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DETERMINATION OF Pu-239,240 TISSUE CONCENTRATIONS IN NON-OCCUPATIONALLY EXPOSED RESIDENTS OF NEW YORK CITY

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ANNUAL REPORT

to the

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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TABLE OF CONTENTS

ABSTRACT

The following study reports on the Pu-239,240 concentrations in various tissues obtained from individuals residing in New York City. Twenty-six tissue samples have been analyzed for their Pu-239,240 content, which include sections from the right lung, the liver, bone (4th and 5th vertebrae) and the kidney. The tissues were obtained at autopsy from a selected population not occupationally exposed to plutonium and whose deaths were the result of causes other than metabolic disorders.

A detailed description is presented of the radiochemical procedures employed to separate Pu and electrochemically deposit plutonium isotopes prior to alpha spectrometry with Si surface-barrier detectors. Results of these measurements are given as activity per gram wet weight and activity per gram of calcium in the individual tissue. All results have been compared to similar measurements made at other laboratories and with estimates of concentration based on metabolic models.

To date, the magnitudes and the distribution of the measured values are consistent with the values inferred from the ICRP lung model and measured concentrations of air.

I. INTRODUCTION

Aside from localized productions and accidental releases of plutonium from nuclear reactors, weapon losses and underground nuclear detonations, the major source of generalized plutonium release to the environment has been from atmospheric weapons testing. The most reliable and best estimate of the amount so produced in above ground nuclear weapons testing was first made by Harley[1] and later updated by Wrenn[2], who concluded that a total of approximately 440,000 Ci of Pu-239,240 had been produced and distributed in the atmosphere. Estimates of the activity produced are given in Table 1 which includes the space nuclear releases to the atmosphere.

Most of the activity is associated with Pu-239, although almost 40% is associated with Pu-240, and 3% with Pu-238. From a practical point of view, both Pu-239 and Pu-240 have long half-lives and the alpha energies of the emitted alpha particles are generally indistinguishable with conventional counting techniques. The salient feature of this source is that essentially all of it, (on the order of 0.4 MCi), has been released to the environment to date.

There have been many studies which describe the transport of plutonium to man beginning with Pu-239 which has been released into the environment from nuclear weapons

Table 1.

GLOBALLY DISTRIBUTED AMOUNTS OF ALPHA EMITTING PLUTONIUM FROM ATMOSPHERIC INJECTIONS

SOURCES	AMOUNT (CURIES)	% ACTIVITY BY ISOTOPE Pu–238	Pu–239	Pu–240
ATMOSPHERIC TESTING 1945–74				
DEPOSITED NEAR TESTING SITE	110,000	3	58	39
DEPOSITED WORLD WIDE	330,000	3	58	39
SPACE NUCLEAR	17,000	100	—	—
TOTAL	457,000			
TOTAL GLOBAL EXCLUDING NEARIN TO TESTING SITE	347,000			

testing. In brief, the major transport vector to date appears to have been air; Bennett[3] has shown, in fact, that plutonium present in human tissues from a non-occupationally exposed population of New York City can be accounted for by applying the ICRP inhalation model[4] to the observed concentrations of plutonium in ground level air in the New York area.

In view of the extreme radiotoxicity of this element and its importance in man's energy economy, it is essential that the distribution and concentration of plutonium in various human organs from non-industrially exposed individuals be studied on a systematic, long-term basis.

Analysis of organ burdens of fallout plutonium is essential in defining those parameters used to estimate the transfer of plutonium from the environment to man.

In the present report, preliminary results will be presented for the Pu-239,240 concentration of 20 different tissue samples from 12 autopsy cases from a non-occupationlly exposed population of New York City. By comparison of these results with calculated values derived from lung modeling techniques and air concentration data, we will eventually be able to verify transport models of these materials in the environment and their metabolism and kinetics in the body. In addition, we will establish accurate background

values for these radionuclides in the body to act as a reference point for assessing the impact of increased sources of intake in a plutonium economy.

II. PROTOCOL FOR TISSUE PROCUREMENT

The autopsy tissue samples included in this study were selected preferentially from accident victims or others where sudden death had occurred. Severe disease cases, alcoholics, and drug addicts were avoided as non-representative of the general population. When possible, subjects were lifelong residents of New York City and within the age range of 20 to 45 years old. Fifty sets of autopsy tissues have thus been obtained from New York City residents. Each set of tissues included the right lung, 500 grams of liver, one kidney, the hilar lymph nodes, blood and half the bodies of three thoracic vertebrae. In a few cases, the bronchial tubes were also included. A few cases of drug overdose are involved in the study, but the individuals were on a methodone program and reportedly free of intravenous injections for at least one year prior to death. Therefore, acute drug poisoning was the cause of death. A breakdown of the age groups and causes of death are tabulated in Table 2.

The tissue samples were taken at the time of autopsy by the prosector who investigated the entire case and determined the cause of death and established the evidence for the presence of pathological changes. All wet weights of specimens were established at the time of autopsy.

Table 2. Age Groups and Cause of Death for New York City Tissue ^{239}Pu Analyses

Age Group	Cause of Death		
	Accidental	Overdose/ Poisoning	Other
15-20	5	3	0
21-30	9	13	1 (Leukemia)
31-40	9	3	2 (TB, Diabetes)
41-50	3	0	1 (MS)
Over 60	0	1	0
	26	20	4

Epidemiological data included smoking and drug habits, past medical history and occupation of the subject. Histological evidence indicated normal organ function with respect to chronic changes. The autopsy technique usually involved the Rokitansky method of removing each organ through a thoraco-abdominal incision.

The lung was weighed prior to any incision to determine how much congestion was present. The pulmonary arterial tree was opened from one side, and the bronchial tree from another. In order to inspect the lung for any lesions, a long coronal section was made along the lateral border through the lung to the hilum.

The liver was excised, weighed and sliced in sections. Each section was again inspected and palpated for any lesions. The kidney with the perirenal fat was next removed. The capsule of the kidney was taken off, and then the organ weighed. The kidney was then split along the midline and a microscopic section taken for examination.

The lymph nodes were taken in the following manner: the paratracheal and peribronchial nodes along the two mainstream bronchi were stripped, the hilar nodes, which often are embedded within the pulmonary parenchyma, were searched for in the manner of a surgical pathologist looking for nodes involved with cancer in a resected specimen. To complete the sampling, a section of bone including half of three thoracic vertebrae was taken.

A complete explanation of the histological protocol followed with these tissues has been previously published[5,6].

III. Pu-242 TRACER

Plutonium-242 tracer solution employed in this study was obtained from the U.S. Energy Research and Development Administration's Health and Safety Laboratory (HASL), New York.

The solution was originally prepared by the Lawrence Livermore Laboratory (LLL), California [7]. The mass spectrometer analysis of the solution performed by LLL and the gross alpha and alpha spectrometry measurements performed by HASL [8] are given in Table 3.

Plutonium-242 was chosen in preference to Pu-236 for several reasons. First, the Pu-242 alpha energy of 4.90 MeV is significantly lower than the 5.15 MeV alpha energy of Pu-239, thus eliminating the problem of degraded alpha energy in the region of interest. Second, the Pu-242 half-life of 3.79×10^5 years permits use of a single, highly purified solution for the duration of the project. Finally, no decay corrections need be applied to the tracer activity.

Table 3

^{242}Pu Tracer Purity Certification[7]

Isotopic analysis by mass spectrometric measurement[8]

Atom ratio	
$^{239}Pu/^{242}Pu$	0.0000006 ± .0000002
$^{240}Pu/^{242}Pu$	0.0000004 ± .0000002
$^{241}Pu/^{242}Pu$	0.0000030 ± .0000004

Using the half-lives of

^{242}Pu	3.79×10^5 y
^{239}Pu	2.44×10^4 y
^{240}Pu	6.58×10^3 y
^{241}Pu	13.2 y

yields the following activity percentages:

	Total Activity	Alpha Activity
^{242}Pu	92.0667%	99.9968%
$^{239,240}Pu$	0.0030%	0.0032%
^{241}Pu	7.930%	---

The mass spectrometric measurements were performed in August 1971.

IV. PLUTONIUM RADIOCHEMICAL METHODOLOGY

The chemical procedure employed in isolating plutonium from the sample matrix is described in this section. The basics of the analysis are adapted from the HASL method for the radiochemical determination of plutonium in tissue[9]. The procedure is composed of three major divisions which can be designated: (1) sample preparation, (2) ion exchange separation, and (3) electrodeposition.

A. Sample Preparation

The tissue samples, are received by our laboratory, and initially digested with concentrated nitric acid[5,6]. After wet ashing, the concentrations of the solutions are adjusted to approximately 8M and the final sample volume made up to either 25, 100 or 250 ml depending on the original sample size. Prior to the initial ashing procedure, an appropriate amount of Pu-242 tracer solution is added to the samples in order to quantitate the chemical recovery of the Pu-239,240. To insure that the samples are completely free of organic materials which interfere in the isolation of the plutonium, an equal volume of concentrated H_2SO_4 is added to each sample which is then digested again until dense sulfur trioxide fumes are evolved, and organic removal is complete.

Although H_2SO_4 is effective in removing residual organic material, it is necessary at this step to quantitatively remove sulfate from the solution since strong complexes are

formed between the Pu^{+4} and the sulfate ions which strongly interfere in the ion exchange separation. To effect the separation, 300 ml of 1:3 HCl with 1 mg of iron carrier is added to the sample, and through the subsequent addition of concentrated NH_4OH, the plutonium is coprecipitated with iron in the hydroxide form. The precipitate is filtered from the solution using Whatman 42 (ashless) filter paper and the filtrate is discarded. The precipitate is washed, and the filter paper and the precipitate are transferred to the original beaker and ashed with concentrated nitric acid. In order to insure complete separation of the plutonium from the sulfates, all cations are reprecipitated, in a similar manner, the precipitate is washed and transferred to the original beaker and ashed.

The solution is then adjusted to 100 ml in 1:1 HNO_3 and visually inspected for suspended particulates. If particulate matter is observed, it is filtered (using Whatman #40 filter paper) and transferred to a platinum dish where it is dried at 110°C and ignited at 600°C in a muffle oven. The residue remaining in the dish is dissolved in 25 ml HF and taken to dryness, whereupon it is redissolved in 25 ml of 1:1 HNO_3 and recombined with the filtrate.

