MEDICAL **W**ASTE **S**MALL QUANTITY GENERATOR MODEL:

A model for estimating medical waste produced by private practitioners at the state level.

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EXECUTIVE SUMMARY.

This model is based primarily on total county population- rather than an actual number of practitioners- that allows the amounts of medical waste produced by physicians, dentists, and veterinarians to be projected for any state. For physicians and dentists, the calculations are done on the county level and all counties are then summed up to obtain a total figure for the state. A different methodology is used to calculate the amount produced by veterinarians, with that figure being added to the first to obtain a projection for the total amount of medical waste produced yearly by all three types of practitioners.

Table A. ***Summary of all projected annual amounts of medical waste for two states, New York and New Jersey.***

	N E W Y O R K			N E W J E R S E Y		
Units	physician	dentist	vet.**	physician	dentist	vet.**
lbs./year*	1,846	1,928	538	7,512	7,776	242
tons/year	923	964	269	376	389	121
tons/month	76.9	80.3	22.4	31.3	32.4	10.1
% of total	43	45	12	42	44	14
TOTALS-->	**N.Y: 4,342,000 lbs./year 2,156 tons/year 179.6 tons/month**			**N.J: 1,772,000 lbs./year 886 tons/year 73.8 tons/month**		

(* = figure x 1000) (** = veterinarian)

In creating the model, it was first necessary to show that using various population parameters (sex, race, age, ethnicity) to calculate the number of visits yearly for any county, yields figures that closely approximate those obtained by merely using total population alone. This was done by applying available national visit rates for all physicians and dentists (15-19, 33) to all of the four parameters mentioned above, for five test counties. Since rates were available for a number of physician specialties- *general & family practitioners, internists, obstetrician/gynecologists* and *pediatricians*- these were applied to the aforementioned parameters at the county level to obtain a projected number of annual visits to those particular specialties.

Age was the only parameter that was found to give a significant difference (see table 8, page 15)- defined as a > 10%

change from the original number of visits based on total population alone- but only for pediatricians, not for other physician specialties or dentists. Age was therefore used as a population parameter for calculating the annual number of visits to this specialty, but should only be used in cases where the segment of the population > 14 years old makes up 80% or more of the total county population. Race and sex should also be used as parameters in some situations.

Race should only be used as a parameter if the black population is known to constitute 30% or more of the total population in any county. Sex was found to generally have no effect, this probably being due to the fact that all counties tested have a proportion of males to females being an almost exact 49:51 ratio. If the proportion of females begins to exceed 49% in any county, the difference obtained (in projected visits) may then become significant since the female visit rate is slightly higher than that for males. For all parameters, when borderline cases (eg, with respect to the conditions above) occur, the parameter in question should be applied to a number of test counties (no more than 5) to test for any significance.

After the number of visits is obtained, the next step is to multiply it by the amount of medical waste (in pounds)/patient visit (representing the average amount of medical waste that each patient brings with them) to obtain a figure for the amount of medical waste generated annually. This is done for all physician specialties (those listed above & a category including all the rest), for dentists, and both are added to obtain the physician and dentist total. It was shown that detailed calculations for the largest (most populous) county can be "scaled down" to obtain to obtain the total average amount for all other counties, thus only one rigorous set of calculations is all that is required (assuming all conditions concerning the population parameters discussed above are met). The amounts of medical waste generated from physician and dental visits, is projected by taking 49% and 51% out of the total figure for average waste respectively. The amount of (average) waste generated by veterinarians was calculated by multiplying the average medical waste/calendar month (pounds monthly per vet.) by the number of practicing veterinarians, since projecting patient visits in this case is not possible.

Since the model calculated the amount of medical waste independent of the actual numbers of office based physicians and dentists in any given county, when comparing calculated amounts between two counties (using this model) one must first make sure that the counties being compared have similar numbers of both types of practitioners. If this turns out not to be the case, individuals in the underserved county may utilize private (physician or dentist) health care in a neighboring county. With the help of computer modeling- when used in conjunction with this model- it may become possible to compare any two counties. Such "migration" of medical waste across county lines may also come about as a result of a number of factors that have little or no predictive value (eg. personal preference).

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MEDICAL WASTE SMALL-QUANTITY GENERATOR MODEL:

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I INTRODUCTION:

The rash of beach closings which occurred during the past year has served to effectively focus public attention on the nations waste management problems. Along with other material- such as wood, municipal garbage and other solid wastes- various types of medical wastes were discovered washed up on beaches in and New York, New Jersey, and in several Northeast and Great Lakes states. The medical waste included various syringes, tubings, and blood encrusted vials. It was suggested at the time that some of the syringes may have been discarded by I.V. drug users, but the subsequent finding of unused syringes and marked prescription bottles, as well as blood containing vials, seemed to implicate medical facilities rather than any particular individual as the source. In addition, the present widespread fear of AIDS served only to fan rather that alleviate the fears of the beach going public (1,2,3).

The washups began in 1987, but it was only after the most recent occurrences during the 1988 beach season- one in which a vast majority of bathers avoided the beaches completely -that local legislatures and ultimately congress, took legislative action. This was culminated on November 2, when President Ronald Reagan signed the Medical Waste Tracking Act of 1988 (H.R.3515- commonly referred to as MWTA '88) into law (4). The act mandates that EPA set up a pilot program to track the disposal of medical waste in New York, New Jersey and the Great Lakes states, marking the first federal response to the much publicized beach washups (4,5,6). Part of the information needed to implement such a program is a knowledge of the amounts of medical waste that are generated from various sources. The Medical Waste Generation and Management Study was conducted by EPA in late 1988 to provide an initial estimate of the medical waste problem in New York and New Jersey (7).

1. Medical waste defined.

The survey enabled preliminary estimates to be made on the amounts of medical waste produced in New York and New Jersey by small quantity generators as defined in MWTA'88 as those producing 50 lbs. per calendar month or less of medical waste. For the purpose of the survey, medical wastes were defined as those which fall into the following listed categories:

A. Cultures and stocks of infectious agents and associated biological.

B. Blood, blood products and body fluids (other than urine) at least 20cc. of liquid volume per vessel.

C. Pathological wastes consisting of tissues, organs, body parts (including products of conception) and wastes discarded after surgery, obstetrical procedures, autopsy, and laboratory procedures.

D. Needles and syringes or any other laboratory articles (ie. sharps) that might cause punctures or cuts including intravenous tubing with needles attached, vacuum collection containers/tubes containing blood, slides, etc..

E. Carcasses, body parts, and bedding of all research animals that were intentionally exposed to pathogens.

F. Solid wastes generated from rare, unusual or special cases involving highly communicable diseases.

G. Wastes generated as a result of renal dialysis, including tubing and needles.

H. Other discarded materials associated with patient care, ie. disposable diagnostic supplies, cotton balls, laboratory aids.

2. Need for a model.

Although the aforementioned survey did provide preliminary estimates on medical waste production for Region II, the results were based on a lengthy survey and numerous interviews. There was still the need for a small generator model that can use available sources of information to arrive at similar estimates for the amounts of waste defined as medical generated by small quantity generators, dentists and veterinarians in particular, in New York and New Jersey. Ideally, the model should be applicable to any state and be predictive using a wide variety of conditions.

3. Need to show differences.

In order to create such a model, there is an obvious need to demonstrate that using one set of population parameters compared to another (ie. age versus sex) will indeed affect/not affect the outcome of the estimate. Unfortunately, many possible comparisons

often cannot be made due either a lack of information, or incompatibility of information from various sources. All such differences, or a lack thereof, will be illustrated as they occur.

4. Inherent problems.

There are two main problems that need to be taken into account when constructing a medical waste model for private practitioners: The mobility of the practitioners under consideration, and the variability in the amount of medical waste produced from one practitioner to another of the same type (ie. specialty).

There is no ideal way of classifying private practitioners (ie. doctors, dentists and veterinarians) according to geographic region. Unlike hospitals- which must prove to the state that they are needed in that area before opening- private practitioners can set up practice anywhere they wish (8,9). The problem of variability between the same type of practitioner, stems from the fact that the number of patients seen in any period of time- when comparing within the same specialty- may vary widely from one practitioner to another. Using the "average" number of patients as a factor in the model, may therefore not yield a realistic estimate for medical waste produced (8).

Both these problems can be overcome by looking at the average amount of medical waste each patient generates during an average visit, since this is a measure that would vary much less from one practitioner to another (within the same specialty) regardless of location (8). Of course it then becomes necessary to first estimate the number of visits, and then multiply out both to obtain an estimate for the amount of medical waste produced. By applying these parameters at the county level (within a state), a distribution within that state may then be obtained. The methodology utilized for this project will be detailed in following sections.

