

# Pesticide Poisoning in South Florida

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## An Analysis of Mortality and Morbidity and a Comparison of Sources of Incidence Data

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DEATH DUE to pesticide poisoning has been routinely documented each year since 1956 in south Florida. In this area, pesticides have been responsible for 9% to 10% of all deaths due to poisons by solids, liquids, gases, and vapors. Pesticides have been responsible for 49% of deaths due to poisoning among children, making these chemicals the leading cause of pediatric poison mortality.<sup>1</sup> In Puerto Rico, Kaye<sup>2</sup> has reported that pesticides are the leading cause of fatal poisoning.

The limitations of present incidence data based upon nationwide mortality reports have been described by Hayes and Pirkle.<sup>3</sup> McCarthy<sup>4</sup> has also recognized the difficulties with these data, finding it necessary to obtain death certificates in order to determine specific cause. Even if such data were readily available, it would reflect only accidental mortality due to pesticides, since suicidal and homicidal categories have not been examined.

The Community Studies Section of the Pesticides Program has been collecting available incidence data on both fatal and nonfatal pesticide poisoning whether of a suicidal, homicidal, occupational, or accidental nature. Interim reports on poisoning in south Florida were published in 1965 by Davies et al.<sup>5</sup> and again in 1966 by Davies et al.<sup>6</sup> Since 1964, the Community Studies, Dade County and the Dade County Medical Examiner, have been working together to determine the

true incidence of pesticide poisoning in the south Florida area.

The purpose of this report is to present the accumulated data from these two sources in an effort to define the epidemiologic characteristics of pesticide poisoning in this area and to compare these data with nationwide statistics. Furthermore, Poison Control Center (PCC) data from this area were analyzed to determine the relationship between the reported and the true incidence of mortality and morbidity due to pesticides. This latter comparison is important in comprehending nationwide statistics on poisoning which are derived from PCC reports.

### Materials and Methods

Mortality data for the years 1956 to 1967 were acquired from the records of the Office of the Medical Examiner, Dade County, Florida. Mortality data for the United States for the years 1956, 1959, 1961, 1962, and 1965 were acquired from the Public Health Service, Vital Statistics, Mortality Data, books A and B.

Morbidity data for the years 1964 to 1967 were acquired from the records of the Community Studies on Pesticides, Dade County, Florida. Records of the two PCCs in Dade County for the years 1964 to 1966 were obtained from Mr. H. L. Verhulst, Chief, Poison Control Branch, Public Health Service.

The population of Dade County was 498,620 in 1950; 950,394 in 1960; and 1,182,000 in 1967. The racial composition was 17% Negro in 1950, 15% Negro in 1960, and 13.7% Negro in 1967. By interpolation from a graph, the populations and racial characteristics for intervening years were obtained.

### Results

**Dade County Mortality Data.**—During the 12-year period from 1956 through 1967, there were 1,317 deaths due to poisons in Dade County. The leading agents were drugs and medicines, which accounted for more

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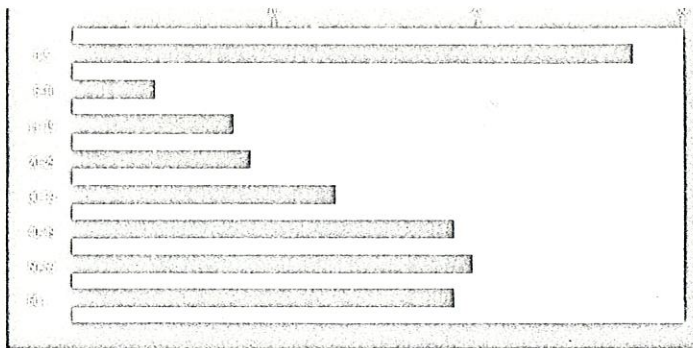


Fig 1.—Distribution of cases of pesticide mortality in south Florida by age (age unknown in one case), 1956-1967.

than half of the deaths. The next most frequent agent was carbon monoxide, followed by pesticides and alcohols. The number of deaths due to pesticides varied from year to year, and no trend was apparent. Suicides accounted for anywhere from 51% to 72% of overall poison deaths in each of the 12 years. The records of the medical examiner and community study revealed 121 deaths due to pesticides. Ten of these had occurred outside Dade County, but they had been investigated by the medical examiner or the community study.