B. Ion Exchange Separation

The sample is now ready for the ion exchange separation. The ion exchange resin used in this procedure, Bio-Rad AG1-X4, specifically binds plutonium and thorium under specified conditions. The conditions critical for preferential

binding are 1) that the solution normality be adjusted to 8N, and 2) that the plutonium be in the +4 valence state. The normality adjustment is accomplished by calculating the normality of a 100 µl aliquot via standard acid-base titration and diluting the solution with the appropriate volume of deionized-distilled water. To adjust the valence of the plutonium to the +4 state, the sample is heated to 90°C and 100 mg of $NaNO_2$ added to the solution.

The ion exchange separation is performed in two steps using a large ion exchange column, followed by a smaller column. The first column contains 25 ml of wet resin which is conditioned before use with 1:1 HNO_3 to convert it from the chloride to the nitrate form. Approximately one-half of the resin in the large column is washed into the sample solution which is then agitated for five minutes to promote contact of the resin beads with the plutonium containing solution. This solution is then passed through the column at maximum flow rate. Plutonium has a strong affinity for the resin at the adjusted normality while all the other elements (excluding thorium) have very little or no affinity. When the solution reaches the top of the resin column, the plutonium and thorium that are bound to the column are eluted with 200 ml of 0.4N HNO_3 - 0.01N HF solution and the eluent taken to dryness.

After twice adding 5 ml of HNO_3 to the residue of the evaporated eluent and taking it to dryness, the sample is prepared for the second column which contains 5 ml of wet

resin. Preparation of the sample solution for this purpose is exactly the same as for the large column, except that the residue is dissolved in only 15 ml of 1:1 HNO_3. Once the solution has passed through the small column, three 5 ml additions of HCl are allowed to flow through the resin to strip thorium ions from the column. This step preferentially removes any thorium bound to the column leaving any plutonium untouched. After the third HCl wash, three 10 ml washes of 1:1 HNO_3 are performed to wash any residual HCl from the column. Finally, the plutonium is eluted from the column into a separate beaker using 100 ml of 0.4 N - 0.01 N HF solution, and the eluent is again taken to dryness.

C. Electrodeposition

The final step in the procedure involves the electrodeposition of the eluted solution containing plutonium onto a platinum planchet. The first step involves the conversion of the eluted plutonium from the nitrate to the chloride form. Once this is accomplished, the plutonium is dissolved in 1 ml of HCl and transferred to a plating cell where the acidity of the solution is adjusted with NH_4OH to a pH of 2.8 using thymol blue indicator (pH range 1.2 to 2.4) to minimize the formation of polymeric plutonium. Two drops of 2 N HCl are then added to reduce the pH slightly since the efficiency of electrodeposition is increased at a slightly lower pH. Plutonium is then electroplated onto the platinum planchet at a constant current of 1.2 amps for a period of

one hour, whereupon the platinum disc is removed from the cell, washed with deionized-distilled water, ethanol and then flamed with a bunsen burner. The sample is then counted by alpha spectrometry as described in the next section.

V. ALPHA SPECTROMETRY

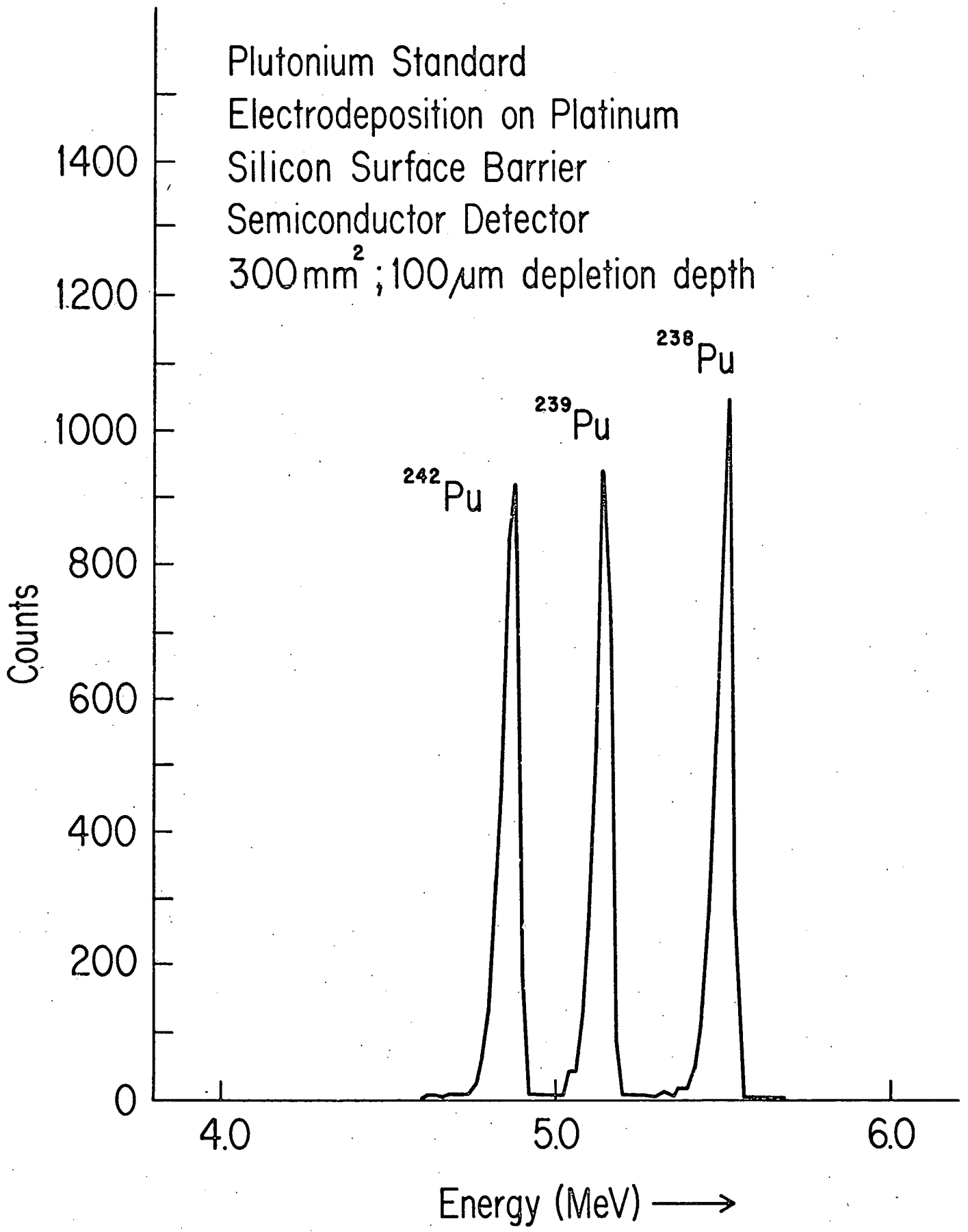
In order to measure the expected ultra low-level concentrations of Pu-239, 240 in tissues from unexposed persons, two state-of-the-art solid state alpha spectrometry systems were acquired and installed in a temperature and humidity controlled counting room. Each of the systems consists of a Gamma Products vacuum chanber with reproducible sample positioning, an ORTEC 300 mm^2 ruggedized Si surface barrier solid state detector having a 100 μm depletion depth, and various high stability electronic modules including charge sensitive preamplifier, high voltage supply and biased amplifier.

The alpha spectra are collected in a 512 channel multichannel analyzer over the energy range of 4000 to 8000 keV. The energy calibration and efficiency of the solid state detectors are measured with electrodeposited standards consisting of a mixture of Pu-242 (4.9 MeV), Pu-239 (5.15 MeV), and Pu-238 (5.5 MeV). The resolution of the systems with the calibration standard to detector distance of 1 mm is about 30 keV FWHM (Fig. 1). The counting efficiency of the detectors at this same distance is about 25%. The detector and planchet blank background in the region of 4.9 - 5.5 MeV is less than 1 count/1000 minutes.

The systems have proven quite stable with no spectral shifting. This parameter is extremely important since long counting periods, up to 5000 minutes, have been employed in determining the plutonium activity of the tissue samples.

Figure 1 -- Plutonium Calibration Standard

[Pu-242 (4.9 MeV), Pu-239 (5.15 McV) and Pu-238 (5.5 MeV) electrodeposited on platinum.]


Plutonium Standard
Electrodeposition on Platinum
Silicon Surface Barrier
Semiconductor Detector
300 mm^2 ; 100 μm depletion depth
^{238}Pu
^{239}Pu
^{242}Pu
Counts
0
200
400
600
800
1000
1200
1400
4.0
5.0
6.0
Energy (MeV) ⟶

VI. RATIONALE AND METHODOLOGY FOR STABLE CALCIUM MEASUREMENTS

Reports of fallout ^{90}Sr in the skeleton have demonstrated that the direct comparison of bone concentration data from numerous investigations could be best accomplished through expression of data on a "per gram of calcium" basis. Since calcium content is usually directly proportional to ash weight of most tissues, dry ashing at elevated temperatures can be avoided if the calcium content is independently determined. With the advent of sophisticated measurement systems, such as, atomic absorption spectrophotometry, the accurate measurement of stable calcium in all human tissues is possible. Furthermore, since no naturally occurring stable chemical congener of plutonium has been identified and plutonium has been shown to be a "bone seeker," it is advantageous for comparison purposes to determine calcium and to express the data as "per gram of calcium" in the present program. Finally, certain pathological disorders (e.g., calculi) can be identified and the tissues excluded from statistical analysis due to the presence of abnormal concentrations of calcium. In the future we will utilize measurements of Fe content to subtract that part of the wet weight value due to the presence of blood.

The atomic absorption (AA) method of stable element determination is capable of detection in the part per million (ppm) range.

A tissue sample wet ashed in nitric acid is adjusted to a known volume, usually 100 ml. A 1 ml aliquot of the sample is diluted to an appropriate volume with a 1% lanthanum in 1:19 nitric acid solution. The lanthanum acts as a hold-back carrier to eliminate possible interferences from aluminum, phosphorus, silicon, sulfur and their anions.

The atomic absorption spectrophotometers used in that study are available to us for measurement of the metabolically important alkaline earth element, calcium, in all tissues.

