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Unanticipated Prevalence of Symptoms Among Dairy Farmers in Michigan and Wisconsin

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Adverse human health effects resulting from exposure to polychlorinated biphenyls (PBBs) were unknown until the accidental contamination of Michigan dairy farm animal feed in 1973–1974. Human exposure resulted from the consumption of contaminated meat, milk, dairy products, and eggs. In November 1976, the Environmental Sciences Laboratory conducted comprehensive examinations of 933 farmers and residents in Michigan who were likely to have consumed farm products contaminated with PBB. A comparison group of 229 Wisconsin dairy farmers were examined in March 1977 and the same scientific and medical staffs that conducted the Michigan survey were responsible and the same procedures used.

A complete history of symptomatology by organ system, including year of first onset, duration, frequency, and severity of each symptom was obtained by a physician on all adults examined. Statistical analysis of the prevalence of symptoms at the time of examination or during the preceding year in the Michigan and Wisconsin populations studied found the Michigan group to have a significantly higher prevalence of skin, neurological, and musculoskeletal symptoms. The increase was seen among the younger age groups 16–35 and 36–55. Michigan females had a higher prevalence of neurological symptoms than the Michigan males.

The existing differences could not be explained without considering an etiologic role for exposure to PBB.

The accidental contamination of Michigan dairy farm animal feed by the polybrominated biphenyl (PBB) compound FireMaster in 1973-1974 was followed by illness and death of many of the cattle which had consumed the PBB-containing feed (*1*). Under rapidly instituted state and federal regulations, over 500 farms were quarantined and approximately 23,000 dairy cattle, 1.6 million chickens, and 5 million eggs were destroyed (*2*). Full awareness of the contamination and subsequent attempts to curtail its spread came after contaminated meat, milk, dairy products, poultry, and eggs had already been distributed commercially for over 9 months. Widespread human exposure resulted from the consumption of the contaminated products, and it is now estimated that the majority of Michigan residents have detectable quantities of PBB stored in their body fat (*3*). The potential toxicologic manifestations of human exposure to PBB had not been investigated prior to the accident. The potential public health consequences of widespread human exposure to this highly toxic chemical warranted intensive clinical investigation of exposed persons to ascertain whether the level of exposure experienced represented a serious health hazard.

In response to concerns regarding reports of the appearance of adverse health effects among some of the Michigan dairymen exposed to PBB and the possible association of such signs and symptoms to their PBB exposure, the Environmental Sciences Laboratory of the Mount Sinai School of Medicine of the City University of New York, was invited by Michigan State authorities to plan and conduct comprehensive clinical and laboratory examinations of PBB exposed Michigan farm residents to determine whether patterns of adverse health effects were present and to develop a broad base of

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clinical and laboratory information concerning such a population.

Materials and Methods

Population Studied

The principal route of exposure had been through the ingestion of contaminated produce. Farm family units were invited to participate voluntarily in the survey, as were families which had purchased farm produce directly from those farms. Estimating four individuals per farm unit, a maximum of 200 Michigan farm family units could be examined. A comparable group of Wisconsin dairy farm families (not exposed to PBB) was also studied; a maximum of 75 Wisconsin farm families could be included. Three Michigan farm subgroups, Michigan Chemical Company employees, and the Wisconsin comparison group were selected.

Group 1. Stratified Random Invitations to PBB Contaminated Farms. Only farms whose animals and produce had been tested for PBB were included. It was considered that information containing dates of sampling, measured levels, number of animals destroyed would be valuable in estimating the relative dose of PBB experienced by individual farm units. It would also be possible to estimate the period of time during which ingestion of contaminated produce continued before each farm became aware of the potential danger.

The Michigan Department of Agriculture generously provided a list of all farms tested for PBB. Included were the results of tests and other characteristics of the farms. For sampling purposes, the lists dated March 25, 1976 (quarantined premises), and April 8, 1976 (low level farms) were used. The lists contained 1049 farms.

By using a computer-generated random numbers list, 150 farms were selected for invitations. The sample was supplemented by an additional 50 invitations identified from the quarantined farms portion of the MDA list. Quarantined farms were ranked by total number of animals destroyed and date of quarantine (earliest to latest) and the first 50 farms were sent invitations. An additional supplement of 25 invitations was selected randomly from farms which had been tested and found to have trace or no detectable PBB in their herds (242 farms). A total of 225 unsolicited invitations was sent. Telephone followup was attempted to all nonrespondent farms.