II <u>THE MODEL</u>:

1. Estimating the annual number of visits to office based physicians at the county level.

A. Number practicing and visits.

According to the 1985 summary of the National Ambulatory Medical Care Survey (or NAMCS) there was an estimated 636.4 million office visits made to non-federally employed office based physicians in the U.S. between March 1985 and February 1986. This represents a 60 million increase since 1980, the visit rates have however remained fairly constant since then (10,11). This includes visits to both doctors of medicine (M.D.'s) and doctors of osteopathy (D.O.'s), with almost 95% of those visits to the former (10). Physicians of osteopathic medicine are designated as physicians and surgeons- they work within the same

specialties and utilize the same treatments and techniques as doctors of medicine. The only difference is that D.O.'s recognize the importance of the musculoskeletal system in health and disease, and often use their hands to diagnose/correct structural problems relating this body system (12).
The numbers of private practicing physicians can be broken down as follows (12,13,14):

Table 1. ***The number of practicing physicians in New York and New Jersey.***

TYPE	NEW YORK	NEW JERSEY	U.S. TOTAL
M D.	29,118	10,961	552,716
D.O.	1,074	1,569	28,403
TOTAL:	30,192	12,530	581,119

B. Method.

The number of estimated yearly visits was calculated (for physicians) by using national visit rates for different groups taken from summary reports on the various medical specialties, published as part of the National Ambulatory Medical Survey (or NAMCS)(15-18). Rates were available for only five medical specialties, but according to the 1985 NAMCS summary (10) these made up almost 70% of all office visits to all physicians. The rates of patient visits to all of the specialties used differ widely when comparing among specialties (within the NAMCS), with the highest total rates being those for General and Family practitioners (85.7 visits/100 persons) and Internists (32.4 visits/100 persons)(15,16). It is obvious then that pooling much of this specialty data would yield either an over, or under inflated estimate of yearly office visits. It should also be taken into consideration that one cannot assume that physicians practicing in different specialties generate the same or similar amounts of medical waste, since services rendered (eg. procedures done) may differ greatly from one specialty to another. Indeed, a review of physician data received from the Medical Waste Management Study (7) done at EPA, seemed to support this assumption. Unfortunately, due to the lack of quantity- as well as quality- of the survey data (ie there were differences in the way physicians applied the medical waste categories to their respective practices) the amount of medical waste on a per-patient per-visit basis could not be obtained for all specialties for which information on visit rates was available.

Along with the total population visit rates- this referring to the visit rate for a specialty that is adjusted for all ages and sex- those for the parameters of various sub-populations were also available. These rates were applied to the matching sub-populations at the county level, and the resulting totals were compared for differences. Out of New York States' 62 counties,

five were selected at *random*, taking only population size into consideration (eg. a county closest to 100,000 in population was chosen on that basis alone, since a random selection might ensure unbiased results). Within these five test-counties, the rates for various medical specialties were applied to the various sub-populations (also reffered to as population parameters). Total county population, sex, race, ethnicity, and age were the sub-populations used (when the rates for each were available).

Medical specialists are physicians who concentrate on certain body systems, specific body structures and scientific techniques to diagnose and/or treat certain disorders. A physician can be certified as a specialist in a field of medicine after having completed the training required by the associated specialty board (eg. an internist would be certified to practice internal medicine by The American Board of Internal Medicine). There are 23 specialty boards which are recognized by the American Board of Medical Specialties that can grant such accreditation.

The medical specialties used in estimating patient visits to physicians include (20):

General and Family Practitioner: The medical specialty that provides health care within a family context. The only difference between General practice and Family practice is that the latter must have at least one year of residency training. General practitioners are currently being phased out.

Internist: Similar to the above, except that general internists also function as consultants to other specialists and are competent to handle critically ill patients and non-surgical disorders in an emergency room setting.

Pediatricians: Physicians trained in the care of individuals from childhood to young adulthood.

Obstetrics and Gynecology: Physicians trained in the medical and surgical care of the female reproductive system and associated disorders.

General Surgeons: Physicians trained in the medical and surgical care of the female reproductive system and associated disorders.

Applying available rates to the above five specialties will be referred to as the **RATES METHOD.** Visits to all other specialties, which comprised of about 30% of all total visits in 1985 (10), were estimated by taking a proportion out of those visits based on each counties total population. A variation of this method (the *second* method) was used to calculate a new rate, which was then compared to the one that was used to screen for large variations (the rates method). This is necessary because the assumption that the rates on both levels (county vs. national) are similar, must be tested. The number of visits calculated using

this second method was compared to that using the first method. The second method will be referred to as the **PROPORTIONING METHOD.** Both will be illustrated below for one county and specialty.

C. EXAMPLE: *Queens County.*
Specialty: *General and Family Practitioners.*

1) RATES METHOD.

This approach adjusts the 1980 county population figures for each parameter (eg. age, sex, etc...)(21,22), and multiplies the adjusted figure by the appropriate rate to obtain a number of visits based on that parameter. The 1980 population had to be used as a base for calculating 1987 estimates since all updates on this type of census data are done only on the national level and sometimes regional (but not in this case), which leaves only total population available at the county level. Therefore one must rely on the assumption that the percentages of various segments of the population used will be similar, since the amount of change for the various parameters will not be fully known until completion of forthcoming census (23).

The population parameters used were those for which rates could be obtained for the five specialties used (15-19). Those used for *General and Family Practitioners* (15) include: total population, sex, race, and age. Ethnicity was used only for the last three specialties listed (see page 5). The number of visits was calculated for each characteristic, and the total population figure was used as the base for comparison. Only if the number of visits- calculated using any of the population parameters -differed from the total population estimate by more than 10%, was it considered significant. As it turned out most variations were closer to half that cutoff percentage difference.

For estimating visits based on total population, current available total population estimates for each county were used (24).

a) ***Total population.***

-of *Queens County*: 1,920,700 persons (1987) (24).

Visit rate/100 persons(per year)= .86 (or 86%) (15).

.86 x 1,920,700 persons= **1,651,802 visits/year.**

b) ***Sex.***

Before applying the sex specific rates to the male and female populations of Queens, the populations were first adjusted to 1987 levels.

This is done by:

First dividing the population of each characteristic (21,22) by the total county population (both for 1980) to obtain the proportion (percent out of the total population) for each separate parameter (eg. the percent of the total Queens population that all males in Queens represent). Then multiplying each proportion by the total 1987 county population (21,22) to obtain the respective amounts to be added to each, to make the adjustment.

Example: Adjusting 1980 male Queens population to current levels:

1987 TOTAL Queens population= 1,920,700 persons (24).
1980 TOTAL Queens population= 1,891,325 persons (21).
1980 .....Male: 878,181 (21).
1980.....Female: 1,013,144 (21).

Adjusting males:

(878,181 /1,891,825) X 1,920,700= 891,820 Males for Queens, 1987.

Adjusting females:

(1,013,144 /1,891,325) X 1,920,700= 1,028,880 Females for Queens, 1987.

The adjusted populations for each parameter (table 2: those for sex in this case- column 4 below) are then multiplied by their respective rates (column 5) to obtain an estimated number of visits for each (column 6), which are then added to obtain a total for all visits using that parameter.

Table 2. ***Summary of calculated physician visits, calculated separately by sex, for Queens county.***

SEX	1980 POPULATION	% OF TOTAL	1987 POPULATION	RATE	VISITS
MALE	878,181	54	891,820	71	633,194
FEMALE	1,013,144	54	1,028,880	100	1,028,880
				TOTAL VISITS:	1,622,074

CHANGE FROM TOTAL POPULATION: 0.62%
RESULT: **NOT SIGNIFICANT.**

c) *Race.*

All adjustments are made the same way except that three need to be done (one each for the *white*, *black*, and *other* categories) instead of the two (for each sex) above. All rates are for visits/100 persons (15) unless otherwise stated.

Table 3: *Summary of physicians calculated using race.*

RACE	1980 POPULATION	% OF TOTAL	1987 POPULATION	RATE	VISITS
WHITE	1,335,805	71	1,356,552	88.6	1,201,905
BLACK	354,129	19	359,629	76.4	247,757
OTHER	201,391	11	204,519	30.2	61,765
				TOTAL VISITS:	1,538,427

CHANGE FROM TOTAL POPULATION: 6.8%
RESULT: **NOT SIGNIFICANT.**

d) *Age.*

All calculations were made the same way as above, except thta the rates for age were given for five age groups (15), so the rates for the first two groups (see table 4 below) were averaged to simplify calculations. Results using the five age groups are shown below, since it was first necessary to show that no significant differences arise from averaging the first three groups shown.