At present, stable calcium concentration has been measured in each sample prior to analysis for plutonium on one of the three instruments listed below:

1. Perkin-Elmer Model 303 with Boling burner head and acetylene-filtered compressed air.
2. Jarrell-Ash Model 82-270 with Boling burner head and acetylene-filtered compressed air.
3. Instrumentation Laboratory Model 453 with automatic background subtraction, a Boling burner head and an acetylene-filtered compressed air.

A set of calcium standards ranging from 0 to 50 ppm are employed to obtain a calibration curve. Least squares fitting of the standard curves has given linear correlation coefficients greater than 0.98 for each instrument used to measure calcium.

To date we have measured the stable calcium content of each tissue sample prior to radiochemical analysis for ^{239}Pu. The stable calcium data are listed in Table 4. The error term associated with an individual value is < 10%. The mean values obtained at New York University are compared in Table 5 with the calcium values estimated by ICRP and LLL. Thus far all NYU values are well within the ranges reported elsewhere.

Table 4

Stable Calcium in New York City Autopsy Samples

Age at Death	Sex	μg calcium/g wet weight			
		Lung	Liver	Kidney	Vertebrae
15	M		45	326	
18	M		41	100	
18	M		35	87	
19	M		46	145	
22	M		63	86	
22	M		-	-	56,525
23	F		67	86	19,700
24	F	100	25	104	27,400
25	F		29	92	
28	M		77	-	
29	F		43	49	
30	M		43	68	
33	M		31	-	
37	F		50	116	
38	M		45	106	
43	F		31	90	60,900
Unknown	Unknown	69	49	138	56,400
$\bar{X}$±1 S.E.			45±14	114±66	44,185±19,120
Number of Samples		2	16	14	5

Table 5

Comparison of Measured Stable Calcium in Human Tissue

	Mean Values in µg/g Calcium in Tissue Wet Weight			
	Lung	Liver	Kidney	Bone
NYU	85±22	45±14	114±66	44,185±19,120*
Sample Range	(69-100)	(25-77)	(49-326)	(19,700-60,900)
ICRP	87	50	94	100,000
80% Range	(40-120)	(24-94)	(58-171)	(63,000-160,000)
LLL	121	63	108	119,400
Sample Range	(70-176)	(29-144)	(57-176)	(119,400-119,400)

*Vertebrae only.

VII. SAMPLE INFORMATION - COMPUTER COMPILATION

A ready reference computer card listing has been developed as a means of rapid data retrieval and identification of tissue sample status (see Appendix 1). The open coded system lists the New York University case number, the specific tissue code number, name of the tissue, the age, sex, smoking history, cause of death and occupation of the subject. The data section of the card includes the tissue wet weight, percent of the wet weight analyzed for plutonium, pCi Pu-239 per kg of wet weight and μg stable calcium per gram of wet weight. Space is also available to list the measured values of the eight trace metals previously determined[5,6]. The card listing can be used to interrelate plutonium values with trace metal concentrations, age, sex or year of death and for general data entry and statistical operations.

VIII. Pu-239, 240 RESULTS IN TISSUES OF NEW YORK CITY RESIDENTS

To date the largest number of autopsy tissue samples from New York City have been analyzed by the Los Alamos Scientific Laboratory (LASL)[10,11]. Small sample sizes of New York City tissues were analyzed at LASL (< 50 g of lung, < 50 g of liver, < 10 g of bone and < 10 g of gonad) with a detection limit quoted as ∿ 0.015 pCi Pu-239. The LASL data were plotted as log normal distributions and the 50th percentile of the distribution was reported. The LASL data from the 1973 and 1976 reports are summarized in Table 6.

The detection limit per organ depends on the sample size analyzed as well as the detection limit per planchet. Since our sample sizes were generally ten times larger than the LASL samples, and since our detection limit for each analysis is about the same as theirs, our technique is able to measure 1/10 the amount found by the LASL study.

In addition, HASL[12] reported results for plutonium concentration of six vertebral samples (50 to 75 g of ash) from New York City residents. The reported mean was 0.0012 pCi Pu-239/g ash, yielding a calculated value of 0.31 ± .02 pCi Pu-239/kg wet weight.

We have now completed the analyses of twenty-six New York City tissue samples for Pu-239. These data are tabulated in Tables 7 and 8 and a sample spectrum of one liver sample is given in Figure 2. The wet weights of tissue analyzed were 500-600 g of lung, 150-700 g of liver,

Table 6. LASL 50th Percentile Distribution of ^{239}Pu in New York City Tissues

Tissue	pCi ^{239}Pu/kg 1973	1976
Lung	0.18 (26)*	0.30 (36)
Liver	0.77 (26)	0.62 (32)
Vertebrae	0.90 (25)	0.37 (32)
Gonad	0.45 (26)	0.34 (33)

* ( ) Number of Samples Analyzed.

Table 7. NYU Pu-239, 240 Results in New York City Tissues

Year of Death	Age of Death	Sex	Cause of Death	pCi Pu-239, 240/kg wet weight				
				Lung	Liver	Kidney	Vertebrae	Nodes
1973	-	-	-		0.38±.16	0.11±.08	0.87±.39	
1974	15	M	Acc		0.39±.07	0.27±.17	-	
1974	18	M	Acc		0.52±.12	-	-	
1974	18	M	Acc		-	0.65±.31	-	
1974	23	F	OD		0.71±.06	0.09±.11	0.29±.23	
1974	25	F	OD		0.73±.51	-	-	
1974	27	M	OD	0.45±.09	0.54±.09	0.02±.01	0.54±.18	0±1.3
1974	28	M	OD		0.37±.07	-	-	
1974	30	M	Acc		-	0.09±.13	-	
1974	37	F	Acc		0.51±.29	0.08±.14	-	
1974	43	F	Acc		0.14±.01	0.12±.12	0±2.6	
1974	47	M	OD	-0.09±.09	0.20±.09	-1.1 ±1.1	-	
Number of Samples				2	10	9	4	1
Mean					0.45	0.04	0.43	
Median					.39 to .51	.09	.29 to .54	

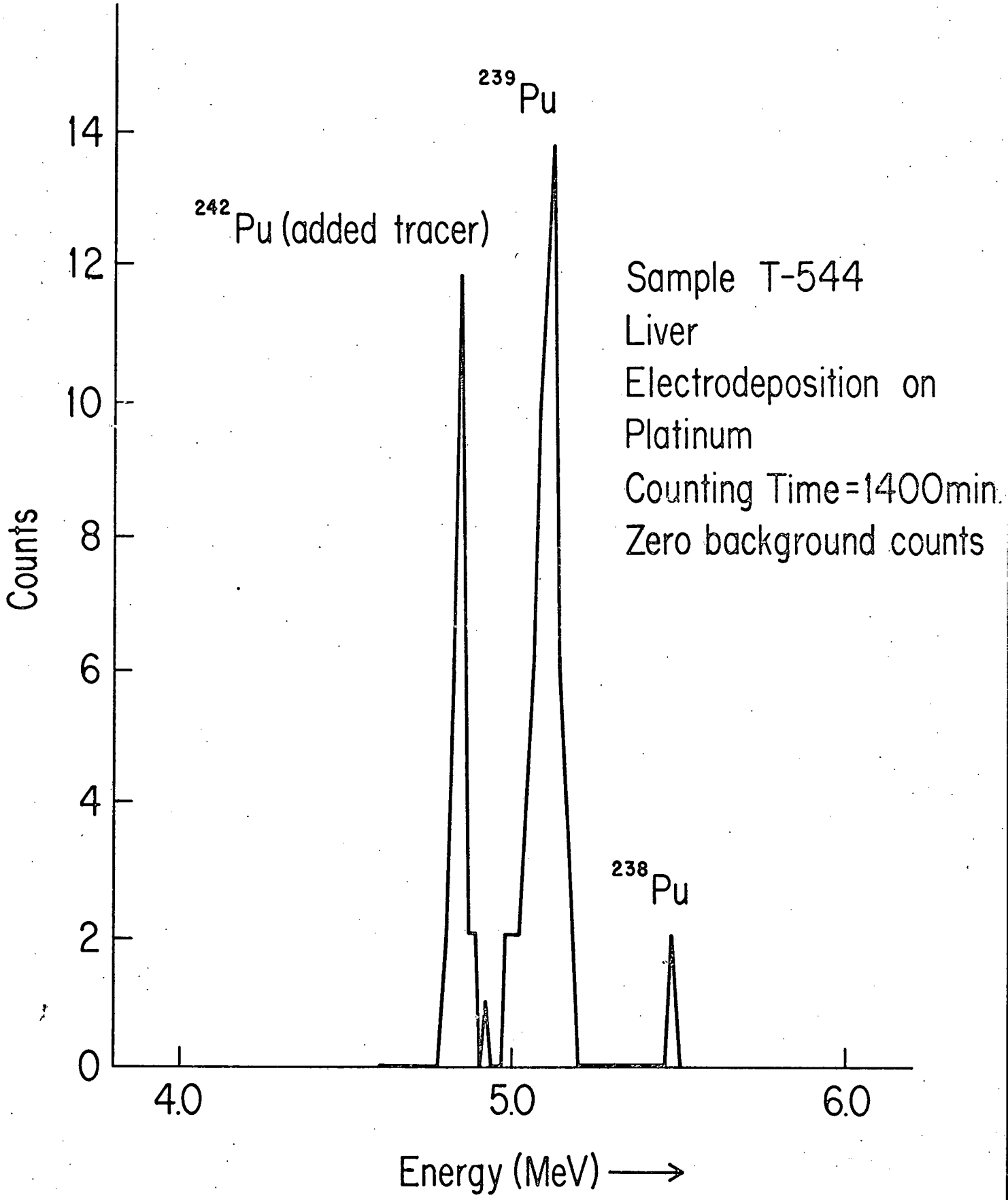
Table 8. pCi Pu-239, 240/g Ca in New York City Tissue

Year of Death	Age at Death	Sex	Cause of Death	pCi Pu-239, 240/g Ca		
				Liver	Kidney	Vertebrae
1974	15	M	Acc	8.67±1.56	0.83±0.52	
1974	18	M	Acc	14.85±3.43	-	
1974	18	M	Acc	-	6.50±3.10	
1974	23	F	OD	10.60±0.90	1.05±1.28	.01±.01
1974	25	F	OD	25.17±17.59	-	
1974	27	M	OD	-	-	
1974	28	M	OD	4.81± 0.91	-	
1974	30	M	Acc	-	1.32±1.91	
1974	37	F	Acc	10.20±5.80	0.69±1.21	
1974	43	F	Acc	4.52±0.32	1.33±1.33	

Figure 2

Sample T-544 Liver Counting

Time 1400 Minutes


239Pu
242Pu (added tracer)
238Pu
Sample T-544
Liver
Electrodeposition on
Platinum
Counting Time=1400min.
Zero background counts
Counts
0
2
4
6
8
10
12
14
4.0
5.0
6.0
Energy (MeV) ⟶

90-130 g of kidney, 50-150 g of vertebrae and 10 g of lymph nodes. To insure meaningful data, the analyses of lymph nodes are being held in abeyance for possible judicious compositing.

