HETA 95-0375-2590
Bally's Park Place Casino Hotel
Atlantic City, New Jersey

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Douglas Trout, M.D., M.H.S., and John Decker, M.S., C.I.H. of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Barbara Mackenzie, Jenise Brassell, and Max Kiefer. Desktop publishing was provided by Pat McGraw. Statistical support was provided by Charles Mueller, M.S.

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July 1996

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SUMMARY

In August 1995 the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a Health Hazard Evaluation (HHE) concerning exposure to second-hand (environmental) tobacco smoke (ETS) among employees at Bally's Park Place Casino Hotel in Atlantic City, New Jersey. In response to this request, NIOSH conducted a field study on March 13-16, 1996, during which environmental sampling, questionnaire administration, and biological monitoring were conducted.

Vapor-phase nicotine and respirable particulates were monitored as marker substances for exposure to ETS. A total of 18 personal breathing zone (PBZ) samples for nicotine were collected. In addition, ten area samples for nicotine vapor and ten area respirable dust samples were collected at various gaming pit locations. Personal airborne nicotine exposures for the March 14 (Thursday evening) monitoring ranged from 6-12 $\mu g/m^3$ (geometric mean: 8 $\mu g/m^3$), expressed as time-weighted averages (TWAs). The highest personal sample result (12 $\mu g/m^3$) was found on a dealer working Caribbean Stud Poker. Area TWA air concentrations (6-10 $\mu g/m^3$, geometric mean: 8 $\mu g/m^3$) were similar to the personal sample results. For the March 15 (Friday evening) monitoring, the personal sample results were slightly higher, ranging from 4-15 $\mu g/m^3$ as TWAs (geometric mean: 10 $\mu g/m^3$). The highest personal sample result (15 $\mu g/m^3$) was again found on a dealer working Caribbean Stud Poker. Area air concentrations ranged from 8 to 16 $\mu g/m^3$ as TWAs (geometric mean: 11 $\mu g/m^3$). The two highest area air concentrations on each night were taken at poker registration and the poker tables. On both evenings, area air concentrations of respirable dust fraction ranged from non-detected (detection limit: 20-30 $\mu g/m^3$) to 90 $\mu g/m^3$. The concentrations of both nicotine and respirable dust were similar to those published in the literature for other non-industrial indoor environments. Carbon dioxide concentrations generally were less than the 1000 ppm criterion suggested by the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE). Temperature and relative humidity measurements taken throughout the gaming areas were all within the ranges specified by ASHRAE.

Twenty-nine employees (10% of the total number of dealers and supervisors at work during the evaluation) participated in the medical evaluation, including 18 dealers and 11 supervisors. No participants reported current tobacco use. The geometric mean serum cotinine levels were 1.34 nanograms per milliliter (ng/ml) (pre-shift) and 1.85 ng/ml (post-shift), which both exceeded the mean value of 0.93 ng/ml for participants in the Third National Health and Nutrition Examination Survey (NHANES III) who had reported exposure to ETS at both home and work. Post-shift cotinine levels for both serum and urine were significantly greater than pre-shift levels. There was a weak positive correlation (not statistically significant) between serum and urine cotinine values (post-shift) and airborne nicotine for those who had PBZ air sampling performed during their workshift. Four persons worked all or part of their shift at non-smoking tables; there were no differences in the serum and urine cotinine levels, nor in the PBZ nicotine levels, between these persons and participants who reported working at smoking tables. Four

participants worked at poker tables during their workshift; their measured post-shift serum cotinine levels were 2.22, 2.33, 2.70, and 2.91 ng/ml, which were among the highest levels observed in our evaluation.

This evaluation demonstrates that employees working in the gaming areas of a large casino are exposed to ETS at levels greater than those observed in a representative sample of the U.S. population, and that the serum and urine cotinine of these employees increases during the workshift. Exposure to ETS is similar throughout the gaming area, and it appears that other groups of casino employees not participating in this evaluation are likely exposed to ETS at levels similar to those of participants.

NIOSH recommends that workers not be involuntarily exposed to tobacco smoke. This is best accomplished by eliminating tobacco use from the workplace and implementing a smoking cessation program for employees. Until tobacco use can be completely eliminated, Ballys should make efforts to protect employees from ETS by isolating areas where smoking is permitted. Separate smoking areas with dedicated ventilation are a means to accomplish this. Restricting smoking to the outdoors (away from building entrances and air intakes) is another method to protect employees from ETS.