Figure 1 represents these cases distributed by age. It was apparent that all age groups were involved, especially children 5 years old or under who comprised 27 (23%) of the cases. These were primarily accidental ingestions of pesticides by young children in and around the home. The older age groups were involved primarily through suicidal ingestion of pesticides. Adults 40 years or older comprised 48% of the cases. The route of exposure in over 90% of these cases was oral. There were three cases with dermal exposure, and five cases due to inhalation. On a race basis, 56% of cases were in whites. This, however, indicated that the prevalence of Negroes among these cases was about three times greater than one would expect from the racial characteristics of the area. Fifty-six percent of the cases occurred in males.

Figure 2 represents the agents involved in pesticide poisoning. Sixty-five (53%) of the cases involved organophosphates, with parathion involved in 53 of these 65. The heavy metal of greatest importance was arsenic.

posure to more than one pesticide. One patient drank a mixture of four pesticides plus solvent.

The seasonal distribution of these cases indicated that mortality due to pesticides was a year-round phenomenon in south Florida. No month was without pesticide-caused deaths. The month with the greatest incidence was October, followed by June, July, August, and September. The

month with the least incidence was March. Thus, pesticide-caused death was primarily a summer and early fall occurrence.

The manner of death was suicide in 57.0% of cases, accident in 29.8%, homicide in 9.9%, occupational in 2.5%, and unknown in one case. The prevalence of suicide was thus not too dissimilar from that experienced with overall poison mortality in Dade County.

*Suicides.*—There were 69 cases in the suicide category with 36 men and 33 women. There were 55 cases among whites and 14 among Negroes. The Negro prevalence was 20%, which is somewhat greater than Negro representation in the community which declined from 17% to 13.7% over this 12-year period. The mean overall age for these cases was 46.3 years with a range of 14 to 96 years. The mean age for Negroes was 35.1 and for whites was 49.1. Among men, it was 49.2 and among women, 42.3. The fact that Negroes were younger than whites became clear when the ages were distributed into specific race and sex categories. The mean age for white men was 50.0, for white women it was 47.2, for Negro men it was 47.0, but for Negro women it was 26.1. Thus, the young Negro female appeared to be a distinct group among these suicides. A further determination was made to ascertain preference for particular pesticides. Organophosphates were used in 27 cases (39%), nicotine sulfate in 12 cases, and arsenicals in 10 cases. Parathion was involved in 17 of the 27 organophosphate cases, and malathion in seven. All cases of death due to nicotine sulfate involved ingestion of nicotine sulfate

were race and sex preferences for agents. Sixty-four percent of cases among Negroes involved organophosphates, 33% of cases among whites, 39% of cases among men, and 39% of cases among women. Organophosphates were involved in 40% of cases among white men, 24% among white women, 33% among Negro men, and 88% among Negro women. Thus, the women of both races were quite divergent in their preference for agent.

An additional observation regarding suicides was the presence of measurable levels of either alcohol in blood or cerebrospinal fluid or both in 30% of these cases. Only 27 cases among the entire group of 121 fatalities had measurable levels of alcohol, and 21 of these 27 were in the suicide category.

The seasonal distribution of these suicides disclosed the peak month to be October, with June next, followed by August and September. Only ten cases occurred during the four-month tourist season of December to March.