Table 4: *Summary of physicians calculated using five age groups.*

AGE	1980 POPULATION	% OF TOTAL	1987 POPULATION	RATE	VISITS
< 3	68,454	3.6	69,517	90.2	62,704
3-14	280,602	14.0	284,960	42.0	119,683
15-44	816,458	43.0	829,139	77.0	638,437
45-64	444,482	23.0	451,385	109.0	492,101
> 64	281,328	14.0	285,697	151.0	431,402
				TOTAL VISITS:	1,744,236

CHANGE FROM TOTAL POPULATION: 5.6%
RESULT: **NOT SIGNIFICANT.**

To combine the first three categories, the total number of visits nationally had to be divided by the total number of persons (in the U.S.) to give an averaged rate for both groups. This was done for all specialties where age groups needed to be combined.

Example: Combining the first two age groups above.

# of national visits
(for the first three age groups combined)= 97,004,500 (15)
Total number of persons in the nation = 154,201,000 (15)

97,004,500/154,201,000= .63, or 63 visits per 100 persons in this age group (all those < 45 years old).

The following is the result obtained by using three age groups:

Table 5: ***Summary of physician visits calculated using five age groups.***

AGE	1980 POPULATION	% OF TOTAL	1987 POPULATION	RATE	VISITS
< 45	912,947	63.0	1,183,616	63.0	745,678
45-64	444,482	23.0	451,385	109.0	492,010
> 64	281,328	14.0	285,697	151.0	431,402
				TOTAL VISITS:	1,669,061

CHANGE FROM TOTAL POPULATION: 1.0%
RESULT: **NOT SIGNIFICANT.**

CHANGE FROM USING FIVE AGE GROUPS: -4.3%
RESULT: **NOT SIGNIFICANT.**

It is therefore apparent that the combining the age groups had no significant effect on the outcome.

Visits to all other specialties were calculated using the same method with the rates used coming out of the same survey data (15-19). Results of these calculations are shown in tables 7 and 8 (pages 15-17). The only changes in the above calculations were minor, and involved using different age grouping rather than any changes in method (see *Top of*, page 13).

2) PROPORTIONING METHOD.

For the second method- taking an appropriate proportion out of the national number of annual visits, by specialty, based on a county population for the parameter being used- can be broken down into the following three steps (25):

Step 1: For the parameter being used, the percent of the national population that the county population represents must first be calculated (1980 population was used for both, since they were the only ones available for all the parameters used). This is accomplished by dividing the county population (21,22) by the national population for the parameter (26-30).

Step 2: The resulting proportion in then multiplied by the number of visits nationally for the specialty (15-19) to obtain the number of projected annual visits (to that specialty). The result is then compared to the number of visits for the parameter that was previously calculated using the *rates method*.

Step 3: The number of calculated visits is then divided by the population of queens (both for the parameter under consideration) to obtain a rate that can be compared to the national rate. This was done because the assumption that the rates will be similar to the national rates for parameters used had to be tested (25). Note that what is actually being compared are the 1980 visit rates for both the county and the nation (see a-d below)

a) *Total population (General practitioners)*

Step 1: Queens population (1980)= 1,891,325 persons (21).
U.S. population (1980)= 222,674,000 persons (26).

[1,891,325 / 222,674,000]= proportion out of the national population that the Queens population represents.

Step 2: Visits nationally (1980)= 190,850,000 total visits (15).

[1,891,325 /222,674,000] x 190,850,000= 1,621,022 visits for Queens(1980).

Change from original visit estimate: 3.5% **NOT SIGNIFICANT**

Step 3: number of visits*, Queens /Queens population (both for 1980).
(* calculated in step 2 above)

1,621,021 /1,891,325= .857 Change from rate used (.86)= .003 or .3%

NOT SIGNIFICANT

b) *Sex*.

Calculations are made the same way as above, except that two sets need to be made to compare the male and female rates separately.

For males: **Male** Queens population (1980)= 878,181. (21).
-Total U.S. population (1980)= 107,429,000 (26).
-Total U.S. visits.....= 76,132,500 (15).

[878,181 /107,429] x 76,132,500= 622,346 male visits (in Queens).

622,346 /878,181= .71 = Male visit rate for queens.

Change from rate used (.71)= .0% **NOT SIGNIFICANT**

For females: **Female** Queens population (1980)= 1,013,144. (21)
-Total U.S. population (1980)= 115,244,000 (26).
-Total U.S. visits.....= 76,132,500 (15).

[1,013,144 /115,244,000] x 114,720,000= 1,008,559 female visits (Queens).

1,008,559 /1,013,144= 1.00 = Female visit rate for queens.

Change from rate used (1.00)= .0% **NOT SIGNIFICANT**

Total visits (male + female)= 1,645,079 visits

Change from original visit estimate: 1.0% **NOT SIGNIFICANT**

c) *Race*.

Three sets of calculations are needed here.

White: Queens population (1980)= 1,335,805 (21).
-Total U.S. population (1980)= 191,052,000 (26).
-Total U.S. visits.....= 169,230,000 (15).

[1,335,805 /191,052,000] x 169,230,000= 1,184,677 white visits.

1,184,677 /1,133,5805= .886 = white visit rate for Queens.

Change from rate used (.886)= .0% **NOT SIGNIFICANT**

Black: Queens population (1980)= 354,129 (21)
-Total U.S. population (1980)= 26,107,000 (26).
-Total U.S. visits.....= 19,948,500 (15).

[354,129 /26,107,000] x 19,948,500= 271,300 black visits.

271,300 /354,129= .77 = black visit rate for Queens.

Change from rate used (.764)= .5% **NOT SIGNIFICANT**

Other:

Queens population (1980)=	201,391	(21).
-Total U.S. population (1980)=	5,515,000	(26).
-Total U.S. visits.....=	1,667,000	(15).

[201,391 /5,515,000] x 1,667,000= 60,845 other visits.

60,845 /201,391= .320

Change from rate used (.302)= .0% **NOT SIGNIFICANT**

Total visits (white + black + other)= 516,822

Change from original visit estimate: 6.7% **NOT SIGNIFICANT**

d) *Age.*

Three sets of calculations are done here for the thee age groupings used.

< 45 years old:

Queens population (1980)=	1,813,616	(21).
-Total U.S. population (1980)=	154,201,000	(26).
-Total U.S. visits.....=	97,004,500	(15).

[1,183,616 /154,201,000] x 97,004,500= 746,935 visits, this age group.

746,935 /1,183,616= .63 = visit rate for this age group

Change from rate used (.63)= .0% **NOT SIGNIFICANT**

45-64 years old:

Queens population (1980)=	444,482	(21).
-Total U.S. population (1980)=	43,963,000	(26).
-Total U.S. visits.....=	47,729,000	(15).

[444,482 /43,963,000] x 47,729,000= 447,290 visits, this age group.

447,290 /444,482= 1.07= visit rate for this group.

Change from rate used (.09)= -1.8% **NOT SIGNIFICANT**

> 64 years old:

Queens population (1980)=	281,328	(21).
-Total U.S. population (1980)=	24,512,000	(26).
-Total U.S. visits.....=	36,933,500	(15).

[281,328 /24,512,000] x 36,933,500= 406,267 visits for this age group.

406,267 /281,328= 1.44 = visit rate for this age group.

Change from rate used (-.07)= -4.5% **NOT SIGNIFICANT**

Change from original visit estimate: -4.1% **NOT SIGNIFICANT**
(see *total population*)

Calculations for the other specialties were performed in the same manner as for General and Family practitioners with few exceptions.

For Internists, Obstetrician/Gynecologists, and General Surgeons, the age groups were divided up as: < 15, 15-44, and > 44 years old.

For Pediatricians: < 6, 6-14, and > 14 years old.

All age groups were congregated so as to keep the highest rates intact, as was done for General and Family practitioners above (see tables 3 and 4). Information on ethnicity was only available for internists, obstetrician/gynecologists, and general surgeons only. The calculations were made by applying the available rates (as was done above) to the two categories (hispanics & non hispanics) within that parameter (16,18,19). For Obstetrician/Gynecologists only female population was used, since they account for 99% of all visits to this specialty (19).

3) Results.

For both methods used, the only significant difference (defined as a > 10 % variation from the total population estimate) was observed for pediatricians when using age. Since three out of five test counties gave this result (see table 8), age will therefore be used when calculating visits for that specialty. It is interesting to note that Kings County which has a larger population than Queens County (see table 7 page 35) had a much lower difference (8% versus 17% for Queens). This may be because the two highest rates- 210 and 57 (both visits per 100 persons in the population) for the < 6 and 6-14 age groups respectively -were applied to smaller segments of the population for Kings County.