KEYWORDS: SIC 7011 (Casino Hotels), Environmental tobacco smoke (ETS), nicotine, respirable suspended particulates (RSP), cotinine, serum, urine, casino, indoor environmental quality (IEQ), biological monitoring.

TABLE OF CONTENTS

INTRODUCTION

In August 1995 the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a Health Hazard Evaluation (HHE) concerning exposure to second-hand (environmental) tobacco smoke (ETS) among employees at Bally's Park Place Casino Hotel in Atlantic City, New Jersey. In response to this request, NIOSH performed a field study on March 13-16, 1996. In June 1996 study participants were notified in writing of the results of their medical testing.

BACKGROUND

Workplace Description

Bally's Park Place Casino Hotel was constructed in 1979 and offers a variety of gaming activities, including slot machines, roulette, blackjack, baccarat, craps, and poker. Gaming activities are in operation 24 hours per day, seven days a week. The casino employs approximately 800 persons who work on the casino floor, of which approximately 330 are full-time dealers and approximately 180 are full-time dealer supervisors. Employees work one of three shifts and are given a variable number of breaks per shift, depending on their job title. The casino floor has 71,380 square feet (ft^2), and the poker room (a separate area) has 8,679 ft^2. The casino has a maximum total occupancy of 9,560 persons. The number of employees working at a given time varies with the expected number of patrons; Friday and Saturday nights are generally more crowded.

Tobacco smoking is permitted throughout the casino floor. Although some gaming tables are designated as non-smoking, the non-smoking tables are generally located adjacent to tables where smoking is permitted. The employee cafeteria has smoking and non-smoking areas, but these areas are not physically partitioned, and tobacco smoke is evident in the non-smoking area. Employee lounges are designated non-smoking areas. Employees do not smoke while on duty.

The heating, air-conditioning, and ventilation system is controlled by a Honeywell building management system. A total of 17 supply and return fans serve approximately 80 variable air volume (VAV) boxes on the casino floor. Supply fans are rated at 47,000 cubic feet per minute (cfm), return fans are rated at 45,000 cfm, and each VAV box provides an average 4,000 cfm. Based on outdoor temperature, the system is designed to allow variable amounts of outside air into the casino. During mild climatic conditions, for example, the system will bring more outside air into the building; on very cold or hot days, outside air rates will be reduced. The minimum settings for outside air intake, however, are reportedly set at approximately 30%. Specifications for outside air intake based on occupant load were not available from Bally's management. However, assuming maximum casino capacity (9,560 persons) and minimum outside air intake (30%), an outside air rate of 25 cubic feet per minute per person (cfm/person) can be calculated. The poker room is supplied by a separate supply fan rated at 24,000 cfm, with 100% make-up air. Four exhaust fans for this location are located on the roof.

Environmental Tobacco Smoke

The combustion of tobacco results in a complex array of air contaminants; smoke from the burning tobacco that is not inhaled by the smoker (side stream smoke), combined with exhaled smoke, is referred to as environmental tobacco smoke (ETS). Occupational exposure to ETS is recognized as an important public health issue.[1,2] NIOSH has determined that ETS poses an increased risk of lung cancer and possibly heart disease to occupationally exposed workers and recommends eliminating or restricting tobacco use in the workplace.[3] Although many workplaces are adopting policies which restrict smoking, occupational exposure to ETS remains a concern among some of the 110 million Americans who work outside the home.[4,5] Occupational ETS exposures have not been evaluated epidemiologically to the extent that home exposures have;[3] in particular, there is very little information

available concerning the exposure of casino employees in the United States to ETS.