*Accidents.*—There were 36 cases in the accidental category with ten whites and 26 Negroes, or 24 men and 12 women. This disproportion of Negroes is in sharp contrast to the racial composition of the community and in sharp contrast to the prevalence of Negroes in the suicide category. The mean overall age for this group was 14.1 years with a range of three months to 75 years. There were no particular age differences on a race or sex basis. The mean age for men was 13.1, for women it was 16.0, for Negroes 14.1, and for whites 14.0. Twenty-three (64%) of the cases involved organophos-

21 of the 23. There were race and sex differences regarding agents with 73% of the Negro cases involving organophosphates, 40% of white cases, 70% of male cases, and 50% of female cases. The race difference regarding organophosphates in this accidental category was rather similar to that among the suicide cases, but with these cases in the accidental category, the major factor was the young Negro male. The mode for accidental poisoning was the 1-year-old Negro boy.

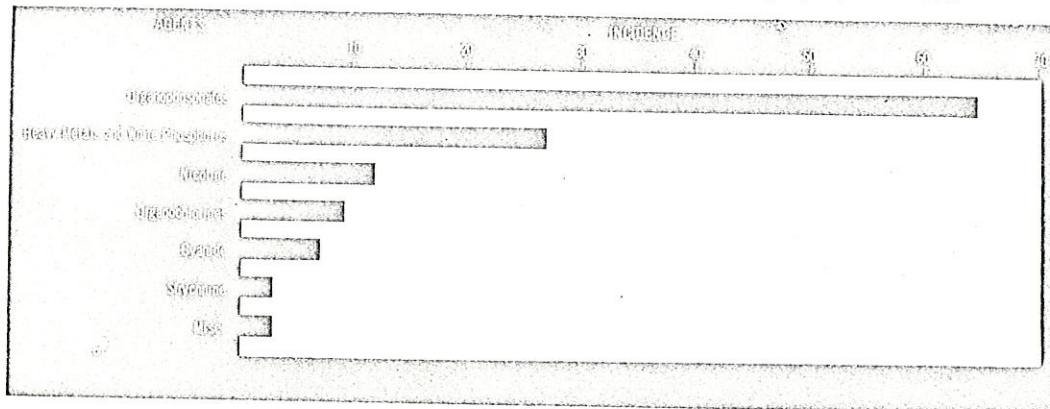
Twenty-one (58%) of the cases in this category occurred in children under 5 years of age, and 16 of the 21 occurred in Negroes. Seventeen (86%) of these 21 cases involved an organophosphate. Thus, the Negro boy and parathion was the major combination among accidental deaths due to pesticides. The seasonal distribution of these cases showed April to be the peak month with June, July, and September close behind. No accidental deaths occurred during May, but all other months were represented.

The difference between accidental and suicidal death from pesticides was primarily reflected in the parameters of age, race, sex, and agent.

*Homicides.*—There were 12 cases wherein the information indicated homicide. Seven of these occurred outside Dade County. Eleven cases involved parathion and one involved arsenic. This, however, is a very insignificant portion of the homicide picture in south Florida.

*Occupational.*—There were three cases of

Fig 2.—Distribution of cases of pesticide mortality in south Florida by agent, 1956-1967.



these occurred in Negroes and was due to parathion.

**National Mortality Data.**—Nationwide statistics from 1956 through 1965 indicated that death from poisoning by solids, liquids, gases, and vapors had risen from a rate of 3.9 per 100,000 population (1956) to 5.0 per 100,000 population (1965), a rise in rate of 28%. In Dade County, the death rate from poisons in 1956 was 8.1 per 100,000 population, and in 1965, the rate was 11.7. Thus, Dade County reflected even more strongly the nationwide increase in poison mortality, maintaining a rate more than twice that of the nation. The county rate rose even more in 1966, but it declined in 1967. Suicides have consistently represented the majority of poison deaths nationally, and the rise in overall poison mortality is due to the increase in the suicide category. Essentially the same is true for Dade County.