Group 2. Consumers of Produce Bought Directly from Farm Families Participating in the Survey. Each farm that accepted our invitation was asked to supply the names of all families which had regularly purchased produce directly from its farm, and whose members were not themselves livestock farmers. All such consumer families were then invited and encouraged to have their entire family participate. Invitations were sent to 106 such families.

Group 3. Self-Selected Michigan Farm Families. It was of interest to also examine families with individuals who were believed to have symptoms or disease possibly related to PBB exposure, but who were not included in the randomly selected groups specifically invited. Families who sought referral to the study through physicians, attorneys, farmers' Advisory Council members, or by personally contacting our Laboratory were included in this group. Invitations were sent to 72 self-selected families.

Employees of the Michigan Chemical Corporation. In cooperation with the Oil, Chemical and Atomic Workers International Union which represented the employees of the Michigan Chemical Corporation, manufacturers of PBB, invitations were offered to all 270 current employees. This group was of special interest, because their exposure to the PBB product was by direct contact, without the possible mediation of an intermediate host animal which might have changed the original material through metabolic alteration. The workers' route of exposure was also different from the farmers, with larger inhalation and skin absorption components.

Wisconsin Dairy Farmers. A comparison group of non-PBB-exposed families which would have the same general farm environmental exposures except for the PBB was sought. There were no easily identifiable groups of Michigan dairy farmers which we could be assured had had no PBB exposure. However, a listing of all dairy farms in the greater Marshfield area of Wisconsin had previously been prepared by the Marshfield Medical Foundation for use in selecting a Farmers' Lung study group. These farms were located in western Wisconsin. Animal and feed sources were different from those in Michigan and we were reasonably confident that very little or no PBB contaminated animal feed or produce had reached the area.

A collaborative study with the Marshfield Medical Foundation to survey a randomly selected group of Wisconsin dairy farmers for Farmers' Lung Disease as well as effects of possible farm chemical exposures was conducted. Invitations were sent to 400 farm families selected in a statistically random manner from a list of approximately 4000 farms in the greater Marshfield area. Complete family units were invited to participate and the same scientific and medical staffs that conducted the Michigan sur-

vey were responsible for the Wisconsin survey as well, and the same procedures were used.

Examination Protocols

Table 1 lists the questionnaires administered and the laboratory tests performed for all groups. Questionnaires were developed by utilizing the Yusho experience with PCBs (*4-6*) and the Environmental Sciences Laboratory's experience in examination of PCB exposed workers; the Michigan Department of Health's (*7*) initial study of farm residents and suggestions from the clinical experience of Michigan physicians (*3, 8*).

Laboratory tests were chosen for their utility as rapid screening techniques, for as many organ systems as possible, to serve as indicators of areas which might need further in-depth exploration. Tests not suitable for mass administration (endocrine function studies, connective tissue disease markers, immunocompetence evaluation, porphyrin metabolism), were performed for selected individuals in pilot studies.

A comprehensive review of current and past medical history and symptoms was obtained by the examining physician. Specific symptoms of interest were grouped by organ systems. For each symptom, the individual was asked, if possible, to approximate when the symptom became apparent, its character, duration and frequency if a recurrent symptom. All were also asked whether they felt the symptom was unusual for them. Visits to a physician for treatment of the symptom was recorded as a relative measure of severity. Symptoms not requiring a physician visit were categorized as "seldom" (less than once a month) or "frequent" (more than once a month). At the time of examination, physicians were asked to record their opinion as to whether the symptom was unusual for the person, and significant. Special attention was given to evaluation of symptoms before and after 1973.

This initial report analyzes symptoms reported present at the time of examination, or which had occurred during 1976. Only adults age 16 and over who were in the random invitation or consumer groups are included; the group of self-selected individuals are omitted in this evaluation of symptoms. Complaints of degree "seldom" to "frequent physician visits" are grouped together as positive responses. No correction is made for symptoms which were present prior to 1973 or those which may have had another medical explanation. The subjective evaluation of the physician or patient as to significance is not included. Symptoms were grouped into organ system categories, as listed in Table 2.

A 2 × 2 chi-square test was used to statistically test the significance of differences in the prevalence of symptoms.

Table 1. Adult PBB survey examination.