Because of the many potentially toxic agents in ETS and the various possible toxicological endpoints of interest, it is not feasible to assess exposure to all relevant substances in ETS. Vapor-phase nicotine, which accounts for approximately 95% of nicotine in ETS, is currently the most widely accepted marker for ETS exposure.[6-8] One potential drawback of vapor-phase nicotine is that the adsorption and emission properties of vapor-phase nicotine on indoor surfaces could decrease (or increase) its concentration relative to other ETS components.[8] Respirable particulate has also been used as a marker of ETS, but it may be difficult to separate the ETS-associated particulate from that of other indoor sources.[6-8]

Biologic monitoring of exposure to ETS is most commonly conducted by measuring cotinine in the serum and/or urine of potentially-exposed persons.[2,7,9-11] Cotinine, which is the major metabolite of nicotine, has a half-life of approximately 16-20 hours and documents exposure to nicotine primarily from the previous one to two days.[2] Although there are many published studies which report serum and urine cotinine levels in various populations, procedural differences between laboratories may make it difficult to compare these values.[12] An advantage to using serum cotinine as a biomarker is the recent development of a sensitive analytic method which has been used to assess the exposure of a representative sample of the U.S. population to ETS.[2]

METHODS

The field study was performed March 13-16, 1996, and consisted of industrial hygiene and medical evaluations. The study population consisted of dealers and supervisors; there were approximately 279 dealers and supervisors scheduled to work the second shift (generally the busiest shift of the day) on March 14 and 15. During the evening of March 13 NIOSH investigators were present in the Bally's employee cafeteria to distribute information sheets describing the HHE and to talk to employees. All non-smoking dealers and supervisors contacted in the cafeteria that night were asked to participate in the HHE. Employees participated on one night only (either March 14 or 15).

Industrial Hygiene

Environmental monitoring was conducted to assess airborne concentrations of nicotine vapor and respirable dust. Full-shift area and personal breathing zone (PBZ) sampling was conducted during the second (swing) shift on March 14 and March 15, 1996.

Nicotine

PBZ and area air samples for nicotine vapor were collected by drawing air through XAD-4 sorbent tubes (SKC #226-93) with battery-powered SKC Pocket Pumps® at air flow rates of 150 milliliters per minute (ml/min) for personal samples and 200 mL/min for area samples. Sampling was conducted for approximately eight hours. The analyses for nicotine were conducted at NIOSH using a modified version of American Society for Testing and Materials (ASTM) method D5075-90a, "Standard Test Method for Nicotine in Indoor Air."[13] The front and back sections of each XAD-4 tube were desorbed separately in 1 ml modified ethyl acetate. After the addition of the desorption solvent and the quinoline internal standard, all samples were allowed to desorb for a minimum of 30 minutes before analysis. To improve the ratio of nicotine to quinoline during quantitation, 20 microliters (μL) of the quinoline secondary standard (the method originally used 50 μL) was used as an internal standard. The samples were then analyzed by gas chromatography (nitrogen-phosphorous detector) using a Hewlett Packard HP6890 equipped with a 30-M RTX-5 (0.25 mm ID, 0.25 μm film) fused silica capillary column. Separation of the analyte was achieved using the following temperature program: 60ºC ramped at 15ºC/minute to 200ºC.

Respirable Particulate

The total mass of respirable particulate was collected according to NIOSH Method 0600 using pre-weighed polyvinyl chloride (PVC) filters installed in Dorr-Oliver nylon cyclones.[14] Sampling was conducted at a flow rate of 1.7 liters per minute (L/min) for approximately eight hours. A total of nine area samples were collected at the center tables in various gaming pits (locations in the casino gaming area are referred to as pits). The cyclone is a centrifugal separator, which collects particulate less than 10 µm diameter, with a median cut point of 3.5 µm. The samples were analyzed for particulate total weight by gravimetric analysis with the following modifications: 1) The filters and back-up pads were stored in an environmentally controlled room and subjected to room conditions for at least two hours for stabilization prior to tare and gross weighing. 2) Two weighings of the tare weight and the gross weight were performed. The average of the weighings were used for the total weight analyses. The total weight of each sample was determined by weighing the sample plus the filter on an electrobalance and subtracting the previously determined tare weight of the filter. The instrumental precision of the electrobalance is 0.001 milligram (mg). Due to variable factors such as hygroscopicity of the sample and the physical integrity of the filter itself, actual precision can be considerably less. Because of these factors, the limit of detection was 0.02 mg per filter sample.

Carbon Dioxide, Temperature, and Relative Humidity

Indicators of occupant comfort were also measured. These indicators were carbon dioxide (CO_2) concentration, temperature, and relative humidity (RH). Measurements were taken at representative locations throughout the casino.