**Suicides.**—In comparing the national experience at suicide with that in Dade County, several observations were made. Nationwide statistics from 1956 to 1965 indicated an increasing suicide rate, especially suicide by poisons. In 1956, 23% of suicides were due to poisons; in 1965 this rate was 28%. During the same period of time the overall suicide rate progressed from 10.0 to 11.1 per 100,000 population, an 11% increase in rate. The suicide by poison rate rose from 2.3 to 3.1 per 100,000 population, a 35% increase in rate. In actual number of suicide by poison cases, there was an increase from 3,905 cases to 5,995 cases (a 53% increase) over the ten-year period 1956 to 1965. During the same period of time, the suicide rate in Dade County increased from 12.7 in 1956 to 18.5 in 1965, a 45% increase in rate. In 1956, 35% of suicides were due to poisons; in 1965 this was 46%. The suicide by poison rate rose from 4.5 in 1956 to 8.5 in 1965.

In 1965, firearms were the leading cause of suicide, with hanging second, and poisons third. Poisons represented 28% of suicides. For the same year, the national statistics indicated 202 suicides in Dade County; however, the records of the Dade County Medical Examiner disclosed 215 suicides, 213 of which had occurred in the county. The major cause of suicide in the county was poi-

sonicides. Firearms were involved in 62 cases and hanging in 27 cases. Thus, Dade County differs from the nation in poison mortality rate, suicide rate, suicide by poison rate, and frequency ranking of causes of suicide.

Comparisons between Dade County suicide data and national suicide data showed an apparent race difference restricted to the pesticide cases. Nationwide data indicate about 6% of suicides to be Negroes and 3% of suicides by poison to be Negroes, with Negroes representing 10% to 11% of the general population. In Dade County, about 5% of suicides were Negroes, and 2% of suicides by poisons were Negroes, with Negroes representing about 14% of the county population. Thus, in these two categories, Dade County had somewhat less Negro prevalence than the nation. However, among the suicides by pesticides, 20% were Negroes, which is quite in excess of expectation. There were, in addition, moderate sex differences. Nationwide, about 39% of suicides were women, and about 50% of suicides by poison were women. In Dade County, about 40% of suicides were women, and 60% of suicides by poison were women. Among the suicides by pesticides, 48% were women. Thus, Dade County had a somewhat greater representation of women among suicides in general. But among suicides with pesticides, the rate was similar to the nation.

**Accidents.**—National accidental poison mortality remained at 1.6 to 1.5 from 1956 to 1960, but since then has tended to be higher. It was 1.7 in 1961, 1.7 in 1962, 1.9 in 1963, 1.8 in 1964, and again 1.9 in 1965. In actual practice, the number of deaths due to accidental poisoning increased 38% from 1956 to 1965 (2,635 cases to 3,636 cases); most of these were due to solids and liquids. The number of cases has progressively increased since 1956, but the rate has tended to be higher only since 1960. The number of cases for each year is too small and variable from year to year in Dade County to calculate meaningful percentages. However, the race characteristics of the accidental deaths due to pesticides differed from that of the nation. Nationwide, Negroes were involved in about 18% of accidental poison deaths. Among the accidental deaths due to pesticides in Dade

men represented about 62% of the accidental poison deaths. Among the accidental pesticide cases in Dade County, 67% were men.

Thus, a comparison between Dade County and the nation indicates specific quantitative differences in several categories. Categories, such as homicide, are difficult to compare because of small number, ie, how often accurate diagnosis is reached in homicide by poisons on a national scale is unknown. Mortality data indicates about 20 to 40 homicides per year in the United States. Other categories, such as occupational, are impossible to compare, because no comparable nationwide mortality data are available. Table 1 indicates the changes in national mortality between 1956 and 1965. The endemic of the automobile is included for comparative purposes.

**Dade County Morbidity Data.**—For the years 1964 through 1967, both mortality and morbidity data were available in Dade County. These cases were found to fall in the same categories as the mortality data. During these four years there were 133 cases of documented pesticide poisoning, of which 47 (35%) were fatal. The three major categories of poisoning are presented in Table 2. This indicates, as did the mortality data, the apparent differences between manners of poisoning as to age, race, sex, and agent. In addition, case fatality rates are markedly different.

There were 37 cases of attempted suicide with pesticides which represents 28% of the cases. Sixty-one (46%) were in the accidental category, and 25 (19%) were due to occupational poisoning. There were, in addition, eight homicides, plus two unclassified cases.