Item	Information
Farm history questionnaire	Characterization of farm, chemicals used on farm, where and how much commercial feed purchased, etc.
Dietary habits	Detailed history of eating habits over past years, home or store origin
Lifetime occupational history	All jobs ever held (including part-time), detailed possible toxic exposures, years of farm residence
Past medical history	Past and present medical difficulties, medications, hospitalizations, alcohol use
Family history questionnaire	Complete pregnancy and outcome histories
Respiratory history	Medical Research Council questionnaire on chronic bronchitis, smoking history
Symptomatology questionnaire	Past and present symptoms grouped by organ systems
Physical examination	Complete (no pelvic or rectal examination)
Ophthalmologic examination	Symptoms and eye-related history questionnaire, acuity, color blindness, tonometry, slit lamp, fundal examination
Dermatologic examination	Total body skin examination, special questionnaire
Laboratory tests	Routine urinalysis, urine for porphyrins, complete blood count, blood chemistries, zinc protoporphyrin (ZPP), carcinoembryonic antigen, serum PBB, DDT, serum for special tests (farmers' lung precipitins, endocrine function, rheumatoid factor, ANA, immunocompetence testing, serum for storage, serum PBB (drawn for those volunteering to be part of MDH long-term study)
Lung function testing	Spirometry, flow-volume curves
Chest x-ray	All those over age 40, or by examining physician's request.
Percutaneous needle fat biopsy	Volunteers (300 done)
Neurologic examination	Examinees with unexplained neurologic symptoms were referred to our neurologist for additional evaluation
Behavioral evaluation	Random and by physician referral

Table 2. Grouping of symptoms by organ system.

Organ system	Symptoms
Chest	Persistent cough
	Wheezing
	Episodes of tightness in chest
Skin	Appearance of an unexplained rash
	Occurrence of acne
	Increased sensitivity to the sun
	Burning sensation on the skin
	Darkening or thickening of the skin
	Discoloration or deformity of finger or toenails
	Slower or poorer healing of cuts
Neurological	Headaches
	Blurred vision
	Dizziness
	Depression
	Continual fatigue
	Perception changes
	Nervousness
	Sleeplessness
	Sleepiness
	Muscle weakness
	Difficulty walking
	Parasthesias
	Loss of balance, clumsiness
Musculoskeletal	Joint pain
	Swelling in joints
	Pain in lower back and legs
Gastrointestinal	Unexplained loss of 10 lb or more
	Loss of appetite
	Nausea (unassociated with acute infection)
	Vomiting (unassociated with acute infection)
	Abdominal pain
	Episodes of abdominal cramps
	Diarrhea
	Constipation

Results

Table 3 shows the acceptance rate of the various subgroups which were invited. The acceptance rate for the random invitation and consumer groups was similar. The self-selected group, as expected, had the highest rate and the Wisconsin group had the lowest. Twelve invitations from group 1 were returned because the address on the MDA list was insufficient. Telephone follow-up was attempted for all nonrespondents in the random invitation and consumer groups. Telephones were unlisted for 34 of the random invitation farms. The remaining nonrespondents were contacted and briefly questioned concerning their reasons for not participating. The most frequent excuses given were: examination site too distant; examination required too much time away from work; inconvenient examination dates; "didn't eat contaminated produce," "farm not affected," "no health problems." The telephone interviews resulted in 17 additional positive responses. Of those families scheduled for examinations conducted November 4-11, 1976 in Grand Rapids, Michigan, 3% did not appear.

Table 3. Construction of groups.

Group	Invitations sent	Invitations accepted	Response rate, %	Total participants
Michigan	403	228	56%	993
Wisconsin	400	67	17%	228
Michigan subgroups				
Random invitations	225	107	48%	399
Consumers	106	59	56%	153
Nonrandom invitations	72	62	86%	441[a]

[a] Includes 58 "walk-ins" and those given telephone invitations during or just prior to the examination.

The overall response rate was less in the Wisconsin group. This had been anticipated. In order to gather comparable information to that obtained in Michigan, the same comprehensive examination was performed. Many more Wisconsin families would have participated had the examination been less rigorous. Other factors which reportedly contributed to the lower participation rate were: a choice of only two examination days, both on a weekend; increased activity on the farms due to early preparation for Spring planting; no personal benefit to be gained from attendance, since they felt well and knew they had not purchased contaminated feed or animals.

Of those scheduled for examination March 26, 27, 1977, 18% did not attend.

General Population Characteristics

Table 4 gives the distribution of the Michigan participants by their relationship to the quarantine status of the index farm.

Figure 1 shows the age distribution of the Michigan and Wisconsin populations surveyed. The mean age for Michigan was 28.3 ± 18.6 years and that for Wisconsin was 32.8 ± 20.5 years. The Wisconsin group was slightly, but not significantly, older than the farmers in Michigan.

Figure 2 demonstrates that the sex distribution of the two groups was similar.

Table 4. Participant's relationship to quarantine status of index farm.