Instantaneous measurements of CO_2 concentrations were obtained using a Gastech Model RI-411A Portable (direct reading) CO_2 monitor. The principle of detection is non-dispersive infrared absorption. The instrument was zeroed (zero CO_2 gas source) and calibrated before use with a known CO_2 source (span gas). The monitor provides CO_2 concentrations in 25 parts per million (ppm) increments, with a range of 0 - 4975 ppm. Measurements were obtained at various intervals and locations throughout the building. Outdoor readings were taken to determine baseline CO_2 levels.

Dry bulb temperature and RH levels throughout the building were determined at various intervals. Outdoor readings were obtained for comparison purposes. Instrumentation consisted of a TSI VelociCalc Plus model 8360 meter with a digital readout. This unit has humidity and temperature sensors on an extendable probe. The temperature range of the meter is 14 to 140°F and the humidity range is 20 - 95%.

Medical

The medical evaluation included a self-administered questionnaire and biologic monitoring for exposure to cigarette smoke. After giving informed consent and confirming that they did not currently use tobacco products, employees filled out a questionnaire which included questions on work history, tobacco use history, and exposure to ETS. Participants were asked to report the amount of time (hours/minutes) that they were exposed to ETS on the day of the evaluation and for the four previous days.

Pre- and post-shift blood and urine specimens were collected from each participant. Blood samples were centrifuged on-site, and all serum and urine specimens were frozen with dry ice. Four samples of both serum and urine from each night of testing were split and sent to the laboratory as additional samples not identified as duplicates. For those participants who had two samples sent to the laboratory, the second ("split") sample result was not used in subsequent analyses; one sample result per individual participant was used. Deionized water was sent in sample containers for the lab to use as field blanks.

All samples were sent to The National Center for Environmental Health, Division of Environmental Health Laboratory Sciences. Serum cotinine was determined for each serum sample in duplicate by high-performance liquid chromatography (LC) / atmospheric-pressure chemical ionization tandem mass spectrometry according to a standard protocol.[2] The limit of detection (LOD) was 0.050 nanograms per milliliter (ng/mL). The mean of two determinations is reported as the final result for all individual samples.

Urine cotinine analyses were made by using a similar LC tandem mass spectrometric procedure described above with the same LOD. However, for these samples, a preliminary hydrolysis of the cotinine glucuronides was carried out. Thus, the urine cotinine results are the **total** (free cotinine + cotinine glucuronide) levels in the sample. The mean of two determinations is reported as the final result for all individual samples. Because some investigators have reported urine cotinine measurements corrected for creatinine, we measured creatinine for all urine samples using a Kodak Ektachem 250 Dry Chemistry Analyzer and a standard two-point enzymatic method. Subsequent review, however, revealed that the most appropriate means of reporting urine cotinine is without creatinine correction,[15-17] therefore urine cotinine values are reported in ng/ml.

Serum and urine cotinine levels were log normalized to reduce the skewness in their distributions. Statistical analyses were performed using Epi Info, Version 6[18] and SAS.[19] A p value less than 0.05 was considered statistically significant.

EVALUATION CRITERIA

ETS

Exposure criteria for ETS have not been established, although NIOSH and others have determined that ETS is associated with an increased risk of lung cancer, other lung disease, and possibly heart disease.[3] The issue is problematic, as over 4000 compounds have been identified in ETS,[8] many of which exert their biologic properties through different mechanisms. A common strategy for assessing exposure to ETS is to monitor one or more "marker" substances and use these as an index of exposure. Selection of these compounds is based on their ease of measurement and specificity to ETS, and not necessarily because they are the most toxic components of ETS.

In this survey, vapor-phase nicotine and respirable particulate were monitored as marker substances for exposure to ETS. The concentrations of these markers in ETS are consistently lower than their respective occupational limits, which were based primarily on acute effects. The NIOSH Recommended Exposure Limits (REL) and the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Value (TLV™) for nicotine, used for exposure assessments in the agriculture industry, are 500 micrograms per cubic meter of air ($\mu g/m^3$).[20,21] The U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) general industry Permissible Exposure Limit (PEL) for respirable particulate not composed of a substance that has its own PEL, is 5,000 $\mu g/m^3$ (the ACGIH TLV is 3,000 $\mu g/m^3$; there is no REL).[22] In contrast, the mean area air nicotine concentrations reported in ETS studies of public buildings have ranged from 0.7 - 37 $\mu g/m^3$; concentrations in restaurants and bars have ranged from 2.3 - 65.5 $\mu g/m^3$; and concentrations in gaming parlors and betting shops have ranged from 11 - 19 $\mu g/m^3$.[6,23] Respirable particulate measurements have ranged up to 115 $\mu g/m^3$ in office buildings and up to 843 $\mu g/m^3$ in restaurants.[6] In all these situations, it must be emphasized that the NIOSH and OSHA criteria for nicotine and respirable dust markers are not applicable to ETS exposures.