Assuming the ICRP[13] wet weight values for standard man (1 kg lungs, 1.8 kg liver, 0.31 kg kidneys and 5 kg bone) and that our samples were representative of the whole organs, we may estimate the organ burdens from our measured values. Since, with one exception, the year of death was 1973, we may compare the New York City organ burdens with those calculated by Bennett for the year 1974.

An additional comparison with Bennett's estimate of content in bone may be made on the basis of activity per gram of calcium. This normalization procedure is important since Bennett's measured estimates of bone concentration were based on ashed vertebrae while our current estimates are based on vertebrae wet weights. Since the typical U.S. vertebrae specimen analyzed at ERDA's Health and Safety Laboratory (HASL) contains 0.37 g Ca/g ash, we may compare our measured values of Pu-239 and stable calcium in vertebrae with the HASL values on the basis of calcium content. These computations give an NYU vertebrae mean (n = 4) of 2.7×10^{-3} pCi Pu-239/g Ca in agreement with the HASL vertebrae mean of 3.2×10^{-3} pCi Pu-239/g Ca.

It is expected that the additional cases will yield the high quality information required for refined modeling of Pu-239 distribution in environmentally exposed humans.

In the final table (Table 9), a comparison is made between the organ burdens inferred from our preliminary data and the burdens calculated by Bennett using measured air concentrations and the ICRP model. Both the magnitudes and the distributions of the mean measured values are consistent with the values inferred from the ICRP model and measured air concentrations. Because the number of samples is so small for all organs, this result must be considered only suggestive and preliminary. It will be necessary to have the full complement of tissue samples before firm conclusions can be drawn.

Table 9. Measured and Calculated Pu-239

Organ Burdens for New York City

		pCi Pu-239		
		NYU Measured Average	Bennett*	
Organ	# Samples	(1973)	Calculated (1974)	Measured
Lung	2	0.18	0.12	-
Liver	10	0.81	0.91	-
Kidney	9	0.01	0.02	-
Bone	4	1.0**	1.0	1.6

* Bennett's estimates are based on the use of air sample measurements measurements as an input to the ICRP lung and metabolic model for Pu (4).

**Durbin[14] as shown in the monkey that the concentration of Pu in vertebrae is about 2.2 times the average skeletal concentration. And if it can be assumed that this same ratio can be applied to man, the estimate of the Pu in the skeleton becomes 1 pCi with an approximately equal amount in liver plus lung.

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Appendix 1

Sample Data -- Number, Age, Tissue, Sex
Smoking History, Cause of Death, Occupation
Wet Weight, Pu-239, 240 DPM and
Trace Metal Concentrations

T134 LG BK							84.0	NA										
T140 SM BK							28.8	NA										
T143 LUNG	19	F	99	POISONNG	HOUSEWIFE	0.2506		2.966			20000	100	15	500	4		21	1
T144 LIVER	19	F	99	POISONNG	HOUSEWIFE	0.5077		3.604			8200	540	148	1600	84	2	47	5
T145 KIDNY	19	F	99	POISONNG	HOUSEWIFE	0.0962		3.300			51300	20	62	2000	510	1	40	61
T147 VERT	19	F	99	POISONNG	HOUSEWIFE	0.0511		2.850			6100	37	2	2600	1	1	115	1
T148 BLOOD	19	F	99	POISONNG	HOUSEWIFE	0.0541		NA			37200	102	13	830	6	2	20	6
T149 LY ND	19	F	99	POISONNG	HOUSEWIFE	0.0057		2.426			9800	75	18	570		15	61	
T142 LG BK								4.148										
T152 LUNG	36	F	00	CARD ART	HOUSEWIFE	0.4344		0.214			10100	100	9	400	2	4	13	17
T153 LIVER	36	F	00	CARD ART	HOUSEWIFE	0.5326		0.236	LOST									
T154 KIDNY	36	F	00	CARD ART	HOUSEWIFE	0.1655		0.193			11000	230	76	1400	410	1	35	95
T156 VERT	36	F	00	CARD ART	HOUSEWIFE	0.0309		0.181			4700	58	3	2900			194	
T157 LY ND	36	F	00	CARD ART	HOUSEWIFE	0.0037		0.191			11800	123		610		108	54	14
T151 LG BK								0.192										
T160 LUNG	37	M	01	AUTO ACC	PARK DEPT	0.4629		0.164										
T161 LIVER	37	M	01	AUTO ACC	PARK DEPT	0.6595		0.142										
T162 KIDNY	37	M	01	AUTO ACC	PARK DEPT	0.1811		0.153										
T163 VERT	37	M	01	AUTO ACC	PARK DEPT	0.0929		0.231										
T165 BLOOD	37	M	01	AUTO ACC	PARK DEPT	0.0609		NA										
T166 LY ND	37	M	01	AUTO ACC	PARK DEPT	0.0073												
T159 LG BK								0.255										
T169 LUNG	27	M	99	BRON PNE	TEANECK	0.5404		0.170			3400	120	2	700	1		13	16
T170 LIVER	27	M	99	BRON PNE	TEANECK	0.6774		0.188			1800	290	42	4200	31		64	34
T171 KIDNY	27	M	99	BRON PNE	TEANECK	0.0992		0.178			7100	190	90	2200	1500		58	233
T172 VERT	27	M	99	BRON PNE	TEANECK	0.0448		0.923			15000	67	11	2100	1		320	180
T174 BLOOD	27	M	99	BRON PNE	TEANECK	0.0694		NA			13400	75	7	450	3		12	9
T175 LY ND	27	M	99	BRON PNE	TEANECK	0.0067		0.187			4000	60	0	422	0			
T168 LG BK								0.161										
T177 LUNG	25	M	99	HOM STAB	UNKNOWN	0.5181		0.155			14600	81	4	700	37		21	26
T178 LIVER	25	M	99	HOM STAB	UNKNOWN	0.4588		0.082			900	260	12	260	0	9	11	13
T179 KIDNY	25	M	99	HOM STAB	UNKNOWN	0.1960		0.225			5090	200	93	3000	1600		74	18
T180 VERT	25	M	99	HOM STAB	UNKNOWN	0.0509		0.201			530	26	1	1300	1		31	94
T182 BLOOD	25	M	99	HOM STAB	UNKNOWN	0.0268		NA			17300	143	8	350			25	
T183 LY ND	25	M	99	HOM STAB	UNKNOWN	0.0101		0.201			6200	80	10	700	18			
T176 LG BK								0.258										
T186 LUNG	21	M	99	OD METH	UNKNOWN	0.5936		0.129			19700	90	6	830	38		23	
T187 LIVER	21	M	99	OD METH	UNKNOWN	0.3825		0.123			2000	920	30	3200	110		116	90
T188 KIDNY	21	M	99	OD METH	UNKNOWN	0.1176		0.205			10100	330	68	2400	1270		77	
T189 VERT	21	M	99	OD METH	UNKNOWN	0.0576		0.162				31	1	410	1		16	
T191 BLOOD	21	M	99	OD METH	UNKNOWN						20900	129	19	250			22	
T185 LG BK								0.175										
T194 LUNG	25	M	00	AUTO ACC	DRIVER	0.2533		0.196			21200	120	12	1000	6	7	53	35
T195 LIVER	25	M	00	AUTO ACC	DRIVER	0.4047		0.169			2800	330	130	3700	44	2	100	146
T196 KIDNY	25	M	00	AUTO ACC	DRIVER	0.1094		0.184			3000	220	90	3300	1460	29	87	176
T198 BLOOD	25	M	00	AUTO ACC	DRIVER	0.0655					44700	110	4	710			51	14
T193 LG BK								0.144										
T201 LUNG	30	M	99	AUTO ACC	UNKNOWN	0.2987		0.227			20700	150	20	1200	77	9	29	
T202 LIVER	30	M	99	AUTO ACC	UNKNOWN	0.4540		0.198			800	350	21	3300	10		22	8
T208 KIDNY	30	M	99	AUTO ACC	UNKNOWN	0.0929		0.242			5200	200	80	3100	1630		16	56
T203 VERT	30	M	99	AUTO ACC	UNKNOWN	0.0265		0.141			19200	19	34	3500			820	87
T205 BLOOD	30	M	99	AUTO ACC	UNKNOWN	0.0234		NA			46700	76	9	640			25	13
T206 LY ND	30	M	99	AUTO ACC	UNKNOWN	0.0084		0.179			12300	18	48	600			30	
T200 LG BK								0.211										
T210 LUNG	22	M	00	INFARCT	STUDENT	0.4239		0.161			23000	130	12	940	37		31	25
T211 LIVER	22	M	00	INFARCT	STUDENT	0.4727		0.176			800	110	12	3700	53	10	166	11
T212 KIDNY	22	M	00	INFARCT	STUDENT	0.1058		0.174			8500	360	77	2300	550		76	940