**Suicides.**—Among the 37 cases of attempted suicide, there were 26 fatals representing thus a case fatality rate of 70%. The mean age for these was 39.3 years with a range of 15 to 86. There were 18 men to 19 women and 12 Negroes to 25 whites. The mean age for men was 43.1 and for women, it was 36.0; mean age for Negroes was 28.1 and for whites it was 45.0. These differences in age were due to the prevalence of young Negro women in this group. The case fatality rates for specific race and sex groups were: 58% for Negroes, 76% for whites, 78% for men,

*Table 1.—Comparison of Mortality in Selected Types of Mortality, From 1956 to 1965*

Category of Death	% Increase in Rate (Cases per 100,000 Population)	% Increase in No. of Cases
Deaths from poisons	28%	47%
Accidental	19%*	38%
Suicidal	35%	53%
Deaths from suicide	11%	29%
Auto deaths	6.8%	24%

\* Year-to-year variations in rate. Mean rate of period 1961 to 1965 is 17% greater than mean rate of 1956 to 1960.

*Table 2.—Comparison of Manners of Pesticide Poisoning in South Florida, 1964 to 1967*

Parameters	Suicidal	Accidental	Occupational
No. cases	37	61	25
Mean age	39.3	8.6	33.3
% negro	32%	61%	60%
% male	50%	69%	100%
Case fatality rate	70%	22%	4%
Percent due to organophosphates	60%	72%	96%

and 63% for women. Twenty-two of the cases (60%) involved organophosphates. Sixteen (51%) of the 26 fatal cases involved organophosphates. Race and sex preference for organophosphates were: Negroes, 83%; whites, 48%; men, 61%; and women, 58%. Race differences were thus again quite apparent. The Negroes' preference for organophosphates apparently gave rise to a lower case fatality rate than among whites.

**Accidents.**—Among the 61 cases of accidental poisoning, there were 11 deaths representing a case fatality rate of 22%. There were 37 males and 17 females, 33 Negroes, and 21 whites. Seven cases had unknown age, race, and sex. The preponderance of Negroes was again apparent. The mean age for these was 8.6 years with a range of three months to 51 years. The mean age for whites was 11.8 and for Negroes it was 7.0. The mean age for men was 9.6 and for women it was 6.9. The mode for accidental poisoning was the 1-year-old boy, especially the 1-year-old Negro boy. Organophosphates were involved in 72% of the overall accidental cases and 90% of the fatalities in this group. The case fatality rates by race and sex were 24% for Negroes, 14% for whites, 21% for men, and 18% for women.

Thirty-six (58%) occurred in children un-

Year	Total No. of Ingestions	Total No. of Pesticide Ingestions	% Involving Pesticides	Total No. <5 yrs of Age (% of cases)	Total Due to Pesticides <5 yrs of Age (%)
1964	794	56	7.1	361 (45.4)	43 (11.9)
1965	1,069	98	9.2	536 (50.1)	66 (12.3)
1966	1,206	101	8.4	681 (57.3)	80 (11.7)
Totals	3,069	255	$\bar{x}$ 8.3	1,578 ( $\bar{x}$ 51.0)	189 ( $\bar{x}$ 11.9)

der 5 years of age; of these, seven were fatal, a case fatality rate of 17%. There were 26 Negroes and ten whites, 24 men and 12 women, again indicating the susceptibility of the young Negro child, especially male children. Twenty-nine (80%) of these cases involved an organophosphate, primarily parathion.

*Occupational.*—There were 25 cases due to occupational poisoning, of which only one subject died. All cases occurred in men with ten whites and 15 Negroes. The mean age for this group was 33.3. Twenty-four of the 25 cases involved organophosphates, primarily mevinphos (Phosdrin) and parathion. The one death was due to parathion.

*Poison Control Center Data.*—The two PCCs in Dade County had records for 1964, 1965, and 1966. These records were compared with the data for the same three years from the medical examiner and community study.