Likewise, there are no NIOSH, ACGIH, or OSHA criteria for cotinine in blood or urine. Although studies reporting cotinine levels in non-smokers exposed to ETS have been summarized,[23] differences in laboratory methods make it difficult to compare cotinine levels determined in different laboratories. A study of more than 600 non-smokers attending a medical clinic found a mean urine cotinine level of

8.8 ng/ml (range 0 - 85), with increased levels correlating with reported exposures.[9] Another study found a mean urine cotinine level of 9.2 ng/ml among non-smokers exposed at home or work.[24] A recent study measuring serum cotinine in over 2600 working adults reported the following geometric means by category: 1) no reported ETS exposure -- 0.132 ng/ml; 2) reported ETS exposure at work -- 0.318 ng/ml; 3) reported ETS exposure at home -- 0.651; 4) reported ETS exposure at home and work -- 0.926 ng/ml.[2]

Although some foods, including tea, tomatoes, potatoes, and cauliflower, have been shown to contain nicotine in measurable quantities and therefore be a source of cotinine in the body,[25] the amount of cotinine in serum as a result of food intake has been shown to be extremely low relative to that resulting from tobacco exposure.[2]

Carbon Dioxide

Carbon dioxide is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate whether adequate quantities of outside air are being introduced into an occupied space. The American Society of Heating, Refrigeration, and Air-conditioning Engineers' (ASHRAE) most recently published ventilation standard, ASHRAE 62-1989, Ventilation for Acceptable Indoor Air Quality, recommends outdoor air supply rates of 30 cubic feet per minute per person (cfm/person) for casinos, 20 cfm/person for office spaces, and 15 cfm/person for reception areas, classrooms, libraries, auditoriums, and corridors.[26]

Indoor CO_2 concentrations are normally higher than the generally constant ambient CO_2 concentration (range 300-350 parts per million [ppm]). When indoor CO_2 concentrations exceed 800-1000 ppm in areas (usually offices) where the only known source is exhaled breath, inadequate ventilation is suspected. Elevated CO_2 concentrations suggest that other indoor contaminants may also be increased. The 800-1000 ppm criterion is based on a ventilation rate of 20 or 15 cfm/person, respectively; therefore, this criterion is not directly applicable to the casino environment, where ASHRAE recommends 30 cfm/person. Furthermore, CO_2 is not an accurate indicator of ventilation adequacy if the ventilated area is not occupied at its usual level.

Temperature and Relative Humidity

Temperature and RH measurements are often collected as part of an indoor environmental quality investigation because these parameters affect the perception of comfort in an indoor environment.[27] The American National Standards Institute (ANSI)/ASHRAE Standard 55-1992 specifies conditions in which 80% or more of the occupants (typically sedentary office employees) would be expected to find the environment thermally acceptable.[28] Assuming slow air movement and 50% RH, the operative temperatures recommended by ASHRAE range from 68-74°F in the winter, and from 73-79°F in the summer. The difference between the two is largely due to seasonal clothing selection. ASHRAE also recommends that RH be maintained between 30 and 60% RH. Excessive humidities can support the growth of microorganisms, some of which may be pathogenic or allergenic.[29]