Subgroup	Number examined
Random invitations, quarantined farms	298
Random invitations, nonquarantined farms	101
Nonrandom invitations, quarantined farms	198
Nonrandom invitations, nonquarantined farms	243
Consumers, quarantined farms	91
Consumers, nonquarantined farms	62
Total	993

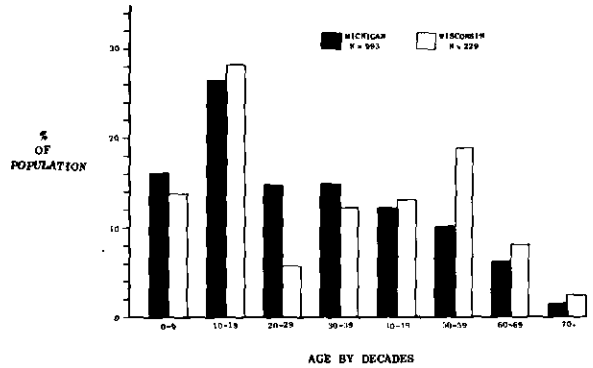

FIGURE 1. Age distribution of Michigan and Wisconsin survey participants.

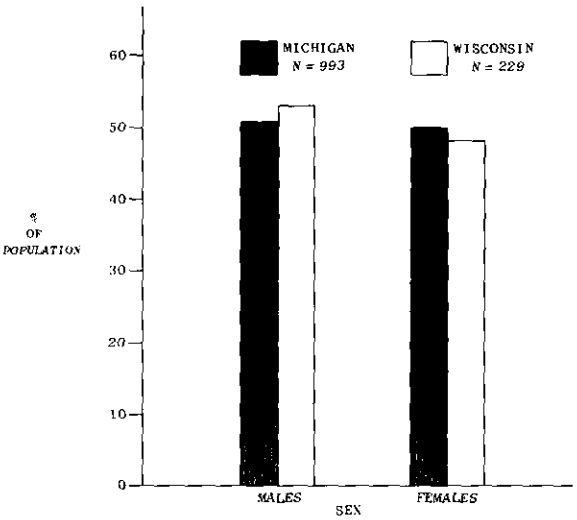

FIGURE 2. Sex distribution of Michigan and Wisconsin survey participants.

Symptoms

It was anticipated that the "nonrandom" participants would have the highest prevalence of symptoms. They were invited, for the most part, because they or their physician felt they may have experienced PBB related health problems. Table 5 shows the prevalence of symptoms by study population subgroups. The nonrandom invitation quarantine farms participants differed significantly from the corresponding random group of quarantined farmers in all categories except "chest." The nonrandom invitation nonquarantined farms participants differed significantly from the corresponding random nonquarantined farmers only in the category "neurological." In subsequent discussion, all nonrandom invitation participants are excluded. A detailed comparison of the consumer groups with their corresponding source of produce is discussed by Lilis et al. (9).

Some complaints occurred with equal frequency in the Michigan and Wisconsin populations, and no statistically significant differences were seen for eye irritation, upper respiratory symptoms, lower respiratory symptoms ("chest"), genitourinary and gastrointestinal complaints. Figure 3 shows the prevalence of the symptom categories "skin," "neurological," and "musculoskeletal" for which statistically significant differences were found, as well as "chest" and "gastrointestinal," for comparative prevalences. The categories of "skin," "neurological," and "musculoskeletal" were significantly more prevalent among all "'random" Michigan participants than among the Wisconsin participants (respectively: $\chi^2 = 5.4$, $p < 0.02$; $\chi^2 = 15.8$, $p < 0.001$, $\chi^2 = 3.8$, $p = 0.05$).

The symptoms of special interest grouped under the heading "neurological" were marked tiredness and fatigue, a striking decrement in an individual's capacity for physical and intellectual work, and concomitantly, an outstanding increase in the number of hours of sleep per day—many persons reported sleeping 14, 16, or 18 hr. This was even more impressive when viewed against the background of the well-known life pattern of farmers, accustomed to a long, physically demanding working day, with an average of only 6 to 7 hr of sleep. Men in their 30's sometimes reported that although they had usually eaten at home, they would take their lunch into the fields so that they could "sneak" a noon nap and their wives would not know about it and become concerned. Weakness, loss of appetite, and weight loss frequently were also reported and resulted in an impressive clinical syndrome especially since, to a large extent, those affected were young adults, otherwise highly fit for their type of activity. Men reported being unable to comfortably lift 100-lb sacks and switched to 50-lb lots in order to be able to manage chores alone. Equipment that previously could be maneuvered in and out of storage by one person now required the aid of an assistant or power equipment. Unusual patterns of reactivity of many of the examined individuals, such as slowness in answering questions, reduced energy of expression and movement, and poor memory were also part of the neurologic syndrome.