Table 6: *Summary of rates and percentage of black population for Kings and Queens counties.*

AGE*	RATE	% of total county population	
	visits/100 persons	KINGS COUNTY	QUEENS COUNTY
< 6	210	7	9.3
6-14	57	11.1	14.0
> 14	3	81.9	77.0

(* years old)

By looking at Broome county (-10.3 % significance), it was observed that the highest age group (> 14 years which was applied to the highest rate) made up 80% of the total population, compared to 82% for Queens county (-18% significance). It would be prudent then to consider using age in calculating county visits to pediatricians when the ≥ 14 age group makes up 80% or more of the county population. It was also observed that as the black population of a county shifts from 19% of the total to 32%, the observed difference goes from 7.4% to -9.4% for Queens and Kings counties respectively. It would therefore be wise to consider race as a parameter when the percentage of the black population begins to exceed 30% in any county. Ethnicity never reached a significance level of more than 4%, which was observed for Kings County (see table 8), which also had the highest hispanic population of all the counties (18% of the total). It is obvious then that the ethnic population will have to be a considerably larger percentage to make a difference, possibly approaching as high as 40% (which is slightly more than twice that of Kings County). It was also observed that the ratio of male to female individuals from county to county varied remarkably slight, being an almost constant 49% males to 51% females. This may of course be due to the fact that only about one tenth of all counties in the state (N.Y.) were sampled. If it is known (or discovered) that a county has a ratio that differs appreciably from this- especially if the number of females (who have the larger rate) is proportionately more- sex should be used to calculate the number of visits for that county.

Table 7: *Summary of estimated physician visits based on total population, for five test counties, using both methods.*

KEY: GP/FP = general and family practitioners.
OBGYN = obstetrician/gynecologist.
GEN. SURG = general surgery.
(-) = not performed. PROPRTNING. = PROPORTIONING

m e t h o d

COUNTY	COUNTY POPULATION	**RATES** (visits)	**PROPRTNING.** (visits)	CHANGE (%)
QUEENS	1,920,700			
GP/FP -		1,662,074	1,593,639	-3.5
INTERNIST -		622,307	601,197	-3.3
PEDIATRICS-		555,082	537,581	-3.1
OBGYNN -		474,151	485,514	2.3
GEN. SURG.-		263,135	254,424	-3.3
BROOME	209,000			
GP/FP -		179,740	171,770	-0.04
INTERNIST -		67,716	64,877	-4.1
PEDIATRICS-		60,401	57,949	-1.8
OBGYNN -		50,786	50,936	0.3
GEN. SURG.-				
EERIE	958,300			
GP/FP -		824,138	-	-
INTERNIST -		310,489	-	-
PEDIATRICS-		276,948	-	-
OBGYNN -		235,062	-	-
GEN. SURG.-		131,436	-	-
ONANDAGA	460,200			
GP/FP -		360,354	-	-
INTERNIST -		149,105	-	-
PEDIATRICS-		132,998	-	-
OBGYNN -		112,340	-	-
GEN. SURG.-		64,047	-	-
KINGS	2,309,600			
GP/FP -		2,001,187	-	-
INTERNIST -		748,310	-	-
PEDIATRICS-		667,474	-	-
OBGYNN -		563,443	-	-
GEN. SURG.-		316,415	-	-

Table 8: *Summary of changes in estimated physician visits showing observed differences from total population estimate for all parameters used, differences between estimates for the same parameter, and the largest rate deviation observed for the five test counties used.*

KEY: R = % change from total population estimate using the RATES METHOD for a parameter.

P = % change (from the rate derived estimate) using the PROPORTIONING METHOD.

CH= largest observed % change between corrected and original rates.

CHART = Characteristic. (-) = not performed.

GP/FP = General and Family practice. ETHN = ethnicity

OBGYNN= Obstetrician/ Gynecologists.

GEN. SURG.= General Surgeons.

s p e c i a l t y

COUNTY & CHART	GP/FP			INTERNIST			PEDIATRICS			OBGYNN			GEN. SURG.		
	R	P	CH	R	P	CH	R	P	CH	R	P	CH	R	P	CH
Queens															
Sex ---	0.6	-3.4	1.8	0.4	-4.1	-0.3	-0.2	-2.0	-7.0				-0.3	4.4	0.7
Race --	-7.4	-1.4	0.8	-6.6	-1.4	0.0	-1.9	-1.5	0.0	-2.0	-4.2	-2.0	-6.4	1.4	0.2
Ethn.--				-5.2	-0.2	0.6				-0.6	-4.3	-2.5	2.5	0.3	0.2
Age ---	1.0	-4.1	4.5	8.1	4.9	3.0	-18.0	2.9	1.0	-4.4	-0.7	-4.3	-0.7	-4.1	-2.0
Broome															
Sex ---	0.0	1.9	0.2	6.1	2.1	5.0	0.0	6.5	4.4				0.0	2.3	0.4
Race --	1.9	3.3	1.4	3.2	3.2	1.3	0.0	3.2	0.9	1.6	2.2	7.4	2.3	3.4	1.1
Ethn.--				2.4	0.7	2.2			-	0.6	0.2	4.3	1.6	6.5	2.3
Age.	2.6	-4.7	-4.6	5.6	3.1	2.0	-10.5	0.0	1.9	-3.2	0.0	6.6	0.7	1.3	5.1
Erie															
Sex ---	0.2			0.0			0.0		-	0.-		-	0.1		-
Race --	0.3	-		0.7		-	0.2		-	0.5		-	0.5		-
Ethn.--				2.0					-	0.5		-	-1.3		
Age ---	-2.0			6.0			-12.0		-	-0.5			-4.0		

s p e c i a l t y

UNTY / IART	GP/FP			INTERNIST			PEDIATRICS			OBGYNN			GEN. SURG.		
	R	P	CH	R	P	CH	R	P	CH	R	P	CH	R	P	CH
ıondaga															
ex ---	0.1			0.0			0.0		-		-		0.7	-	
ace --	0.6			1.6	-		0.0			0.8			1.0		
thn.--				3.1	-	-	-			0.5			2.3		
ge ---	5.4		-	-0.4		-	-9.6			-0.5			1.0		-
ings															
ex ---	0.7			0.0			0.6						0.4		
ace --	-9.4			-10.0			-0.5			-2.5			-8.4		
thn.--				-	-				-	2.0			-4.0		
ge ---	-7.0			6.2			-7.6		-	-0.6			1.2	-	

D. All other specialties.

As previously mentioned, the above five specialties account for almost 70% of all office visits to office based physicians in 1985. That leaves 30% or 191,500,000 visits (10) unaccounted for. Visits to these remaining specialties will be calculated by taking the appropriate proportion out of the number of national visits based on total county population.

Example: *Queens County.*

- county population (1987): 1,920,700 (21).
-TOTAL U.S. POPULATION (1987): 243,400,000 (31).

NATIONAL TOTAL FOR VISITS TO ALL SPECIALTIES UNACCOUNTED FOR (in 1.) ABOVE:

191,500,000 VISITS (10).

Total county population is first divided by the total national population to obtain the appropriate proportion:

[county population (1987)/ U.S. population (1987)]

= [1,920,700/ 243,400,000]

The resulting proportion is then multiplied by the number of

national visits to the remaining specialties (10) to obtain a figure for visits in that county:

[Above] x National total for visits to all remaining specialties = total visits to the remaining specialties for the county.

For Queens:

[1,920,700/ 243,400,000] x 191,500,000 visits = 1,511,150 visits.
(nationally) (annual)

When added to the number of visits calculated for the other 5 categories (in D., above) the resulting figure is the total number of visits to physicians for the county:

SPECIALTIES	PHYSICIAN VISITS
For 5 specialties:	3,470,500
All other specialties:	1,511,150
TOTAL:	4,981,650 *

To check the total number of visits for the county, the number of visits per person will be calculated and compared to the national average. This is done by dividing the number of total county visits by the number of persons:

Calculating average visit rate per person for Queens:

4,981,650 (Queens) visits*/ 1,920,700 persons** =

2.6 average visits/ per person per year.

[*= see TOTAL above] [** = (32)]

Calculating the average visit rate for the nation:

619,390,000 visits (national)(10)/ 238,149,000 persons (32)***

= 2.6 visits/per person per year.

[***NOTE: 1985 population was used to coincide with the year for the number of national visits used].

From the results above, it can be seen that number of county visits estimated using the **rates method** added to the "other" category outlined above, correlates favorably with national data.