RESULTS

Industrial Hygiene

Eighteen PBZ samples for nicotine were collected. In addition, ten area samples for nicotine vapor and ten area respirable dust samples were collected at various pit locations. The results of nicotine vapor and respirable dust fraction monitoring are shown in Table 1 (Thursday evening, March 14-15) and Table 2 (Friday evening, March 15-16). Personal nicotine exposures for the Thursday evening monitoring ranged from 6-12 $\mu g/m^3$ (geometric mean: 8 $\mu g/m^3$), expressed as time-weighted averages (TWAs). The highest personal sample result (12 $\mu g/m^3$) was from a dealer working Caribbean Stud Poker in Pit 3A. Area TWA air concentrations (range: 6-12 $\mu g/m^3$;

geometric mean: 8 $\mu g/m^3$) were similar to the personal sample concentrations. For the Friday evening monitoring, the personal exposures were slightly higher than those of Thursday evening, ranging from 4-15 $\mu g/m^3$ as TWAs (geometric mean: 10 $\mu g/m^3$). The highest personal exposure (15 $\mu g/m^3$) was again found on a dealer working Caribbean Stud Poker. TWA area air concentrations on Friday ranged from 8-16 $\mu g/m^3$ (geometric mean: 11 $\mu g/m^3$). The two highest area air concentrations on each night were at poker registration and the poker tables.

On both evenings, area air concentrations of respirable dust fraction ranged from non-detected (detection limit: 20-30 $\mu g/m^3$) to 90 $\mu g/m^3$ (see Tables 1 and 2). These concentrations of respirable dust are comparable to those documented in office settings; as discussed above, the ETS-associated components of the respirable dust can not be separated from other sources of respirable dust. The respirable dust concentrations did not correlate with the vapor-phase nicotine concentrations taken from the same areas.

On the Thursday second shift, CO_2 concentrations in the casino ranged from 425 to 650 ppm (Table 3). For the Friday second shift, concentrations were slightly higher, ranging from 475 to 850 ppm (Table 4). All CO_2 concentrations generally were less than the 1000 ppm criteria suggested by ASHRAE. These results suggest that sufficient quantities of outside air were being provided to the casino, although it should be noted that this criterion is not directly applicable because of the higher ventilation rates suggested for casinos compared to office buildings (see Evaluation Criteria section). Casino facilities personnel agreed that the mild outdoor conditions at the time of the NIOSH survey would have allowed maximal amounts of outside air to enter the casino's ventilation system, which would have resulted in maximum dilution and removal rates for the tobacco smoke. It is likely that lower quantities of outside air would be provided during other times of the year, resulting in higher tobacco smoke and nicotine concentrations. Based on system specifications provided by Bally's management, however, it appears likely that the ventilation system would meet the ASHRAE recommended outside air ventilation rate of 30 cfm/person except under a combination of maximal occupancy and extreme outdoor weather conditions. Temperatures and humidities (see Tables 3 and 4) were within the ranges specified by ASHRAE.

Medical

Twenty-nine persons (10% of the total number of dealers and supervisors at work during the evaluation) participated in the evaluation, including 18 dealers and 11 supervisors. Twenty of the 29 were men; the average age of all participants was 37 (range 21-53). Fifteen of the 29 participants began the swing shift at 8 p.m. the others had starting times between 6 p.m. and 10 p.m. (all worked eight hour shifts). No participants reported current tobacco use; 15 reported having never smoked cigarettes, 13 reported having their last cigarette more than 1 year prior to the evaluation, and one reported smoking a last cigarette two weeks prior to the evaluation. Seventeen (59%) of the participants reported no exposure to ETS outside the workplace over the four days prior to the evaluation. All participants provided pre- and post-shift urine samples; 28 provided pre- and post-shift blood samples

The serum and urine cotinine levels, with the corresponding PBZ nicotine concentrations (when appropriate), are presented in Tables 5 and 6. One participant (number 8) was found to have cotinine levels approximately 100 times the levels of all other participant and above the 15 ng/ml serum level used as an indicator of active smoking;[2] this person was therefore considered to be an active smoker and the corresponding results were excluded from all analyses. The geometric means and standard deviations are presented in Table 7. Analysis of the split samples (blinded) indicated an overall method coefficient of variation of 2% for both the serum and urine assays in this study; the split sample results are presented in Table 8.