CASE	SAMPL	AG	S	SH	CAUSE OF DEATH	OCCUPATION	KG. WET WEIGHT	%	DPM PU242	PU239 PCI/KG.WW	CALCIUM	FE	CU	MN	ZN	CD	CR	PB	NI
												MICROGRAMS X 100/GRAM WET WEIGHT							
T050	LUNG	30	F	99	SHOT	UNKNOWN	*0.4000		0.682			14500	120	8	1100	9	7		26
T051	LIVER	30	F	99	SHOT	UNKNOWN	*0.4000		0.968			4400	190	34	1900	630	1	40	2
T054	VERT	30	F	99	SHOT	UNKNOWN	0.0312		1.133			95300	27		2300	1		191	111
T052	BLOOD	30	F	99	SHOT	UNKNOWN	0.0272		NA			49500	78	66	1040	5	6	60	16
T053	LY ND	30	F	99	SHOT	UNKNOWN	0.0017		0.234			14300	130	44	1420		116		15
T056	LG BK								1.088										
T060	LUNG	30	T	99	STABBED	UNKNOWN	0.3511		1.160			4700	100	9	2500	13	6	60	80
T062	LIVER	30	T	99	STABBED	UNKNOWN	0.4260		1.012			23100	460	110	5500	157	1	66	12
T061	KIDNY	30	T	99	STABBED	UNKNOWN	0.1194		1.088			13700	210	66	3300	1000	6	56	88
T066	VERT	30	T	99	STABBED	UNKNOWN	0.0439		NA			2500	22		2900	1		***	140
T064	BLOOD	30	T	99	STABBED	UNKNOWN	0.2163		NA										
T065	LY ND	30	T	99	STABBED	UNKNOWN	0.0052		NA			26000	102	15	1260	1	49	344	68
T071	LUNG	33	F	99	AUTO ACC	UNKNOWN	0.2634		0.615			6300	100	6	1400	91	9	16	16
T072	LIVER	33	F	99	AUTO ACC	UNKNOWN	0.3890		0.920			5700	490	200	5000	207	7	77	11
T073	KIDNY	33	F	99	AUTO ACC	UNKNOWN	0.1591		0.879			2130	150	80	4700	2400	11	51	31
T074	VERT	33	F	99	AUTO ACC	UNKNOWN	0.0410					11000	39		3100			456	90
T075	BLOOD	33	F	99	AUTO ACC	UNKNOWN	0.0298					74800	72	5	1290	5	5	67	69
T076	LY ND	33	F	99	AUTO ACC	UNKNOWN	0.0043				LOST								
T077	LG BK								1.137										
T081	LIVER	20	F	99	OD	UNKNOWN	0.3109		1.048			8000	140	11	1900	520	5	36	8
T082	VERT	20	F	99	OD	UNKNOWN	0.0551		NA			4700	62		3500	10	92	267	
T083	LUNG	99	9	99	UNKNOWN	UNKNOWN	0.3461		2.025			2500	94	23	800	36	2	21	35
T084	LIVER	99	9	99	UNKNOWN	UNKNOWN	0.4247		1.530			2000	310	20	800	32	1	61	9
T085	KIDNY	99	9	99	UNKNOWN	UNKNOWN	0.0626		1.235			2700	400	32	4400	1160	10	51	139
T090	VERT	99	9	99	UNKNOWN	UNKNOWN	0.0228		NA			21900	68	1	220	30	32	167	1
T086	BLOOD	99	9	99	UNKNOWN	UNKNOWN	0.0544		NA				84	20	950	17	6	36	4
T087	LY ND	99	9	99	UNKNOWN	UNKNOWN	0.01354		1.240			2400	94	9	150	93	9	78	420
T	LG BK								1.258										
T114	LUNG	99	9	99	UNKNOWN	UNKNOWN	0.3022		1.427			6700	66	4	590	6		12	0
T112	KIDNY	99	9	99	UNKNOWN	UNKNOWN	0.1507		1.347										
T111	VERT	99	9	99	UNKNOWN	UNKNOWN	0.0219		NA			9900	50	2	2900	6	84	301	1
T113	LY ND	99	9	99	UNKNOWN	UNKNOWN	0.0036		0.990			7600	90	7	750	10		35	
T115	LUNG	99	M	99	AUTO ACC	UNKNOWN	0.2335		1.860			9300	120	7	750	35		19	5
T116	LIVER	99	M	99	AUTO ACC	UNKNOWN	0.3790		1.151			3100	690	58	5300	15		151	21
T118	VERT	99	M	99	AUTO ACC	UNKNOWN	0.1050		NA				27	4	2600	2	46	350	
T117	BRAIN	99	M	99	AUTO ACC	UNKNOWN	0.1131		1.414										
T119	LUNG	38	M	99	HOMICIDE	POW OPR	0.4631		0.785			12100	100	4	910	81	3	26	56
T120	LIVER	38	M	99	HOMICIDE	POW OPR	0.5082		3.354			12600	240	40	840	14	3	70	3
T121	KIDNY	38	M	99	HOMICIDE	POW OPR	0.1662		3.171			1030	140	40	2600	2700	13	72	100
T122	VERT	38	M	99	HOMICIDE	POW OPR	0.0710		3.207			18300	28	1	1440	6	20	340	
T123	BLOOD	38	M	99	HOMICIDE	POW OPR	0.0525		NA			11800	80	10	450	1	20	30	
T124	LY ND	38	M	99	HOMICIDE	POW OPR	0.0076		NA			5900	50	1	610	14	90	1	1
T133	LUNG	24	F	02	OD	TRANQUE	0.3773	84.0	0.972		100	3	3000	100	6	600	44	3	20	27
T134	LIVER	24	F	02	OD	TRANQUE	0.5518	91.5	0.465		25	11	7300	400	56	3500	52	9	47	2
T135	KIDNY	24	F	02	OD	TRANQUE	0.1143	88.5	0.749		104	7	6700	150	69	3000	2300	33	55	39
T137	VERT	24	F	02	OD	TRANQUE	0.0314	87.0	1.111		27400	1	8700	51	10	2300	2	38	369	1
T139	BLOOD	24	F	02	OD	TRANQUE	0.0423		NA		43		34400	78	11	53	0	5	17	5
T138	LY ND	24	F	02	OD	TRANQUE	0.00456	28.0	1.351				6500	420	6	460	25		111	33

T213 VERT 23 M 00 INFARCT	STUDENT	0.0452	0.176		15500	115	29	2700	13		515	122				
T214 PLOOD 23 M 00 INFARCT	STUDENT	0.0706	NA		2000	283		1300	35		34	10				
T215 LY ND 23 M 00 INFARCT	STUDENT	0.0015	0.156		6000	50	17	600								
T216 LG BK			0.165													
T217 LUNG 25 F 99 DD	UNKNOWN	0.5385	0.121		8000	100	3	700	3		11	12				
T218 LIVER 25 F 99 DD	UNKNOWN	0.5842	0.140		5300	460	28	4900	59		39	9				
T219 KIDNY 25 F 99 DD	UNKNOWN	0.1116	0.229		6300	330	47	4600	850		40	29				
T220 VERT 25 F 99 DD	UNKNOWN	0.0731	0.156		4500	26	3	2200	8		306	87				
T221 PLOOD 25 F 99 DD	UNKNOWN	0.0568	NA		23300	150	6	1760	13	35	14	10				
T222 LY ND 25 F 99 DD	UNKNOWN	0.0037	0.137		9500	122	7		20		47	69				
T223 LG BK			0.103													
T224 LUNG 35 M 00 PULM TB	MENTL INST	0.2615	0.178	LOST												
T225 LIVER 35 M 00 PULM TB	MENTL INST	0.3196	0.196		5200	210	29	2300	47		13	8				
T226 KIDNY 35 M 00 PULM TB	MENTL INST	0.0697	0.145		5300	250	67	2800	950		30	1				
T227 VERT 35 M 00 PULM TB	MENTL INST	0.0200	0.123		7400	103	3	4200	7		830	121				
T228 PLOOD 35 M 00 PULM TB	MENTL INST	0.0645	NA		11000	120	12	530	20		11	8				
T229 LY ND 35 M 00 PULM TB	MENTL INST	0.0090	0.140		7500	103	16	1440	16		91	56				
T230 BL TR 35 M 00 PULM TB	MENTL INST	0.0112	NA		5200	71	36	890	13		38	22				
T231 LG BK			0.095													
T232 LUNG 36 M 00 NAT DIAB	POSTL CLRK	0.5306	0.196		4200	70	4	1300	6		15	7				
T233 LIVER 36 M 00 NAT DIAB	POSTL CLRK	0.7648	0.231		4600	600	51	7700	94		92	7				
T234 KIDNY 36 M 00 NAT DIAB	POSTL CLRK	0.1524	0.183		5200	130	70	2600	1310		35	65				
T235 VERT 36 M 00 NAT DIAB	POSTL CLRK	0.0522	0.165		5600	23		1900	8		180	82				
T236 PLOOD 36 M 00 NAT DIAB	POSTL CLRK	0.0623	NA		+++++	56		600			23	8				
T237 LY ND 36 M 00 NAT DIAB	POSTL CLRK	0.0028	0.199		25000		45	610								
T238 LG BK			0.245													
T239 LUNG 23 F 99 DD	UE	0.4917	0.250		9300	130	9	800	33		24	9				
T240 LIVER 23 F 99 DD	UE	0.7054	0.249		1400	120	78	3000	43		43	14				
T241 KIDNY 23 F 99 DD	UE	0.1474	0.224		5300	210	51	3100	2580		34	7				
T242 VERT 23 F 99 DD	UE	0.0234	0.212		5000	47	4	3300	17		436	173				
T243 PLOOD 23 F 99 DD	UE	0.0285	NA		32100	114	20	770	22		31	13				
T244 LY ND 23 F 99 DD	UE	0.0029	0.220		8300	190		800	52		52	26				
T245 LUNG 24 M 02 DD METH	CAB DRIVER	0.4491	0.241		32000	90	9	800	33	6	29	26				
T246 LIVER 24 M 02 DD METH	CAB DRIVER	0.3423	0.275		10200	29	105	1100	19	4	73	117				
T247 KIDNY 24 M 02 DD METH	CAB DRIVER	0.1175	0.145													
T248 VERT 24 M 02 DD METH	CAB DRIVER	0.1080	0.277		3400	25	1	2700	1	43	245	60				
T249 PLOOD 24 M 02 DD METH	CAB DRIVER	0.0561	NA		54000	89	5	730	1	2	29	13				
T250 LY ND 24 M 02 DD METH	CAB DRIVER	0.0174	0.116		8500	57	26	680	7	1	13	9				
T251 BL TR 24 M 02 DD METH	CAB DRIVER	0.0235	NA		14000	213	47	++++	19	4	33	4				
T252 LG BK			0.237													
T253 LUNG 23 M 00 FELL	CLRK/SUPER	0.3563	0.112													
T254 LIVER 23 M 00 FELL	CLRK/SUPER	0.5115	0.080													
T255 KIDNY 23 M 00 FELL	CLRK/SUPER	0.0761	0.234													
T256 VERT 23 M 00 FELL	CLRK/SUPER	0.0562	0.084													
T257 PLOOD 23 M 00 FELL	CLRK/SUPER	0.0425	NA													
T258 LY ND 23 M 00 FELL	CLRK/SUPER	0.0016	0.159													
T259 LG BK			0.102													
T260 LUNG		0.3563	0.113													
T261 LIVER		0.5115	0.080													
T262 KIDNY		0.0761	0.234													
T263 VERT		0.0562	0.084													
T264 PLOOD		0.0425*	NA													
T265 LY ND		0.0016	NA													
T266 LG BK			0.102													
T267 LUNG 24 M 99 DD	WHITE COL	0.4453	0.119		7800	90	1	700			11	11				
T268 LIVER 24 M 99 DD	WHITE COL	0.6394	0.107		800	350	21	3300	10		22	9				
T269 KIDNY 24 M 99 DD	WHITE COL	0.1093	0.126		7000	270	90	4500	2560		52	16				
T270 VERT 24 M 99 DD	WHITE COL	0.0439	0.117		5000	75	9	4600	153		150	150				