Table 3 presents the PCC data. Some evident observations from these data were (1) reports of ingestions are on the increase, (2) reports of ingestion of pesticides are on the increase, but this is proportional to the overall increase, (3) around 8% of ingestions involve pesticides, (4) an increasing percentage of ingestions involve children under 5 years of age, (5) ingestion of pesticides by those under age 5 is on the increase, but this is proportional to the overall increase in those under age 5, and (6) around 12% of ingestions by those under age 5 involve pesticides. Around 75% of the reported cases of pesticide ingestion for these three years occurred in children under 5 years. These PCC data showed little seasonal variation, though there was some tendency for more cases to occur in the July-August-September period, but this was not consistent for each of the three years. The PCC reported 14 deaths from poisons over this three-year period, including three due to pesticides.

5 years of age showed 52% male children. The greatest number of cases were among those 1 year of age, with age 2 next in incidence. On a race distribution, about 60% of cases were whites under 5 years of age.

Comparisons for the three-year period disclosed the following: The PCCs reported 14 deaths due to poisons; the Office of the Medical Examiner for the same three-year period had 406 deaths due to poisons. Thus, the reported incidence of poison mortality was 3.4% of the true incidence. The PCC reported three deaths due to pesticides; records of the medical examiner disclosed 29 deaths due to pesticides. Thus, the reported incidence of pesticide mortality was about 10% of the true incidence. However, PCCs are really pediatric centers, and thus a comparison of pediatric pesticide mortality was made. The PCCs reported one pediatric death due to parathion. The records of the medical examiner included eight cases of pediatric deaths plus three in teenagers. These teenage cases might or might not be expected to come to the attention of a PCC. This does not indicate by any means that the PCCs are at fault; it merely indicates that mortality is simply not reported to the PCCs. One may suggest from this that statistics of poison mortality based on PCC reports are probably quite inadequate.

In reviewing the PCC data, it was evident that much ingestion by children was reported but little in adults. This probably indicates that the PCC is called for advice in pediatric accidents but not with intentional ingestion by adults.

During the three years, the PCC had 255 cases of pesticide poisoning, whereas 106 were present in medical examiner and community study records. So, the PCC data was a better indication of morbidity incidence, since only 41% as many cases were reported to the community study.

Considering the cases in the under-5 age group, it was apparent that only 15% as many cases had been reported to the study, and further that the race and sex characteristics of this group in the community study

... 102 cases in the under-5 age group of which 40% were Negro and 52% were boys. The records of the study for this three-year period had 27 cases in the under-5 age group of which 70% were Negro and 70% were boys. Thus, one may conclude that Negroes are indeed disproportionately involved in accidental poisoning, but not quite to the extent implied by the records of the community study. However, the disproportion among the fatal cases is unimpeachable.

Another difference was that 74% of the PCC pesticide cases occurred in those under age 5, while the figure was about 25% among the medical examiner and community study records. How many of these cases overlapped could not be determined, but apparently there were very few.

The following conclusions were made on the basis of the comparison between these three sources of data: (1) the best available mortality data were the records of the medical examiner, (2) the best index to incidence of accidental ingestion by children under 5 years of age were the records of the PCCs, (3) the best index to adult morbidity were the records of the community study, and (4) accurate data requires the use of all three. From this, one may recommend that PCC reporting needs strengthening, all cases of poisoning should have epidemiologic investigation, and these functions should be coordinated with the medical examiner because they greatly complement each other. To actually bring this about would require that physicians make it a practice to report *all* cases of exposure to poisons, and that adequate time and personnel be available to carry out epidemiologic investigations. A community study or a similar type in-depth study aimed at poisons is also helpful for diagnostic and therapeutic assistance as well as providing adequate laboratory support.

**Observations in Cases Due to Organophosphates.**—There were 114 cases of organophosphate poisoning which had some notation about signs and symptoms. There were 33 different signs and symptoms mentioned which were, for the most part, compatible with a cholinergic crisis. Of these 114 cases, 50% were fatal which includes 21 dead individuals on arrival at the hospital. There were also 13 individuals with cardiac arrest

requent finding was miosis.