2. Estimating annual visits to dentists at the county level.

A. Number practicing and visits.

There were an estimated 466,775,000 visits made to dentists in 1986 (33). Aside from those practicing General Dentistry (which is not itself considered a dental specialty) there are seven medical specialties that serve the public through private offices. These include (35):

Oral & Maxillofacial Surgeons: Dentists who are oral surgeons.

Endodontists: Those who work with the root of the tooth (perform root canal).

Orthodontists: Those dealing with dental work relating to braces.

Pediatric dentists: The dental care of children.

Periodontists: Treatment of gums.

Prosthodontists: False teeth, crowns, caps & bridges.

Oral pathologists: Pathology of the mouth.

Upon obtaining a license to practice dentistry from the state, a dental graduate can practice exclusively within any of the above specialties if they acquire the appropriate training to do so (there are no specific requirements for this). The only limitation is that they cannot call themselves a specialist, the titles for dental specialties are reserved for those who complete post-doctoral training. So a dentist who is a General Practitioner can practice Endodontics only, but cannot call him/her self an endodontist (34,35). This obviously complicates matters, since there will be much overlap in terms of procedures performed.

Another problem is that there is no available information on visits rates for any of the specialties, only total rates for all dentists (33). But a specialty breakout is not really necessary, since General Practitioners make up 85-90% of all practicing dentists (36,37). A large majority of these (88%) practice exclusively as part of a private practice (they are office based dentists)(36). The rates given for dentistry in general, were therefore applied to the various population parameters (breakdowns) at the county level. A version of the *proportioning* method was also used, as well as a method that applied crude rates available. All of the three methods were compared for differences. Total population, sex, race, age, ethnicity were the parameters used. Although rates for family income and those having private dental insurance were available, they could not be used because matching data on the county level could not be found. This is unfortunate, since both have been suggested to be strong factors in influencing

whether someone will see a dentist or not (38).

B. EXAMPLE: *Queens County*

1) RATES METHOD.

The rates available for dentists (33) were applied similar to the way the rates for physicians were applied to respective county populations. The only difference is that the rates were given for those persons making 1, 2, 3, 4, and 5-12 visits in the past year. Each of these rates were multiplied by the respective population (or parameter within the population) and totaled to give the number of visits to dentists in the county.

a) *Total population.*

The rates for each of the number of visits (33) were multiplied by the total population of the county and summed up to give a total for the number of visits.

Table 9: ***Summary of calculated dentist visits for total population using available visit rates.***

VISITS	POPULATION*	VISIT RATE**	NUMBER OF VISITS
1	1,920,700	22.8	43,919
2		19.0	729,866
3		5.1	293,867
4		3.4	261,220
5-12		5.4	414,871***
		TOTAL:	1,999,548 VISITS

*Queens County (1987)
**Visits/ 100 persons.
***Figure multiplied by 8, and the divided by 2 to give the figure shown. This was necessary because the number of visits will probably be closer to 5 than 12 (38).

Calculations for sex, race, and ethnicity were performed the same way, with the only difference being that more than one set of calculations needed to be done for each (eg. for sex: the male and female rates were applied to each separately and the calculated visits from each added). Not enough information was available on visit rates for various ages to apply the RATES METHOD to the county population.

2) PROPORTIONING METHOD.

The total number of national visits was multiplied by the proportion of out of the national population that a county represents, to obtain a number of dental visits for that county.

TOTAL POPULATION - ***Queens*** (1987): 1,920,700 persons. (24)
- ***Nation*** (1986): 241,078,000 persons* (31)

TOTAL NUMBER OF NATIONAL VISITS: 466,775,000 (33)

[* National population for 1986 used because all rates used came from a report of the same year (33)]

To obtain the proportion out of the national population that the county population represents, the total county population (24) is divided by the national population (31):

[1,920,700/ 241,078,000] = proportion out of the national population that the county population represents.

This proportion is then multiplied by the total number of visits nationally (33), to obtain a figure for the number of visits in that county:

[1,920,700/ 241,078,000] x 466,775,000 national visits

= 3,718,843 visits to dentists in this county.

CHANGE FROM ORIGINAL ESTIMATE [See 1) above]: 216%

RESULT: **SIGNIFICANT**

Calculations for sex, race, and ethnicity were performed the same way, except that more than one set of calculations was needed for each (eg. for sex, *males*: the proportion of males was calculated by dividing the county male population by the national male population, then multiplying by the total number of visits made by males in the U.S. to get the number of visits made in the county for males). For age, three age groupings were used: < 5, 5-44, and > 44 years (to keep the highest rates intact).

[Note: The numbers of visits nationally (all persons, and broken down within various population parameters) is given in the 1986 Report on the Use of Dental Services (33)].

The resulting change above is obviously very large. For all other parameters used similar large differences were observed. Part of the reason may be faulty recall of those surveyed (in 1986 by NHIS) as well as a significant number of unknowns (33,38). The national number of visits to dentists in 1986 (see above) was almost twice the total U.S. population for that year. When the two estimates above are compared to twice the Queens population (3,841,400), the RATES derived estimate is 50% smaller, whereas

the difference for the PROPORTIONING method is only 3% less. The rates method should therefore not be used.

3) CRUDE RATE METHOD.

This method takes the crude rates available (eg. 2 visits per person per year) and multiplies it by the county population to get the number of visits:

CRUDE NATIONAL VISIT RATE: 2 visits per person/year (33).
(for total population)

1,920,700(Queens population) x 2 per person/year= 3,841,400 visits/year

CHANGE FROM PROPORTIONING ESTIMATE [See 2) above]: 3.1%

RESULT:**NOT SIGNIFICANT**

The last two methods seem to agree very favorably. The same was done for sex, race, ethnicity and age (using the same age groups as in **2)** above). All results for the five test counties- using all methods- are summarized in tables 10 and 11 below. The *base comparison estimate* for determining significant differances between different population characteristics will be the one that was computed using the proportioning method since the rates method (the one that used the available rates) proved unreliable.

Table 10: *Summary of calculated dentist visits for total population, showing differences for various methods used, for five test counties.*

KEY: Change 1 = % change from using RATES method.

Change 2 = % change between CRUDE RATE and PROPORTIONING methods.

	M E T H O D		
COUNTY	RATES	PROPORTIONING	CRUDE RATE
QUEENS			
Visits --	1,999,458	3,718,843	3,841,400
Change 1-	-	216	227
Change 2-	-	-	3
BROOME			
Visits --	206,283	406,351	418,000
Change 1-	-	96	102
Change 2-	-	-	3
Eerie			
Visits --	1,066,587	1,855,460	1,916,600
Change 1-	-	74	79
Change 2-	-	-	3
Onondaga			
Visits --	512,201	891,038	1,916,600
Change 1-	-	74	80
Change 2-	-	-	3

Table 11: *Summary of observed changes for dental visits using all methods, for the five test counties used.*

KEY: 1 = % change from total population estimate (see table 8) using RATES METHOD for each characteristic.

2 = % change in the number of calculated visits between the RATES and PROPORTIONING method, for each characteristic.

3 = % change between number of calculated visits between the RATES METHOD and the *base comparison estimate** for all characteristics

(-) = not performed.

Ethn = Ethnicity.

	c h a n g e		
COUNTY	1	2	3
Queens			
Sex -	6.9	5.9	0.5
Race -	- 2.7	4.6	- 4.4
Ethn -	- 8.0	- 0.4	- 2.8
Age -	-	4.6	1.5
Broome			
Sex -	2.0	6.0	1.9
Race -	1.1	4.6	8.0
Ethn -	3.4	- 3.6	3.4
Age -	-	4.7	- 3.9
Eerie			
Sex -	0.0	6.0	0.6
Race -	0.3	3.5	0.9
Ethn -	1.1	- 1.4	- 0.7
Age -	-	8.4	3.5
Onondaga			
Sex -	- 0.1	0.7	0.1
Race -	**24.0****	3.4	2.3
Ethn -	- 3.5	3.6	2.3
Age -	-	2.7	2.5

*** see text, pg 22.** **** was not considered significant since all other differences are small (note adjoining collumns).**

3. Veterinarians.

Veterinarians can practice in 41 different professional activities, including large, small, and mixed animal practices, which account for the activities of 97% of all self employed veterinarians nationwide. Veterinarians in private practice make up 75% of all those practicing. Out of those, 45% are self employed and in private practice, and 30% work in other types of private practice (40). This 75% (in private practice) is the proportion that will be classified as small quantity generators under MWTA'88. There are 2000 and 900 privately practicing veterinarians in New York and New Jersey respectively (7).