The presence of arthritis-like symptoms in a significant proportion of those examined was perplexing. Joint pain, swelling of joints and deformity have been listed under the heading "musculoskeletal." Young men in their early 30's seemed to be most affected—an age and sex distribution sharply at variance with that usually found in rheumatoid or

Table 5. Prevalence of symptoms among adult Michigan and Wisconsin survey participants by subgroups.

Subgroup	Total examined	Chest		Skin		Neuro-logical		Musculo-skeletal		Gastro-intestinal	
		No.	%	No.	%	No.	%	No.	%	No.	%
Random invitation, quarantined farms	232	19	8	55	24	115	50	91	39	33	14
Random invitation, nonquarantined farms	72	9	13	20	28	29	40	34	47	14	19
Nonrandom invitation, quarantined farms	127	12	9	53	42	84	66	65	51	43	34
Nonrandom invitation, nonquarantined farms	127	21	17	46	36	86	68	63	50	41	32
Consumers of products from quarantined farms	67	8	12	23	34	37	55	22	33	17	25
Consumers of products from nonquarantined farms	35	5	14	12	34	16	46	14	40	9	26
Wisconsin farms	153	18	12	27	18	46	30	47	31	24	16

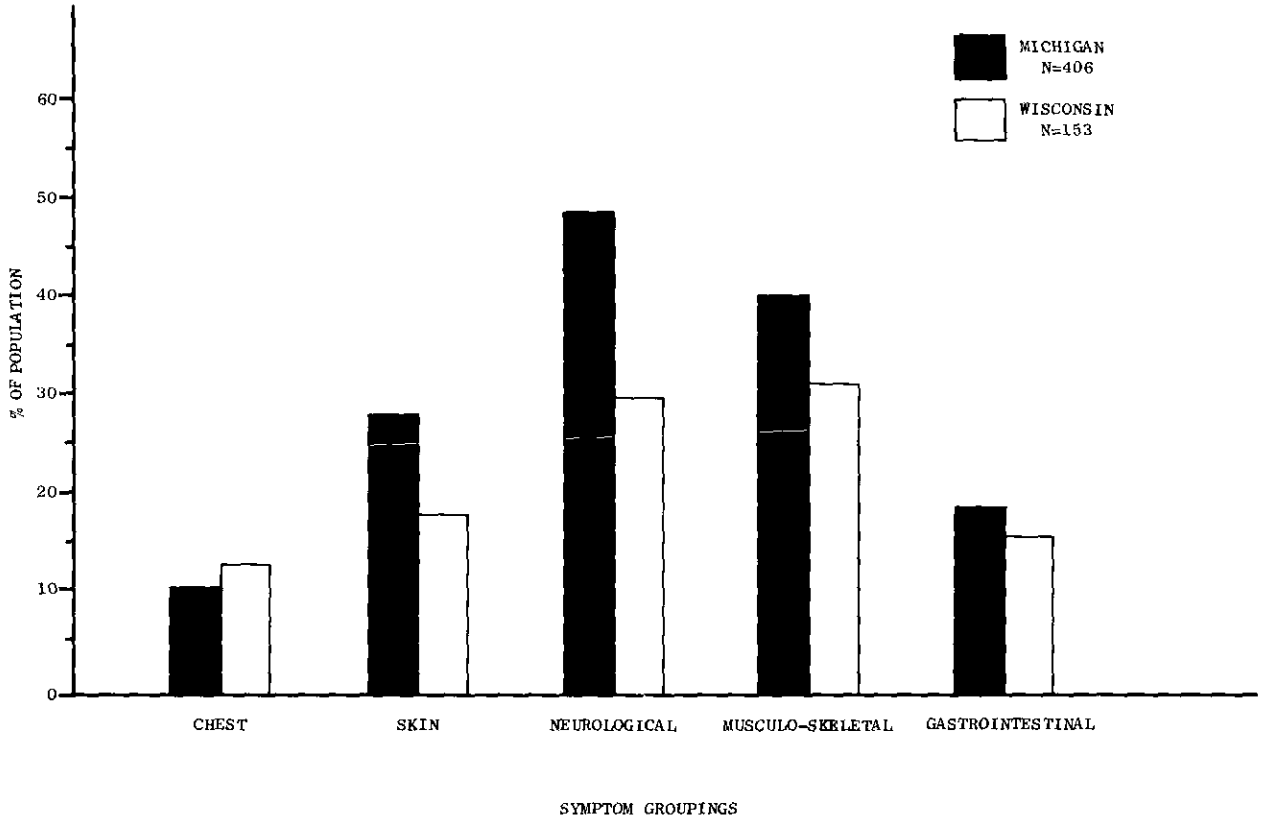

FIGURE 3. Prevalence of symptoms among Michigan and Wisconsin survey participants. Does not include 254 nonrandomly invited participants.