T277	BLOOD	24	M	99	OD		WHITE COL	0.0682*		NA				7800	92	1	700			11	1
T278	LY ND	24	M	99	OD		WHITE COL	0.0064		0.103				7000	125	31	630	8		74	
T279	LG BK									0.145											
T280	LUNG	37	M	01	AUTO	ACC	BANKGUARD	0.4229		0.109				7800	90	10	920	33		17	2
T281	LIVER	37	M	01	AUTO	ACC	BANKGUARD	0.4845		0.199				700	410	11	1900	19		29	8
T282	KIDNY	37	M	01	AUTO	ACC	BANKGUARD	0.1081		0.168				3500	190	104	6000	3050		24	18
T283	VERT	37	M	01	AUTO	ACC	BANKGUARD	0.1370		0.111				4500	36	1	2800	4		152	50
T284	BLOOD	37	M	01	AUTO	ACC	BANKGUARD	0.0630*						9800	89	2	490			12	8
T285	LY ND	37	M	01	AUTO	ACC	BANKGUARD	0.0090*		0.100				3500	64	8	1330	6	3	25	28
T287	LG BK									0.281											
T288	LUNG	45	F	03	MULT	SCR	BED RIDDEN	0.5996		0.198				3000	90	4	720	58		27	8
T289	LIVER	45	F	03	MULT	SCR	BED RIDDEN	0.6547		0.132				700	310	35	4900	150		78	9
T290	KIDNY	45	F	03	MULT	SCR	BED RIDDEN	0.1714		0.157				3000	190	66	3500	3790		49	16
T291	VERT	45	F	03	MULT	SCR	BED RIDDEN	0.0528		0.125				7800	63		3000	8		990	90
T294	BLOOD	45	F	03	MULT	SCR	BED RIDDEN	0.0326*		NA				3400	108	3	540	12	3	22	15
T295	LY ND	45	F	03	MULT	SCR	BED RIDDEN	0.0148*		0.153				4400	86	10	640	25	19	18	30
T296	LUNG	36	F	99	OD		UNKNOWN	0.4413		0.215				10400	180	24	1100	8		22	20
T297	LIVER	36	F	99	OD		UNKNOWN	0.5329		0.159				700	290	32	2100	6		33	18
T298	KIDNY	36	F	99	OD		UNKNOWN	0.1516		0.238				5500	250	94	5500	3500		59	67
T299	VERT	36	F	99	OD		UNKNOWN	0.1013		0.176				1100	48	1	2100	2		420	60
T300	BLOOD	36	F	99	OD		UNKNOWN	0.0026*		NA				16100	196	19	3100		130	29	135
T301	LY ND	36	F	99	OD		UNKNOWN	0.0116*		0.205				3300	97	9	1160	22	19	11	30
T302	BX TB	36	F	99	OD		UNKNOWN	0.0160*		NA				2200	139	16	940	20	16	39	45
T305	LUNG	27	M	01	LEUK		FACT WRK	0.6305		0.161				12000	140	6	870	10	6	9	
T306	LIVER	27	M	01	LEUK		FACT WRK	0.4541		0.129				52000	270	60	7700	8		295	
T307	KIDNY	27	M	01	LEUK		FACT WRK	0.1804		0.162				4100	230	26	800	500		14	170
T308	VERT	27	M	01	LEUK		FACT WRK	0.0922		0.152				10000	64	2	1700	1	29	124	54
T309	BX JR	27	M	01	LEUK		FACT WRK	0.0123*		0.152				10000	140	10	870	1	18	26	49
T310	BX TB	27	M	01	LEUK		FACT WRK	0.0120*		0.152											
T311	BX TB	27	M	01	LEUK		FACT WRK	0.0214*		NA				3000	89	5	580	5	11	13	16
T304	LG BK									0.166											
T314	LUNG	19	M	99	ACCIDEN		UNKNOWN	0.2998		0.171				10000	110	19	1000	19	5	11	
T315	LIVER	19	M	99	ACCIDEN		UNKNOWN	0.5271		0.164				1000	660	38	++++	99	2	6	
T316	KIDNY	19	M	99	ACCIDEN		UNKNOWN	0.1543		0.111				3000	430	71	4200	650	2	26	740
T317	VERT	19	M	99	ACCIDEN		UNKNOWN	0.0822		0.173				6200	51	2	2200	19	34	99	60
T319	BLOOD	19	M	99	ACCIDEN		UNKNOWN	0.0097*		NA				27000	180	10	3000	18	10	4	15
T318	LY ND	19	M	99	ACCIDEN		UNKNOWN	0.0045*		0.162				6800	310	56		78	72	150	311
T320	BX TB	19	M	99	ACCIDEN		UNKNOWN	0.0220*		NA				2000	202	30	4500	36	14	26	30
T323	LUNG	38	F	03	HEPT	ATT	HOUSEWIFE	0.3619		0.132				660	120	1	1600	5	3	13	7
T324	LIVER	38	F	03	HEPT	ATT	HOUSEWIFE	0.5064		0.143				700	410	4	4700	8		24	5
T325	KIDNY	38	F	03	HEPT	ATT	HOUSEWIFE	0.0863		0.169				10000	230	56	4400	2200	3	24	14
T326	VERT	38	F	03	HEPT	ATT	HOUSEWIFE	0.0672		0.134				4900	24		4200		48	141	55
T327	BLOOD	38	F	03	HEPT	ATT	HOUSEWIFE	0.0592*		NA				22000	131	9	1230	1	1	13	3
T328	LY ND	38	F	03	HEPT	ATT	HOUSEWIFE	0.0164*		0.167				12000	160	15	810	15	8	11	
T329	BX TB	38	F	03	HEPT	ATT	HOUSEWIFE	0.0219*		NA				850	380	38		74	1	37	2
T322	LG BK									0.158											
T332	LUNG	27	M	03	BARB	POI	WHT COLLAR	0.6198	81.5	0.302	0.45	0.09		3700	120	2	1500	71		14	6
T333	LIVER	27	M	03	BARB	POI	WHT COLLAR	0.6012	80.0	0.169	0.54	0.09		7600	530	15	8000	54		103	12
T334	KIDNY	27	M	03	BARB	POI	WHT COLLAR	0.1222	84.5	0.145	0.02	0.01		15000	210	78	4200	1700		62	9
T335	VERT	27	M	03	BARB	POI	WHT COLLAR	0.0444	84.0	0.168	0.54	0.18		10600	36	7	5600	18		117	74
T336	BLOOD	27	M	03	BARB	POI	WHT COLLAR	0.0283*		NA				13000	240	19	2200	120	1	33	
T337	LY ND	27	M	03	BARB	POI	WHT COLLAR	0.0118*	40.8	0.099	0.00	1.30		9500	108	19	1460	30	21	34	36
T338	BX TB	27	M	03	BARB	POI	WHT COLLAR	0.0231*		NA				870	168	2	2500	111	2	53	4
T341	LUNG	29	F	01	OD	BARB	SECRETARY	0.4196		0.143				17500	95	7	1050	50	4	18	20
T342	LIVER	29	F	01	OD	BARB	SECRETARY	0.7199		0.156				400	580	13	2500	12	12	28	12
T343	KIDNY	29	F	01	OD	BARB	SECRETARY	0.1109		0.179				7100	230	87	3200	140	320	48	300
T344	VERT	29	F	01	OD	BARB	SECRETARY	0.1269		0.158				8763	26		1		38	67	21
T345	BLOOD	29	F	01	OD	BARB	SECRETARY	0.0633*		NA				43000	160	4	830	7	3	15	21