It should be obvious that there is no real way "patient" visits can be estimated for this group of private practitioners. This made it necessary to use of an average amount of medical waste per month, per practitioner. This figure was then multiplied by the known number practicing in both states to obtain a figure for the average amount of medical waste produced by this type of small quantity generator each month for the respective states. But using this method does not account for variability with respect to the number of possible visits monthly (when comparing between veterinarians engaged in similar practices).

**

4. Calculating amounts of medical waste.

A. Inherent problems.

Estimating the amount of medical waste produced by doctors, dentists and veterinarians is inherently difficult because of two main reasons:

- o A wide range of possible patient loads is possible.
- o The existence of numerous specialties within each of the three disciplines.

A privately practicing physician, dentist or veterinarian may work as many or as few hours as they choose. This may depend on the physicians age (the older he or she is, the fewer hours they may be able to work), his location (urban versus rural) or just the preference of the individual (15-19). This problem is further confounded by the fact that varying practice specialties (within each of the three disciplines) perform a varying array of services. For example, an orthopedic surgeon may see as many as 1000 patients per week, whereas a typical internist would see closer to 500 per week (usually less)(7); but, the internist may follow up with treatment at the time of diagnosis, compared to the orthopedist (whose is a surgeon, and the specialty is designated *orthopedic surgery*) whose practice is mainly diagnostic in nature (41). As was

mentioned previously different specialties may also produce varying amounts of waste due to the inherent nature of the specialty being considered, and there is no way of predicting where a private practitioner will go; although there tends to be a concentration of veterinarians that favors rural over urban areas nationwide (40).

Using patient visits in conjunction with the average amount of medical waste per patient per visit (or per patient visit) will therefore be the measure used in this model. This value, even though there may still be a range, will prove to be more useful since patient load ideally should have no effect on procedures performed. The only exception may be at the extreme end (eg. a situation where a practitioner of any type sees far more patients than the average number) where it is conceivable that procedures may not be performed as often because of time limitations. The curve for medical waste should therefore be almost linear, with a slight decrease possible at the high end (8).

1) Waste per patient visit.

All information on the amounts of medical waste on a per patient basis was gleaned from the Medical Waste Generation and Management Study undertaken at EPA in late 1988. As part of the study, medical waste questionnaires were mailed to physicians, dentists, and veterinarians, out of which 482, 159, and 143 were received in time to be used in the study. But unfortunately, the information from the physician surveys was inadequate for determining the differences (on a per-patient per-visit basis) in the amounts of medical waste produced among various physician specialties. One problem seemed to be differences in the way many of the respondents applied the medical waste definition to their respective practices (7). Another problem- which became obvious after answering numerous phone inquiries shortly after the surveys were mailed- was that they were never *required* to know this type of information, and so many had to make first time educated guesses (42). It was possible in some cases to spot errors (by comparing responses where the sample size was 10 or more) and therefore make the necessary corrections.

a) Physicians.

For physicians, the only meaningful sample sizes (n=10 or more) that could be obtained were those for *General & Family Practitioners* (n=12) and *Internists* (n=13). The mean values for both came out to .034 lbs/patient (per visit). A range of .03 to .05 lbs/patient (per visit) was used (it was observed that some values for both exceeded .04 even after all corrections were made). Since the above two specialties- combined with the remaining three used in calculating the number of patient visits -account for almost 70% of all patient visits to physicians, it was decided to apply the mean figure above to the 70% rather than to each separately (this was also necessary because the sample size for the

other specialties was too small).

For all other specialties (eg. orthopedic surgeons, urologists..etc.) the sample sizes were again inadequate to obtain a meaningful figure to be used in calculations. All available data was therefore pooled, and the specialties treated as one. By looking at the highest and lowest values, it was observed that the lowest values rarely exceeded .05, and the highest .02 lbs/patient (per month). A range of .02-.05 lbs./month was therefore applied to the visits calculated for the "other" category (see page 17) to obtain the amount of medical waste produced by those specialties.

b) Dentists.

Since there was no information available on rates for patient visits to dental specialties, all dentists were included in one broad category. This presents no problem, since (as was noted previously) 80 to 90% of all dentists are in private practice. A figure of .057 lbs./patient (per visit) was obtained using the same methodology as described above (for General & Family practitioners and Internists). This number appears to be high compared to the average obtained for physicians (.034). But it must be taken into account that some dental specialties (oral surgeons in particular) may produce larger volumes of waste (eg. soiled cotton balls and other wastes associated with patient treatment), as well as the fact that a great many general dentists occasionally provide many of the same services that dental specialists provide exclusively.

c) Veterinarians.

As previously stated, there is no information that is available on specialties here- although it is well documented that a majority of veterinarians (75%) work in a private practice (40). The average amounts of medical waste reported for New York and New Jersey were 19.8 and 22.4 lbs./month per practitioner . The average of the two (21.1) will be the figure used- in conjunction with the number practicing- to calculate the total amount medical waste produced by veterinarians in each state separately.

2) EXAMPLE: Calculating the amounts of medical waste produced by doctors, dentists, and veterinarians in *Queens County.*

Table 12: ***Summary of information needed to perform medical waste calculations at the county level.***

COUNTY:	PARAMETER	POPULATION	
Queens.....Total population		(1980)= 1,891,325.	(21)
		(1987)= 1,920,700.	(24)
all adjusted using 1980 population(24) [see page 7]	Female.....	(1980)= 1,013,144	
	Age.....	(1987)	
		[< 6]= 134,716	
		[6-14]= 219,762	
		[>14]= 1,566,221	

NATION:			
Total U.S.....population	(1986)=	241,078,000	(31)
.....population	(1987)=	243,915,000	(31)
."other"physician visits	=	191,500,000	(10)
.....dental visits	=	466,775,000	(33)

1) PHYSICIANS:

a. General & Family Practitioners.

POPULATION	RATE		VISITS (Rounded)
1,920,700 persons x	[86 visits per year/100 persons] (or .86 visits per person per year)	= 1,651,802	**1,652,000**

b. Internists.

1,920,700 persons x [.324 visits]= 622,307 **622,000**

c. Pediatricians.

(age)	(population)		(rate)		
< 6	134,716	x	2.10		
6-14	219,762	x	.57	Total= 456,172	**456,000**
> 14	1,566,221	x	.03		

d. General Surgeons.

1,920,700 persons x [.137 visits]* = 263,135 **263,000**

[* 137 visits per THOUSAND here]

e. Obstetrician-Gynecologists.

1,920,700 persons x [.468 visits] = 474,151 **474,000**

FIVE SPECIALTY TOTAL = 3,467,000
(a.-e.)

f. OTHER
(all other specialties)

[1,920,700/243,915,000] x 191,500,000= 1,507,959 **1,508,000**

---

2) DENTISTS

466,775,000 x [1,920,700/ 241,078,000]= 3,718,843 **3,718,000**

CALCULATING MEDICAL WASTE: (all figures in lbs./year)

I PHYSICIANS

a) [a-e above] Range= .03-.05 lb/patient/visit

i)..visits x .05 = **173,000**
ii)..visits x .03 = **104,000**

b) [f above] Range= .02-.05 lb/patient/visit

i)..visits x .05 = **75,000**
ii)..visits x .02 = **30,000**

II DENTISTS

Range= .05-.06 lb/patient/visit

i)..visits x .06 = **223,000**
ii)..visits x .05 = **180,000**

	PHYSICIANS		DENTISTS		T O T A L	
UNITS*	HIGH	LOW	HIGH	LOW	HIGH	LOW
pounds/year	248000	134000	223000	186000	471000	320000
tons/year	124.0	67.0	111.0	93.0	134.0	160.0
tons/month	10.3	6.0	9.3	7.8	19.6	14.0

(* pounds/year is shown rounded to nearest thousand)

5. Scaling down.

In order for the model to be successful, it should be easy to use, and should be consistent from application to application (eg. no matter what the county population, the error should be small enough for a reasonably accurate estimation of the amount of waste). Having to repeat the calculations above for every county would be too tedious a method, especially in states with many counties. A simpler method, is to perform one set of detailed calculations for the most populous county, and then to *scale down* the resulting waste amounts to project what the amounts for the less populous counties will be.

A. Showing no difference.

In order to show that no appreciable differences exist between the calculated (as detailed above) and *scaled down* waste amounts over the total range of county (population) sizes, both types of calculations were done and the differences compared. As shown below, all counties were placed into one of eight groups based on their population size. Group sizes were set so as to group counties similar in population size together. Fifteen counties were chosen, and their amounts of medical waste calculated. This amount was then compared to a scaled down amount for any significant differences.

1) Method.

Kings county, since it has the largest population, was used as the base county for scaling down all estimates. the following method was used for scaling down medical waste calculations to a county:

- The population of the county being looked into is first divided by the population of the base county (Kings county) to obtain the percentage out of the base counties population that the county represents.