degenerative arthritis. The knees and ankles seemed to be most often affected, although the small joints of the fingers and hands were also reported involved. Tendonitis, with swelling, pain, and crepitations, were present in some of the individuals with joint symptoms, most often affecting the tendons of the extensor and flexor muscles of the hands. The symptoms were most often episodic and affected different joints in a migratory polyarthritis pattern.

The most prominent symptoms grouped under "gastrointestinal" were loss of appetite and weight

loss; abdominal pain without a characteristic pattern and diarrhea had occurred in repeated bouts of several weeks' duration in many individuals. The digestive symptoms were often found in conjunction with the previously mentioned symptoms, especially tiredness, fatigue and sleepiness.

For most of those surveyed who had experienced the above syndromes, the symptoms represented a distinct change from their previous health patterns. For many, these symptoms were of sufficient severity to warrant a visit to a physician.

Figure 5 shows the prevalence of symptoms by sex categories. Within the Michigan group, there were significant differences between the prevalence of "neurological" symptoms among Michigan females and Michigan males, females having a significantly greater prevalence than males ($\chi^2 = 4.0$ $p < .05$). Within the Wisconsin group there were no significant differences between males and females.

Between groups, Michigan males had a significantly higher prevalence of "neurological" symptoms ($\chi^2 = 6.7, p < 0.01$) than the Wisconsin

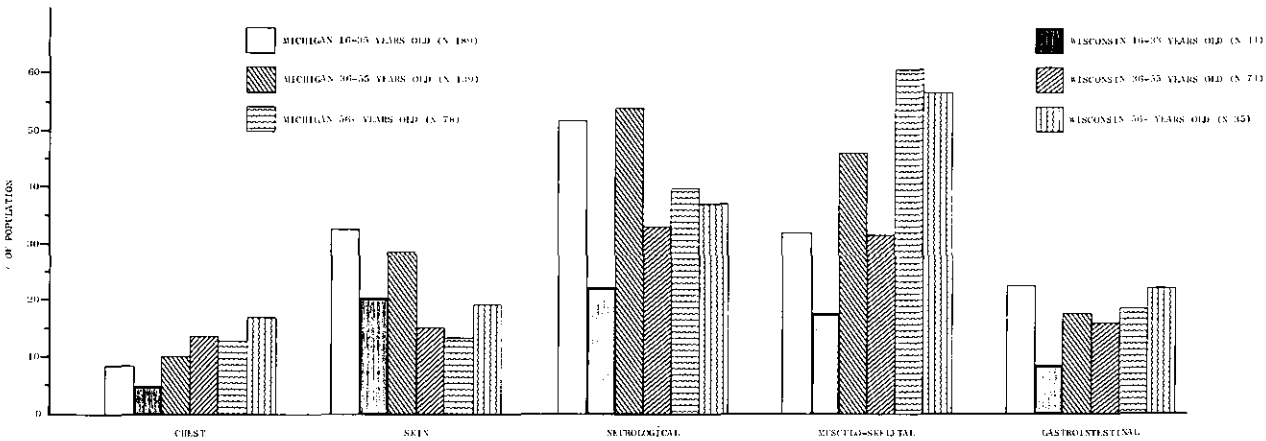

FIGURE 4. Prevalence of current symptoms among adult Michigan and Wisconsin survey participants by age category. Does not include 254 nonrandomly invited participants.

The individual symptoms are not specific for PBB toxicity. The possible association of symptoms with increasing age was investigated. In Figure 4 a trend toward a higher prevalence of symptoms in the older age groups is apparent for Wisconsin participants and to a lesser extent among the Michigan group. Among the Wisconsin group, only "musculoskeletal" reached the $p < 0.05$ level of significance. Similarly, among the Michigan participants only "musculoskeletal" symptoms were significantly were prevalent among the older age groups. "Skin" symptoms were significantly more prevalent among the younger age groups in Michigan ($\chi^2 = 9.8$, df $= 2, p < 0.01$). The differences between Michigan and Wisconsin are marked in the age ranges 16–35 and 36–55. The differences are statistically significant in the 16–35 age range for: "neurological" ($\chi^2 = 12.4, p < 0.001$), and "gastrointestinal" ($\chi^2 = 4.39, p < 0.05$). In the age range 36–55, differences were significant for "skin" ($\chi^2 = 4.0, p < 0.05$), and "neurological" ($\chi^2 = 7.3, p < 0.01$). There were no significant differences between the Michigan 56+ and Wisconsin 56+ age groups.

males. The Michigan females had a significantly higher prevalence of "neurological" ($\chi^2 = 7.2, p < 0.01$), and "musculoskeletal" ($\chi^2 = 4.1, p < 0.05$) symptoms than the Wisconsin females.