T347	LY ND	29	F	01	OD BARB	SECRETARY	0.0101*		0.164				10200	163	19	1200	29	22	39	14
T340	LG BK								0.168											
T350	LUNG	15	F	01	POISON	STUDENT	0.2396		0.165				20000	120	6	970	2	59	19	21
T351	LIVER	15	F	01	POISON	STUDENT	0.2399		0.156				3000	900	31	6200			44	17
T352	KIDNY	15	F	01	POISON	STUDENT	0.0749		0.137				89500	390	77	3100	710	2	56	930
T353	VERT	15	F	01	POISON	STUDENT	0.1448		0.135				1520	20	3	1240	1	17	105	39
T354	BLOOD	15	F	01	POISON	STUDENT	0.0664*		NA				35400	109	2	690	3	2	17	19
T355	LY ND	15	F	01	POISON	STUDENT	0.0070*		0.150				9600	107	64	640	0	19	21	125
T356	BR TB	15	F	01	POISON	STUDENT	0.0127*		NA				4900	108	14	1100	10	8	24	26
T358	LUNG	99	9	99	UNKNOWN	UNKNOWN	0.3500		0.140				11400	97	16	690	5	7	25	23
T359	LIVER	99	9	99	UNKNOWN	UNKNOWN	0.6223		0.129				7500	750	20	59	32	5	141	18
T360	KIDNY	99	9	99	UNKNOWN	UNKNOWN	0.0873		0.142				5300	240	90	4000	2500	11	66	31
T361	VERT	99	9	99	UNKNOWN	UNKNOWN	0.0713		0.126				3200	29	7	1700	1	36	461	69
T362	BLOOD	99	9	99	UNKNOWN	UNKNOWN	0.0305*		NA				20200	57	5	350	3	3	19	15
T363	LY ND	99	9	99	UNKNOWN	UNKNOWN	0.0190*		0.133				6500	63	13	700	3	13	23	33
T364	BR TB	99	9	99	UNKNOWN	UNKNOWN	0.0203*		NA				11000	78	12		5	5	21	12
T357	LG BK								0.161											
T368	LUNG	19	M	02	OD	UE	0.3255		0.096				16000	100	6	970	35	7	25	19
T369	LIVER	19	M	02	OD	UE	0.4586		0.159				2400	4430	23	4400	22	2	80	13
T370	KIDNY	19	M	02	OD	UE	0.0892		0.139				12100	230	85	4400	2350	10	72	43
T371	VERT	19	M	02	OD	UE	0.0810		NA				8000	60	20	3300	5	54	456	70
T372	BLOOD	19	M	02	OD	UE	0.0544*		NA				32600	95	5	740	1	1	25	15
T373	LY ND	19	M	02	OD	UE	0.0127*		0.148				3900	112	4	610	12	8	35	24
T374	BR TB	19	M	02	OD	UE	0.0173*		NA				4900	91	18	1100	16	6	22	24
T376	LUNG	39	M	03	CRSH SKL	BOWERY BUM	0.4353		0.229				17400	173	10	960	39	16	20	18
T377	LIVER	39	M	03	CRSH SKL	BOWERY BUM	0.5643		0.146				700	165	6	1260	7		8	6
T378	KIDNY	39	M	03	CRSH SKL	BOWERY BUM	0.1161		0.125				4700	190	44	4100	2300	1	59	13
T379	VERT	39	M	03	CRSH SKL	BOWERY BUM	0.1207		0.172				7200	38	0	2200	3	53	680	130
T380	BLOOD	39	M	03	CRSH SKL	BOWERY BUM	0.0240*		NA				42900	119	4	720	1	5	32	17
T381	LY ND	39	M	03	CRSH SKL	BOWERY BUM	0.0182*		0.160				11100	63	6	520	6	19	57	5
T382	BR TB	39	M	03	CRSH SKL	BOWERY BUM	0.0220*		NA				1900	75	11	670	17	5	25	9
T375	LG BK								0.181											
T383	LUNG	15	M	00	DROWNED	STUDENT	0.3462		0.156				32400	90	12	1040	8	5	14	12
T384	LIVER	15	M	00	DROWNED	STUDENT	0.5046	75.0	0.158	0.39	0.07	45	3200	2500	120	7000	145	1	58	14
T385	KIDNY	15	M	00	DROWNED	STUDENT	0.0939	69.5	0.124	0.27	0.17	326	8400	250	108	3400	930	6	46	16
T386	VERT	15	M	00	DROWNED	STUDENT	0.1013		0.140				5700	86	7	2900	5	57	89	135
T387	BLOOD	15	M	00	DROWNED	STUDENT	0.0146*		NA				26900	313	12	1280	26	3	27	3
T388	LY ND	15	M	00	DROWNED	STUDENT	0.0119*		0.096				5400	96	13	720	2	90	20	0
T389	BR TB	15	M	00	DROWNED	STUDENT	0.0195*		NA				2800	310	24	1600	42	6	9	16
T395	LIVER	19	M	00	AUTO ACC	STUDENT	0.4679	70.0	0.155			41	5168	2855	1644	8224	115		65	22
T396	KIDNY	18	M	00	AUTO ACC	STUDENT	0.1169	70.0	0.162	0.65	0.31	100	5143	232	90	3599	1109		33	2
T397	VERT	18	M	00	AUTO ACC	STUDENT	0.1146		0.078				9407	66	4	3297	3		79	19
T398	BLOOD	18	M	00	AUTO ACC	STUDENT	0.0608*		NA				32039		102	2	403		11	4
T399	LY ND	18	M	00	AUTO ACC	STUDENT	0.0176*		0.154				11018	118	7	893	3		36	16
T400	BR TB	19	M	00	AUTO ACC	STUDENT	0.0199*						6812	117	26	643	8	5	26	9
T393	LG BK								0.096											
T401	LUNG	44	M	99	SUICIDE	UE	0.3203		0.152				35479	176	11	998	50	48	19	10
T402	LIVER	44	M	99	SUICIDE	UE	0.5768		0.160				7609	451	33	3358	274		39	50
T403	KIDNY	44	M	99	SUICIDE	UE	0.1069		0.165				1597	283	49	5037	3635		30	430
T404	VERT	44	M	99	SUICIDE	UE	0.0560		0.147				12695	59	11	4579	11		354	46
T405	BLOOD	44	M	99	SUICIDE	UE	0.0199*		NA				32676	127	5	842	30		24	9
T406	LY ND	44	M	99	SUICIDE	UE	0.0306*		0.152				6482	72	8	521	14	29	48	17
T407	BR TB	44	M	99	SUICIDE	UE	0.0284*		NA				379	114	18	983	58		26	10
T413	LUNG	37	F	02	SKLL FRT	SECRETARY	0.6314		0.128				23163	192	15	1458	193	5	14	11
T414	LIVER	37	F	02	SKLL FRT	SECRETARY	0.4542	70.5	0.143	0.51	0.29	50	3582	957	51	4060	396		45	14
T415	KIDNY	37	F	02	SKLL FRT	SECRETARY	0.0902	70.0	0.135	0.08	0.14	116	8904	387	55	4445	3251	7		876
T416	VERT	37	F	02	SKLL FRT	SECRETARY	0.0823		0.122				3295	57		3281	6		174	172
T417	BLOOD	37	F	02	SKLL FRT	SECRETARY	0.0403*		NA				16414	406	29	1389	179	2	12	15

T419	LY ND	37	F	02	SKLL FRT	SECRETARY	0.0362*		0.118						882	532	23	1464	119		18	19		
T419	BR TB	37	F	02	SKLL FRT	SECRETARY	0.0131*		NA						7353	160	27	1019	65		21	40		
T419	LG BK								0.299															
T420	LUNG	19	M	00	AUTO ACC	INSUL WORK	0.3338		0.137						25093	25	7	1448	7	1	18	9		
T421	LIVER	19	M	00	AUTO ACC	INSUL WORK	0.5131	74.0	0.136						4765	1012	71	9515	156		132	12		
T422	KIDNY	19	M	00	AUTO ACC	INSUL WORK	0.0841	68.5	0.143						9510	287	94	4920	1055		64	14		
T423	VERT	19	M	00	AUTO ACC	INSUL WORK	0.0930		0.129						11366	42		3958	1		98	62		
T424	BLOOD	19	M	00	AUTO ACC	INSUL WORK	0.0649*		NA						39087	91		535			21	8		
T425	LY ND	19	M	00	AUTO ACC	INSUL WORK	0.0044*		0.156						10057	170		841				17		
T426	BR TB	19	M	00	AUTO ACC	INSUL WORK	0.0199*		NA						1427	77	9	474	5		6	8		
T434	LUNG	30	M	00	AUTO ACC	LONG SHORM	0.5198		0.206						15513	124	25	1066	52	6	18	8		
T435	LIVER	30	M	00	AUTO ACC	LONG SHORM	0.6522	70.0	0.137				43		17436	1052	82	7251	101		89	8		
T436	KIDNY	30	M	00	AUTO ACC	LONG SHORM	0.1474	69.0	0.137	0.09	0.13		68		56479	235	65		1775		39	10		
T437	BLOOD	30	M	00	AUTO ACC	LONG SHORM	0.0703*		NA						33044	134	1	449	2	2	21	6		
T433	LY ND	30	M	00	AUTO ACC	LONG SHORM	0.0197*		0.128						6230	72	10	425	11	11	10			
T439	BR TB	30	M	00	AUTO ACC	LONG SHORM	0.0195*		NA						3376	277	32	1572	81	3	18	6		
T433	LG BK								0.191															
T440	LUNG	29	F	00	HERT ATT	FILE CLERK	0.4173		0.214						30990	280	9	1076	17	2	14			
T441	LIVER	29	F	00	HERT ATT	FILE CLERK	0.3739		0.455						8829	330	115	4244	252		29	16		
T442	KIDNY	29	F	00	HERT ATT	FILE CLERK	0.0731		0.160						7419	302	55	4993	1675	1	21	21		
T443	VERT	29	F	00	HERT ATT	FILE CLERK	0.1091		0.168						9251	36	2	4154	4	1	78	69		
T444	BLOOD	29	F	00	HERT ATT	FILE CLERK	0.0256*		NA						36279	121	4	628	23	5		2		
T445	LY ND	29	F	00	HERT ATT	FILE CLERK	0.0144*		0.130						23108	132	12	750	14	7	10	10		
T446	BR TB	29	F	00	HERT ATT	FILE CLERK	0.0130*		NA						10944	148	13	708	17	13	29	12		
T452	LUNG	23	F	99	OD METH	UNKNOWN	0.4005		0.463						1158	113		814	46		18	11		
T453	LIVER	23	F	99	OD METH	UNKNOWN	0.3663	77.0	0.337	0.71	0.06		67	6	3975	625	51	4530	172	81	154	15		
T454	KIDNY	23	F	99	OD METH	UNKNOWN	0.1003	80.0	0.672	0.09	0.11		86	4	12493	214	56	1570	1359	13	84	9		
T455	VERT	23	F	99	OD METH	UNKNOWN	0.1021*	92.2	0.563	0.29	0.23	19700	1		8198	88	10	3562	29	42	260	198		
T456	BLOOD	23	F	99	OD METH	UNKNOWN	0.0127*		0.433						28898	173	8	972	33		22	16		
T457	LY ND	23	F	99	OD METH	UNKNOWN	0.0175*		0.394						12256	119	7	660	23		24	17		
T458	BR TB	23	F	99	OD METH	UNKNOWN	0.0106*		0.315															
T451	LG BK								0.477															
T500	LUNG	33	M	99	UNKNOWN	UE	0.6264		0.250															
T459	LIVER	33	M	99	UNKNOWN	UE	0.6737		0.389						1104	191	15	1190			33	29		
T460	STOMCH	33	M	99	UNKNOWN	UE	0.1077		0.323															
T461	BILE	33	M	99	UNKNOWN	UE	0.0196*		0.380															
T462	SM BK								0.272															
T447	LUNG	18	M	01	CRSHD HD	COKE PLANT	0.3221		0.745						2294	83	1	914	39	1	19	4		
T448	LIVER	18	M	01	CRSHD HD	COKE PLANT	0.4094	78.0	0.631	0.52	0.12		35		1914	1069	22	4809	58		122	7		
T449	KIDNY	18	M	01	CRSHD HD	COKE PLANT	0.1108	72.0	0.605				87		6737	247	75	2671	526	1	63	20		
T470	VERT	18	M	01	CRSHD HD	COKE PLANT	0.1330		0.575						6481	30	1	1184		29	87	180		
T471	BLOOD	18	M	01	CRSHD HD	COKE PLANT	0.0074*		0.392						57905	81	3	364			67	23		
T472	LY ND	18	M	01	CRSHD HD	COKE PLANT	0.0134*		0.455						6111	63	7	574	3	6	18			
T473	BR TB	18	M	01	CRSHD HD	COKE PLANT	0.0135*		0.388						10470	259	22	1964	22		24			
T474	LUNG	28	M	02	OD	UE/FURRIER	0.5062		0.581						1546	94	33	950	13	2	10	5		
T475	LIVER	28	M	02	OD	UE/FURRIER	0.5698	75.5	0.555	0.37	0.07		77		3460	284	52	3536	47	2	48	56		
T476	KIDNY	28	M	02	OD	UE/FURRIER	0.1596		0.518	LOST														
T477	VERT	28	M	02	OD	UE/FURRIER	0.0835		0.397						32335	95	10	2870	3		241	367		
T478	BLOOD	28	M	02	OD	UE/FURRIER	0.0218*		0.168						59667	121	24	1279	9	2	24	6		
T479	LY ND	28	M	02	OD	UE/FURRIER	0.0265*		0.253						16226	78	15	915	7	5	12			
T487	LUNG	25	F	03	OD	STUDENT	0.5648		0.643						7386	84	1	395	11	1	14			
T488	LIVER	25	F	03	OD	STUDENT	0.6296	64.5	0.651	0.73	0.51		29		5038	379	26	2452	10		50	10		
T489	KIDNY	25	F	03	OD	STUDENT	0.1343	70.0	0.659				92		4548	297	22	2499	32	2	29			
T490	VERT	25	F	03	OD	STUDENT	0.0644		0.627						19580	88	3	4010	7	38	399	142		
T491	BLOOD	25	F	03	OD	STUDENT	0.0669*		0.593						64872	202	11	833	23	3	17			
T492	LY ND	25	F	03	OD	STUDENT	0.0172*		0.436						14670	114	10	747	26	10	37	17		
T493	BR TB	25	F	03	OD	STUDENT	0.0147*		0.657						6612	115	10	758	29		119	13		
T496	SM BK								0.659															