- That proportion is then multiplied by the total amount of medical waste (previously calculated) of the base county, giving the *total average* amount of medical waste for that county being looked at. This will be referred to as the *scaled down* estimate.

EXAMPLE: Scaling down to project the amount of medical waste (high and low) for *Orleans* county.

(Calculated)

Orleans- total medical waste-

HIGH = .41 tons/ month.

LOW = .28 tons/ month.

population (1987) = 39,500 (24).

Kings- total medical waste-
HIGH = **24** tons/ month.
LOW = **16** tons/ month.
population (1987) = 2,309,600 (24).

Population Orleans/ Population kings = proportion.

[39,500/ 2,309,600] x **24** = .41 tons/ month. <---scaled down high estimate.
Change from calculated high (.41 tons) = 0.0% **NOT SIGNIFICANT**

[39,500/ 2,309,600] x **16** = .27 tons/ month. <---scaled down low estimate.
Change from calculated low (.28 tons) = - 2.1% **NOT SIGNIFICANT**

Table 13: ***Summary of categories used to show no differences exist throughout a wide range or population sizes for the amounts of medical waste produced by counties for New York.***

GROUP	POPULATION RANGE	# OF COUNTIES	# TESTED
I	> 2 million	2	1
II	1-2 million	4	2
III	500,000- 1 million	3	2
IV	250,000- 500,000	5	3
V	100,000- 250,000	11	3
VI	50,000- 100,000	18	1
VII	25,000- 50,000	16	2
VIII	< 25,000	3	1
	TOTAL:	62	15

By looking at the summary table on the following page, it can be seen that no significant changes were observed (between calculated and scaled down amounts of medical waste) at all points tested for all categories.

Table 14: *Summary showing the resulting percent change between calculated and scaled down high and low amounts of medical waste, for all test counties in all categories.*

			% difference	
CATEGORY	COUNTY	POPULATION	HIGH	LOW
I	KINGS	2,309,600	-	-
	QUEENS	1,920,700	1.8	- 4.9
II	New York	1,495,000	1.3	0.0
	Bronx	1,213,800	0.0	1.2
III	Eerie	1,495,000	0.0	- 2.9
	Monroe	1,213,800	0.0	0.0
IV	Onandaga	406,200	- 0.4	- 0.6
	Richmond	377,600	2.6	0.0
	Rockland	265,000	1.5	3.2
V	Oneida	247,000	2.8	0.6
	Ulster	165,000	0.7	0.0
	St.Lawrence	111,700	0.8	1.2
VI	Sullivan	70,400	0.7	1.0
VII	Orleans	39,500	0.0	2.1
	Lewis	26,500	1.8	0.6
VIII	Yates	20,000	0.0	- 1.4

B. Use of average waste amounts.

To further simplify calculations, an average amount of medical waste for both physicians and dentists was used. The average amount of waste means taking the simple average between the high and low values for physicians and dentists

respectively.

Table 15: *An example of averaging the high and low waste amounts for a county (Kings County).*

t o n s / m o n t h

PRACTITIONER	HIGH	LOW	AVERAGE WASTE
PHYSICIAN	12.8	6.9	----> 9.9
DENTIST	11.2	9.3	----> 10.3
		TOTAL:	20.1

1) Method: Physicians and dentists.

It was observed during the course of doing calculations that physicians and dentists consistently made up 49% and 51% of the *total* medical waste calculated respectively. Taking an average of the high and low amounts for each (as shown in the table above) should ideally give a *total average estimate* out of which 49% and 51% could be taken to give the respective amounts for physicians and dentists. This will only work if the changes from county to county between the high and low estimates- for both physicians and dentists -are consistent. As the table on the following page shows, this did indeed prove to be the case.

Table 16: *Summary showing the ratio between physician and dentist calculated waste amounts, and the percent difference between the high and low amounts for each.*

		t o n s / m o n t h*		
GROUP	COUNTY	HIGH	LOW	CHANGE (%)
I	KINGS			
a. Physician		12.8*	6.9*	46
b. Dentist		11.2*	**9.3***	17
RATIO (a:b)**		1.14	.74	
II	NEW YORK			
a. Physician		8.0*	4.3*	48
b. Dentist		7.3*	**6.0***	16
RATIO (a:b)**		1.11	.74	
III	MONROE			
a. Physician		3.8*	2.6*	47
b. Dentist		3.4*	**2.9***	18
RATIO (a:b)**		1.12	.90	
IV	ONONDAGA			
a. Physician		2.5*	1.3*	48
b. Dentist		2.2*	**1.9***	14
RATIO (a:b)**		1.14	.68	
V	ULSTER			
a. Physician		0.88*	0.50*	43
b. Dentist		0.79*	**0.67***	15
RATIO (a:b)**		1.11	0.74	
VI	SULLIVAN			
a. Physician		0.38*	0.20*	47
b. Dentist		0.34*	**0.28***	18
RATIO (a:b)**		1.11	0.71	
VII	ORLEANS			
a. Physician		0.22*	0.12*	45
b. Dentist		0.19*	**0.16***	16
RATIO (a:b)->		1.05	0.75	
VIII	YATES			
a. Physician		0.11*	0.10*	45
b. Dentist		0.06*	**0.08***	20
RATIO (a:b)->		1.10	0.75	

(** dentists = 1)

2) Calculated amounts of medical waste NEW YORK: Physicians & dentists.

All medical waste amounts shown (see table 17) below were scaled down using waste amounts calculated for Kings County.

Table 17: *Summary of medical waste calculations for physicians and dentists, by county, for New York state.*

t o n s / m o n t h

GROUP	COUNTY	POPULATION	PHYSICIAN*	DENTIST*	TOTAL
I	Kings	2,309,600	9.8	10.3	20.1
	Queens	1,920,700	8.1	8.6	16.7
II	New York	1,495,100	6.4	6.6	13.0
	Suffolk	1,314,700	5.6	5.8	11.4
	Nassau	1,316,300	6.7	7.0	13.7
	Bronx	1,213,800	5.2	5.4	10.6
III	Eerie	958,300	4.1	4.2	8.3
	Westchester	864,500	3.7	3.8	7.5
	Monroe	699,500	3.0	3.1	6.1
IV	Onondaga	460,200	2.0	2.0	4.0
	Richmond	377,600	1.6	1.7	3.3
	Orange	287,900	1.2	1.3	2.5
	Albany	283,400	1.2	1.3	2.5
	Rockland	265,400	1.1	1.2	2.3
V	Dutchess	258,400	1.1	1.1	2.2
	Oneida	247,000	1.0	1.1	2.1
	Niagara	216,200	0.9	1.0	1.9
	Bregma	209,000	0.9	0.9	1.8
	Saratoga	168,100	0.7	0.8	1.5
	Ulster	165,000	0.7	0.7	1.4
	Resselear	151,400	0.6	0.7	1.3
	Chataqua	141,600	0.6	0.6	1.2
	Schenectady	149,600	0.6	0.7	1.3
	Otswego	120,300	0.5	0.5	1.0
	St.Lawrence	111,700	0.5	0.5	1.0
VI	Steuben	96,900	0.41	0.43	0.84
	Jefferson	95,000	0.41	0.42	0.83
	Ontario	93,000	0.40	0.41	0.81
	Chemung	90,400	0.39	0.40	0.79
	Wayne	88,200	0.38	0.39	0.77
	Tomkins	87,700	0.37	0.39	0.76
	Cattarugas	87,400	0.36	0.38	0.74
	Putnam	82,100	0.35	0.36	0.71
	Clinton	91,700	0.35	0.36	0.71

			t o n s / m o n t h		
GROUP	COUNTY	POPULATION	PHYSICIAN*	DENTIST*	TOTAL
VI	Cayuga	80,000	0.34	0.36	0.70
	Sullivan	70,400	0.30	0.31	0.61
	Herkimer	66,900	0.28	0.30	0.58
	Madison	66,600	0.28	0.30	0.58
	Columbia	61,100	0.26	0.27	0.53
	Otswego	59,500	0.25	0.27	0.52
	Livingston	59,000	0.25	0.26	0.51
	Genesee	58,600	0.25	0.26	0.51
	Washington	57,800	0.24	0.26	0.50
VII	Warren	54,700	0.24	0.24	0.48
	Fulton	53,900	0.24	0.24	0.48
	Montgomery	51,700	0.22	0.23	0.45
	Tioga	51,000	0.22	0.22	0.44
	Chenango	50,600	0.22	0.22	0.44
	Allegany	50,000	0.22	0.22	0.44
	Cortland	48,000	0.21	0.21	0.42
	Delaware	47,000	0.20	0.21	0.41
	Franklin	43,400	0.19	0.19	0.38
	Greene	42,300	0.18	0.19	0.37
	Wyoming	41,600	0.18	0.18	0.36
	Orleans	39,500	0.17	0.17	0.34
	Essex	36,700	0.16	0.16	0.32
	Seneca	32,100	0.14	0.14	0.28
	Schoharie	29,900	0.13	0.13	0.26
	Lewis	25,600	0.11	0.11	0.22
VIII	Yates	20,900	0.09	0.09	0.18
	Schuyler	17,300	0.07	0.08	0.15
	Hamilton	4,900	0.02	0.02	0.04
		TOTAL:	**76.90**	**80.3**	**157.20**

(* May not come out exactly to 49% and 51% due to rounding)

3) Veterinarian medical waste.