Discussion

Statistical analysis of the prevalence of symptoms at the time of examination or during the preceding year in the Michigan and Wisconsin populations studied found the Michigan group to have a significantly higher prevalence of skin, neurological, and musculoskeletal symptoms. The prevalence of neurological symptoms was markedly different. The increase seemed to be mainly among the younger age groups, 16–35 and 36–55.

Additional review of individual symptoms, changes over time and severity of symptoms may further refine these initial results. At this time, 208 of the 406 serum PBB analyses and none of the PBB fat biopsy samples have been completed. No clear relationship between serum PBB level and the presence of any group of symptoms has appeared.

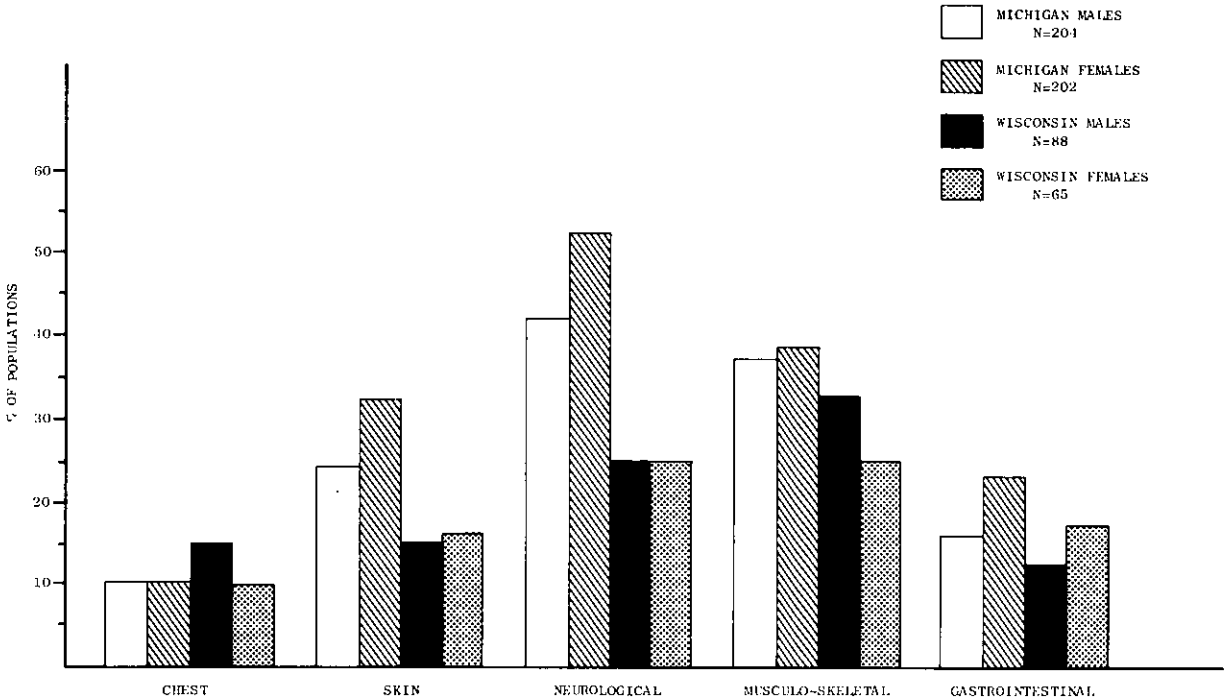

FIGURE 5. Prevalence of current symptoms among adult Michigan and Wisconsin survey participants by sex. Does not include 254 nonrandomly invited participants.

This analysis is consistent with the earlier reports of the Michigan Department of Health (*7*), and Meester and McCoy (*5*). The conclusions of the former report are at variance with ours, in large part, perhaps, because that study lacked a non-PBB-exposed comparison population. However, the prevalence of symptoms was quite similar to that found in this study. Meester and McCoy found higher prevalence than we did. However, the population studied by them was quite similar to the self-selected group only briefly discussed here, rather than randomly selected individuals analyzed in this report.