T497	LUNG	43	F	00	SUFFICTE	HOUSEWIFE		0.3548		0.529						6916	101	5	1008	16	2	17		
T498	LIVER	43	F	00	SUFFICTE	HOUSEWIFE		0.6784	65.0	0.747	0.14		31											
T499	KIDNY	43	F	00	SUFFICTE	HOUSEWIFE		0.0929		0.722	0.12	0.12	90			4118	194	51	6851		7	39	13	
T500	VERT	43	F	00	SUFFICTE	HOUSEWIFE		0.0443		0.649	0.00	2.56	60900			21352	74	4	3294		38	469	81	
T501	BLOOD	43	F	00	SUFFICTE	HOUSEWIFE		0.0232*		0.675						76196	112	7	1098	5	3	27	38	
T502	LY ND	43	F	00	SUFFICTE	HOUSEWIFE		0.0160*		0.592						11756	173	34	1103	10	79	21	106	
T503	BR TR	43	F	00	SUFFICTE	HOUSEWIFE		0.0143*		0.733						12830	170	45	1144	29	21	33	73	
T506	LG BK								77.0	0.512														
T507	LUNG	99	9	99	UNKNOWN	UNKNOWN		0.4158		0.594						9687	69	6	535	21	8	9		
T508	LIVER	99	9	99	UNKNOWN	UNKNOWN		0.3147	74.5	0.586	0.38	0.16	35			4459	469	110	4049	99	5	61		
T509	KIDNY	99	9	99	UNKNOWN	UNKNOWN		0.1372	84.0	0.657	0.11	0.08	69			3759	198	75	2928	3371	2	21		
T510	VERT	99	9	99	UNKNOWN	UNKNOWN		0.0364	77.5	0.734	0.87	0.39	61000			4554	43		2917	5	41	326		
T511	BLOOD	99	9	99	UNKNOWN	UNKNOWN		0.0377*		0.565						21580	96	2	362	5	1	5	9	
T512	LY ND	99	9	99	UNKNOWN	UNKNOWN		0.0082*		0.660						6605	1	24	1098	57	21	36	48	
T513	BR TR	99	9	99	UNKNOWN	UNKNOWN		0.0198*		0.610						6597	97	13	728	39	11	15	37	
T514	LUNG	47	M	00	UNKNOWN	PARK DEPT		0.4449	82.5	0.538	-.09	0.09	69	4		6639		1	500	2	2	7		
T515	LIVER	47	M	00	UNKNOWN	PARK DEPT		0.5666	84.0	0.564	0.20	0.09	49	4		3236		46	7880	145	1	57		
T516	KIDNY	47	M	00	UNKNOWN	PARK DEPT		0.1182	83.5	0.659	-1.1	1.12	138	6		5927		60	3808	1799		27		
T517	VERT	47	M	00	UNKNOWN	PARK DEPT		0.0860	83.5	0.682	LOST		56400	4		17058		3	2524	4	124	170		
T518	BLOOD	47	M	00	UNKNOWN	PARK DEPT		0.0358*		0.706						31694	86	2	688	15	4	12	24	
T519	LY ND	47	M	00	UNKNOWN	PARK DEPT		0.0239*		0.558						17436	122	7	1097	6	25	79	37	
T520	BR TR	47	M	00	UNKNOWN	PARK DEPT										9704	155	25	1145	14	4	25	64	
T521	SM BK									0.629														
T525	LUNG	32	M	02	00		STUDENT	0.4554		0.299						22419		8	926	16	4	19		
T526	LIVER	32	M	02	00		STUDENT	0.6349		0.270						11935		51	1760	36	1	60		
T527	KIDNY	32	M	02	00		STUDENT	0.1117		0.315						12551		97	2904	1068	7	60		
T528	VERT	32	M	02	00		STUDENT	0.1406		NA														
T529	BLOOD	32	M	02	00		STUDENT	0.0116*		0.370						40711	165	6	575	6		10	47	
T530	LY ND	32	M	02	00		STUDENT	0.0235*		NA						66398	68	29	650	10	12	9	16	
T531	BR TR	32	M	02	00		STUDENT	0.0166*		NA						10066	64	18	603	3	6	58	9	
T533	SM BK									0.336														
T534	LG BK									0.393														
T535	LUNG	38	M	03	HEPT ATT	CONST WRK		0.5135		0.262						99805	116	6	924	51	6	21	7	
T536	LIVER	38	M	03	HEPT ATT	CONST WRK		0.9201	83.5	0.283						11646	589	81	2323	180	1	44	3	
T537	KIDNY	38	M	03	HEPT ATT	CONST WRK		0.1560	80.0	0.306						6314	161	62	2551	1259	1	34	8	
T538	VERT	38	M	03	HEPT ATT	CONST WRK		0.1057		0.346						6970	31		2032	1	94	282	185	
T539	BLOOD	38	M	03	HEPT ATT	CONST WRK		0.0226*		0.160						28849	67	2	224		2	1	15	
T540	LY ND	38	M	03	HEPT ATT	CONST WRK		0.0316*		0.302														
T541	BR TR	38	M	03	HEPT ATT	CONST WRK		0.0213*		0.278						14002	118	18	1023	16	7	5	30	
T543	LUNG	82	M	00	POISON	STEEL WRK		0.5672		0.250						12658	61	3	233	1	6	2	6	
T544	LIVER	82	M	00	POISON	STEEL WRK		0.3846		0.264						10434	1109	99	5148	11	2	20	8	
T545	KIDNY	82	M	00	POISON	STEEL WRK		0.1329		0.278						312	6	2	113	53				
T546	VERT	82	M	00	POISON	STEEL WRK		0.1027		0.196						10808	41		2182	1	75	133	139	
T547	BLOOD	82	M	00	POISON	STEEL WRK		0.0634*		0.309						44676	240	3	614	6	2	3		
T548	LY ND	82	M	00	POISON	STEEL WRK		0.0165*		0.349						13790	37	18	266	1	19			
T549	BR TR	82	M	00	POISON	STEEL WRK		0.0287*		0.255						6047	91	10	746	7		7	3	3
T552	LUNG	35	M	01	00		SHIPP CLK	0.6398		0.381						19690	84	10	928	23	7	17	9	
T553	LIVER	35	M	01	00		SHIPP CLK	0.5521		0.412						6038	448	87	3349	35	1	29	8	
T554	KIDNY	35	M	01	00		SHIPP CLK	0.1376		0.340						9257	194	77	6493	3439	8	26	10	
T555	VERT	35	M	01	00		SHIPP CLK	0.0940		0.389						10445	59	14	4335	4	52	177	36	
T556	BLOOD	35	M	01	00		SHIPP CLK	0.0504*		0.381						54812	127	7	908	4		168		
T557	LY ND	35	M	01	00		SHIPP CLK	0.0287*		0.354						15070	85	14	785	12				
T558	BR TR	35	M	01	00		SHIPP CLK	0.0171*		0.384						11067	94	20	1107	25				
T560	LUNG	22	M	02	00		UE	0.6657		0.430						10714	95	2	803	8	2	8	11	
T561	LIVER	22	M	02	00		UE	0.5036	70.5	0.442			63.			5812	578	37	3496	7	3	34	12	
T562	KIDNY	22	M	02	00		UE	0.1010	76.0	0.410			86			6084	213	50	3832	1554	3	42	10	
T563	VERT	22	M	02	00		UE	0.1245	80.5	0.397														
T564	BLOOD	22	M	02	00		UE	0.0639		0.396						23299	257	13	++++	4	4	9	13	