In 44 of the organophosphates cases, cholinesterase activity was determined by the Fleisher-Pope Method. The mean activity in the 38 fatal cases was 0.30 units which is about 16% of the lower limit of normal. On the six nonfatal cases, the mean activity was 0.70, so there was an apparent difference by Fleisher-Pope between fatal and nonfatal cases.

Cholinesterase activity was measured by the Michel method on red blood cells (RBC) in 55 cases. The mean RBC activity in the fatal cases (20) was 0.128 units which is about 18% of the lower limit of normal. The mean RBC activity in the nonfatal cases (35) was 0.27 which is about 39% of the lower limit of normal. Plasma cholinesterase activity was determined in 47 cases. The mean plasma activity in the fatal cases (18) was 0.255, and in the nonfatal cases (29), it was 0.257. Thus, the RBC activity appeared to differ between fatals and nonfatals but not so with plasma activity. Only results of studies on blood drawn from the patients prior to administration of N-methylpyridinium-2-aldoxime chloride (2-PAM chloride) were included in this analysis, because of the rapid rise in cholinesterase activity following the use of 2-PAM chloride.

There were 11 cases (all fatal) on which both Fleisher-Pope and Michel methods were used. The mean activity by Fleisher-Pope was 0.252 units which is 13% of the lower limit of normal. The mean RBC activity by Michel was 0.13 which is 19% of the lower limit of normal. The mean plasma level was 0.146. Thus, the two methods appear to be quite comparable.

#### Comment

The basic differences between Dade County and the nation are quantitative. The poisons involved are not unique to the south Florida area. Certainly, a substantial amount of some of these differences are due to the presence of a system of medicolegal investigation with toxicological competence giving rise to an increased detection of poison deaths and to increased accuracy in determining the specific agents involved. This is probably responsible for a great deal of

there are only a few such systems of investigation in the United States. Accurate nationwide data will not be available on poison mortality until such systems are present in every state and service every county. Such systems in and of themselves are no paragon; they are wholly dependent upon the attitude and capability of the man in charge.

The actual number of pesticide deaths per year for the nation is difficult to arrive at as indicated by Hayes and Pirkle<sup>3</sup> even when dealing only with accidental poisoning. There is simply no single category under suicidal, accidental, or homicidal deaths which represents pesticides. There is no occupational category at all, these being included with accidental deaths. With the increasing amount of mortality due to poisons, there will have to be some improvements in the poison category. This would appear to be most necessary among the suicides.

Other significant observations include (1) the first documented death due to an organophosphate (in this case malathion) in Dade County occurred in January 1959, secondary to suicidal ingestion, (2) the first documented death due to occupational exposure to an organophosphate (parathion) in Dade County occurred in January 1959, (3) the first documented death due to accidental ingestion of an organophosphate (parathion) by a child in Dade County occurred in April 1959, and (4) the first documented homicide with an organophosphate (parathion) in Dade County occurred in July 1961.

### Summary

Pesticides are responsible for about 9% to 10% of deaths due to poisons in south Florida. There are three distinct groups which

usually ingest pesticides, (2) young to middle age adult males who are occupationally poisoned, and (3) middle age to older adults who suicidally ingest pesticides. The majority of pesticide deaths are in the last category. Suicidal and accidental cases of pesticide poisoning occurring in Dade County have certain race and sex characteristics which differ from other types of poisoning beyond those characteristics which cause Dade County to differ quantitatively from the rest of the nation. Mortality data from a medical examiner system are very reliable. Currently, morbidity data require the use of several sources in order to get accurate results.

There is a nationwide need for more reliable data on poison mortality and morbidity. This need can only grow more acute with the passage of time because of the increasing importance of chemicals as a cause of mortality and morbidity. If the progressive changes from 1956 to 1965 in poison mortality are a true indication of things to come, then the number of poison deaths which occurred in 1956 will approximately double by 1977.

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