) Confused or unable to concentrate? (0-4, 5-8)	-0.13	0.34	(-0.80 – 0.54)

[a] With the intercept and time of day (0=morning, 1=evening) included as random effects

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Specific Aim 3: Results of Mixed Models

Table 4.4. Associations Between sIgA Secretion Rate and Odor Reported After Prescribed 10-Minute Outdoor Exposure, Stratified by Modifiers[a]

	β	SE	95% CI
Odor rating (0-5, 6,7,8)			
All records	-0.03	0.03	(-0.09 – 0.04)
Morning	0.04	0.06	(-0.07 – 0.15)
Evening	-0.06	0.04	(-0.14 – 0.02)
Male	0.08	0.06	(-0.04 – 0.21)
Female	-0.07	0.04	(-0.15 – 0.01)
Low mastery	-0.06	0.04	(-0.15 – 0.03)
High mastery	0.03	0.05	(-0.07 – 0.13)
Low John Henryism	0.07	0.05	(-0.02 – 0.17)
High John Henryism	-0.12	0.05	(-0.21 – -0.02)
Low butanol score	-0.10	0.04	(-0.18 – -0.02)
High butanol score	0.12	0.06	(0.01 – 0.24)
No irritation reported	-0.06	0.06	(-0.18 – 0.07)
Any irritation reported	-0.01	0.04	(-0.09 – 0.07)

[a] With the intercept and time of day (0=morning, 1=evening) included as random effects

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Conclusions

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Specific Aim 1: Summary

- Ratings of all of the below increased with increasing odor:
  - Stressed or annoyed?
  - Nervous or anxious?
  - Gloomy, blue, or unhappy?
  - Angry, grouchy, or bad-tempered?
  - Confused or unable to concentrate?

- Strongest association between odor and stress/annoyance

- Modification of odor-stress association:
  - Stronger association in older people
  - Stronger association in people with high John Henryism scores
  - Suggestion of stronger association in morning

Specific Aim 2: Summary

- Any potential association between stress and sIgA secretion confined to particular subgroups
  - Negative association among older people
  - Negative association among those with low John Henryism scores
- Of mood variables, only anger associated with sIgA secretion
- If exclude influential participant,
  - Anger association decreases
  - Nervous association increases

Specific Aim 3: Summary

- Little evidence of association between malodor and sIgA secretion rate
- Strongest evidence of association in subgroups defined by John Henryism score and butanol score
- Potential modification by John Henryism score and butanol score?
  - Modest positive association for low John Henryism and high butanol scores
  - Stronger negative association for high John Henryism and low butanol scores

Conclusions

- Effect of odor on stress or annoyance consistent with large literature of laboratory and field studies

- Little evidence of effect of odor, stress, or adverse mood on sIgA secretion
  - Potential association in particular subgroups (age, John Henryism score, butanol score)?
  - Is the subgroup variation real?

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Public Health Significance

- Malodor from industrial facilities is a widespread environmental stressor.

- If malodor affects immune function via a stress-mediated mechanism, even in a subset of the exposed population, might it have other physiologic effects?

- An issue of environmental justice

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Questions?