As was discussed previously, there is no was to calculate the amounts of medical waste produced by veterinarians, and therefore an average figure for pounds/month for the average veterinarian will be used. This was found to be 22.4 pounds. Multiplying this by the number of practicing veterinarians in the state (2,000) yields a figure of 44,800 pounds or 22.4 tons per month for the state.

4) Total waste: ***New York***.

Adding up the results for physicians , dentists, and veterinarians gives a total figure of **179.6 tons/month** for New York state (see executive summary, table A).

* * * *

III. APPLYING THE MODEL: NEW JERSEY.

1. Physicians and Dentists.

To double check the model, it was applied to New Jersey. As was done for New York, the counties were grouped with other counties having similar (size) populations. The amount of medical waste was calculated for one county from each of the groups, which was then compared to the amounts for those counties derived by scaling down from the amount of medical waste calculated for the most populous county (which for New Jersey is Essex). The groupings used were the same as those used to group the New York counties (see page 31), but only four were needed (since the county populations vary much less over a range than do those for New York).

Table 18: ***Summary of the groupings used to characterize the populations of all counties in New Jersey.***

GROUP	POPULATION	# OF COUNTIES	# OF TRIALS
I	500,000- 1 million	6	1
II	250,000- 500,000	6	1
III	100,000- 250,000	5	1
IV	50,000- 100,000	5	1

The results of all trials (summarized in table 19 below) show that scaling down from the most populous county- when compared with the amounts calculated for those counties -results in only small and non-significant (< 10%) differences.

Table 19: *Summary of the trial county comparisons used, showing that no appreciable differences result from previously calculated amounts (of medical waste) when scaling down the amounts from the most populous county, for New Jersey.*

GROUP & COUNTY	POP*	% difference between calculated and scaled down high and low medical waste amounts. HIGH	LOW	% difference between average calculated and average scaled down medical waste amounts. PHYSICIAN	DENTIST	TOTAL**
I ESSEX MIDDLESEX	844,500 645,700	- 2.3	- 0.0	- 0.0	- 0.0	- 0.3
II BURLINGTON	388,000	0.0	-2.5	1.5	5.8	-2.8
III ATLANTIC	208,500	-4.2	-2.3	1.1	2.3	0.0
IV WARREN	87,200	-1.7	-2.1	-2.5	-2.6	-1.9

(* = population) (** = physician & dentist)

The amount of medical waste for both physicians and dentists in the state is shown in table 20 below.

Table 20: *Summary of medical waste calculations for physicians and dentists, by county, for New Jersey.*

t o n s / m o n t h

GROUP	COUNTY	POPULATION	PHYSICIAN*	DENTIST*	TOTAL
I	Essex	844,500	3.6	3.7	7.3
	Bergen	830,400	3.5	3.7	7.2
	Middlesex	645,700	2.7	2.9	5.6
	Monmouth	553,600	2.4	2.4	4.8
	Hudson	547,200	2.3	2.4	4.7
II	Union	502,500	2.1	2.2	4.3
	Camden	496,300	2.1	2.2	4.3
	Passaic	463,700	2.0	2.0	4.0
	Morris	419,400	1.8	1.8	3.6
	Ocean	403,000	1.7	1.8	3.5
	Burlington	388,000	1.7	1.7	3.4
	Mercer	327,000	1.4	1.4	2.8

			t o n s / m o n t h		
GROUP	COUNTY	POPULATION	PHYSICIAN*	DENTIST*	TOTAL
III	Somerset	221,600	0.9	1.0	1.9
	Glouchester	213,000	0.9	0.9	1.8
	Atlantic	208,500	0.9	0.9	1.8
	Cumberland	137,600	0.6	0.6	1.2
	Sussex	124,300	0.5	0.6	1.1
IV	Huntington	98,900	0.06	0.06	0.12
	Cape May	94,200	0.05	0.06	0.11
	Warren	87,200	0.05	0.05	0.10
	Salem	65,400	0.04	0.04	0.08
		TOTAL:	31.30	32.40	63.70

(* May not come out exactly to 49% and 51% due to rounding)

2. Veterinarians.

As was done for New York, the amount of medical waste produced by veterinarians was calculated by multiplying the average medical waste/month by the number practicing in the state([22.4 pounds/month] x 900 practicing). The amount comes out to 20,160 pounds, or 10.1 tons, for the state per month.

3. Total Waste

Adding up the medical waste amounts for physicians, dentists, and veterinarians gives a total amount of 73.7 tons/month for New Jersey.

[**See Executive Summary, table A., for the summary results of all state medical waste projections]

IV. DISCUSSION.

1. Uses.

The model outlined above was applied to two states, New York & New Jersey, to obtain the amounts of medical waste produced by physicians, dentists and veterinarians. The observation was made that the (yearly) medical waste projected for a state can be scaled down to give a one-time estimate for the whole state. If the amount calculated for New York is scaled down to give and estimate for New

Jersey, the resulting figure was found to deviate by only 5.4% from the calculated figure (for total waste, using the methodology outlined above). This small deviation is probably due to the fact that the two states used are close enough geographically to keep demographic differences to a minimum. But this can not be guaranteed when applying this method nationally, especially as the distance between the two states increases. The model above minimizes demographic differences by using a set of conditions (age, sex etc...) applied to a much smaller geographic area (the county level).

Another important point is that the model serves the purpose of projecting medical waste independent of the actual number of practicing physicians, doctors and dentists in the state being considered. This creates problems when trying to compare states, or even counties, that have dissimilar numbers of these practitioners. Since the model relies heavily on the number of yearly patient visits it truly does reflect the (office based) health care needs of the included population, whether they be in a state or a county. But the smaller the land area, the larger the probability that an individual will go outside their geographic place of residence (eg. the county) to see a private physician, dentist, or veterinarian. This presents problems since there is really no way to know how large or small this phenomena may be. If it is known that one county has half as many physicians as another (but the same amount of physician waste is projected using this model) it reasonable to assume that here too, is a case where some migration from one county to another may occur. It does seem feasible that this could be considered in any future medical waste modeling, possibly being a random computer comparison (eg. comparing the number of physicians with the number of projected visits throughout the state, and to somehow weigh these into the projection for each). Another reason for migration of visits may be just plain old personal preference. Maybe you live close to the county border, and the internist you prefer to attend has a practice just outside county limits, or maybe the topography of the area makes that internist more accessible (it's an easier trip to make). Reasons relating to personal preference are obviously impossible to account for, and this author doubts that any model can ever take this into account.

Using this model to make county to county comparisons is therefore not recommended, unless the actual number of practicing physicians, dentists, and veterinarians in that county are compared also. Such comparisons make this model ideal for health planning uses, since it can be used to map out the needs of the state, county by county, and thus help in identifying shortage areas. Comparisons between states would be more valid, since a larger geographical area is usually being considered, and an individual is more likely to see an office based physician or dentist within his state than outside of it (with the only exception being very small states, of which there are very few). The fact that the model predicts possible yearly patient load makes it a stable predictor for that amount of medical waste produced by all the sources

discussed in this study, since the only way to significantly change the estimate is to either increase or decrease a state's population, or change it's composition (eg. male to female ratio etc...).

2. Improvements.

One of the ways to improve the model is to try to develop a methodology for including the number of practitioners actually practicing in any county, since this would enable county comparisons to readily be made (as discussed above). Another way, would be to utilize the most recent survey (NAMCS for physicians & NHIS for dentists) and census data. The more recent the survey data used, the more confidence one has that the rates being used are accurate. The more recent the last census year, better data can be acquired for the various county parameters used in the model. For the purposes of this model (as already mentioned previously) it was assumed that the proportions within each county (for a particular parameter used) are similar to what they were in 1980. The validity of this assumption will not be known fully until the forthcoming census is complete. The fact that the census may soon be taken every five years, would certainly help in obtaining data needed for this model.

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