The design of this survey does not allow extrapolation of the findings to the Michigan general population, all Michigan dairy farmers, or to those farms which were known to have bought contaminated feed. Although the groups discussed here were selected for invitation in a statistically random fashion, the list from which they came was not representative of all the dairy farms in Michigan, or all the contaminated farms, and acceptance of invitations may not have been random. It cannot be assumed that the farm residents actually examined are necessarily representative of the group invited, had all invitations been accepted.

Because the acceptance rate of the random invitation group was 48%, it was considered that people with symptoms and illness could possibly have selectively participated, while those who considered themselves healthy would decide not to accept. The follow-up telephone interviews with nonparticipants did not find this to be true. Many factors entered into a decision not to participate. In only a small proportion of cases, was purported "good health" the primary reason for not participating. However, it could be expected that were sick individuals to participate in Michigan and healthy individuals stay home, the same self-selection bias might also have occurred in Wisconsin. Such selective factors could be expected to be stronger in the Wisconsin group, where individuals who were healthy had even less reason to participate than their Michigan counterparts.

To test this premise, we examined the medical histories of both groups. Table 6 summarizes the prevalences of illnesses which were reported by the examinees as currently being treated by their family physician. The table only includes illnesses which had a prevalence greater than 1% in either group. With the exception of degenerative arthritis which was significantly more prevalent among the Wisconsin group ($\chi^2 = 4.2$, $p < 0.05$), there were no statistically significant differences in the prevalence of diagnosed illnesses between the Michigan and Wisconsin populations. This observation supported

Table 6. Prevalence among Michigan and Wisconsin farmers of current illnesses under treatment by a physician.[a]

Illness	Michigan random invitation farmers, $n = 399$		Wisconsin farmers, $n = 143$		
	No.	%	No.	%	
Angina	2	0.5	2	1.4	
Heart attack	5	1.3	3	2.1	
Hypertension	31	7.8	16	11.2	
Nasal allergies	11	2.8	6	4.2	
Asthma	3	0.8	3	2.1	
Bronchitis	6	1.5	1	0.7	
Emphysema	5	1.3	1	0.7	
Duodenal ulcer	7	1.8	1	0.7	
Hiatal hernia	5	1.3	1	0.7	
Urinary tract infections	8	2.0	4	2.8	
Prostatic hypertrophy	2	0.5	2	1.4	
Chronic anemia	14	3.5	4	2.8	
Rheumatoid arthritis	8	2.0	2	1.4	
Degenerative arthritis	41	10.3	24	16.8	$\chi^2 = 4.22, p < 0.05$
Degenerative disc disease	8	2.0	2	1.4	
Thyroid disease	34	8.5	8	5.6	
Diabetes	11	2.8	4	2.8	
Skin cancer	2	0.5	2	1.4	

[a] Only adults (age 18 and over) included. List includes only illnesses which had a prevalence greater than 1% in either population.

the comparability of the two groups.

The bias of nonrandom acceptance of invitations in both populations would affect the "representativeness" of each group had extrapolation of results to their respective general populations been intended. However, such extrapolation was not part of the study design and it was concluded that any biases would be operating similarly in each group and could not explain the differences found.

Another possible explanation to consider was the possible role of psychosomatic factors. Certainly, many of the Michigan farmers examined had suffered great losses, which would affect them psychologically. Such trauma was not experienced by the Wisconsin farmers. However, the group of consumers who had not suffered these losses was found to have prevalence of symptoms paralleling those of the farm residents from whom their food products had been purchased. Such similarity was predictable, since the source of contamination was by food consumption and not by virtue of residence (9).

The evaluation of subjective symptoms expressed by patients has long been a keystone of clinical differential diagnosis. In the evaluation of each person, the physician carefully tried to differentiate between psychogenic symptoms and others. The constellation of symptoms presented did not fit well-known recognizable patterns of depression or hysteria. The distinctive hypersomnia was definitely at variance with the often encountered insomnia in persons suffering from excessive psychological stress. The examining physicians' conclusions were that the observed differences were real and while a psychological component may have been present in some cases, it could not be the sole explanation.

Significant differences exist between the prevalence of some groups of symptoms among the randomly invited Michigan farm families and a comparable group of Wisconsin farmers which cannot be explained without considering an etiologic role for PBB. The increased prevalence of symptoms in the Michigan group studied probably represents a complex summation and interaction of effects, not only of PBB, but also of other conditions, and individual susceptibilities.

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