Although six persons had a pre- to post-shift drop in serum or urine cotinine level, post-shift cotinine

levels for both serum ($p<0.01$) and urine ($p<0.01$) were significantly greater than pre-shift levels. Pre- and post-shift serum ($r= 0.63$, $p<0.01$) and urine ($r= 0.58$, $p<0.01$) cotinine values were correlated with each other. For those who had PBZ air sampling performed during their shift, there was a weak positive correlation (not statistically significant) between post-shift serum ($r= 0.43$, $p>0.05$) and post-shift urine ($r= 0.05$, $p>0.05$) cotinine values and airborne nicotine. The mean post-shift serum cotinine value was higher on Friday (3/15-16) than on Thursday (3/14-15), but the difference was not statistically significant. The mean post-shift urine cotinine value was lower on Friday than on Thursday (not statistically significant). There were no statistically significant differences between dealers and supervisors with respect to post-shift serum and urine cotinine levels.

Four persons worked all or part of their shift at non-smoking tables (see Tables 5 and 6 footnotes). There were no differences in the serum and urine cotinine levels, nor in the PBZ nicotine levels, in these persons as compared to those participants who reported working only at smoking tables. The serum cotinine decreased in two of these four persons over the shift.

Four participants worked at poker tables during their workshift; their post-shift serum cotinine levels were 2.22, 2.33, 2.70, and 2.91 ng/ml, which were among the highest in the study. All four of these persons showed increases over the shift.

There was no significant difference in the mean post-shift serum cotinine values between those reporting ETS exposure at home and work (12 participants, geometric mean 1.91 ng/ml) and those reporting no ETS exposure outside of work (17 participants, geometric mean 1.82 ng/ml). There were no statistically significant relationships between cotinine levels and exposure to tobacco smoke (both occupational and non-occupational, as reported in the questionnaire) on the day the sample was taken (mean exposure: 7 hours; range 2 - 10 hours) or for exposures reported for the three days prior to the blood and urine collection (mean exposure: 17.6 hours; range 6.5 - 24 hours).

DISCUSSION AND CONCLUSIONS

This evaluation demonstrates that employees working in the gaming areas of a large casino have more ETS exposure than a representative sample of the U.S. population, as measured in the Third National Health and Nutrition Examination Survey (NHANES III).[2] The mean serum cotinine levels of the casino employees in our evaluation were 1.34 (pre-shift) and 1.85 (post-shift) ng/ml, compared to a mean of 0.93 ng/ml for those participants of NHANES III reporting exposure to ETS at both home and work. A strength of our evaluation is that our laboratory analysis for cotinine was identical to that of the NHANES study. The urine cotinine values in our evaluation are more difficult to compare to those in other studies since most methods for determining urine cotinine measure only free cotinine, whereas the method used in this study measured both free cotinine and cotinine glucuronide and can yield significantly higher values.

The airborne nicotine levels found in our evaluation are similar to those measured in other indoor environments.[5,6,23] Concentrations of respirable particulate were generally typical of non-industrial environments and could not be attributed to ETS (the measured particulate concentrations likely included both ETS and other materials).

By performing our evaluation on a weekday (Thursday) night and a weekend (Friday) night we attempted to evaluate conditions that would be representative of a range of usual casino operations. We did not find statistically significant differences in the environmental or biological measures of exposure between the two nights.

Based on both air and biological monitoring, employees working at the 'non-smoking' tables did not appear to have decreased exposure to ETS. This is not surprising since these non-smoking tables were

generally located directly adjacent to other tables where smoking was allowed. This supports the idea that the exposure to ETS throughout the gaming area is similar and that other groups of casino employees not participating in this evaluation, such as waitresses, cashiers, and security personnel, are likely exposed to ETS at levels similar to the dealers and supervisors. It does appear, based on both air and biological monitoring, that within the gaming area of the casino, employees working at the tables or areas devoted to poker tend to have higher levels of exposure to ETS.

Similar post-shift serum cotinine values from employees reporting exposure to ETS at work only, compared to those reporting exposure both at home and at work, suggest that the ETS exposure among the group of participants is primarily work-related. This finding is supported by others who have demonstrated that occupational exposure to ETS is comparable to domestic exposures to ETS, which is the setting in which epidemiological evidence has demonstrated the adverse effects of ETS.[5]

We did not find significant correlations between cotinine levels and either air nicotine concentrations or reported ETS exposure. This could be due to a number of factors, including the small number of persons evaluated, and the relatively narrow ranges of cotinine values (which were all high relative to the NHANES data), nicotine levels, and hours of reported ETS exposure. Other factors could include limitations associated with questionnaires,[12] nicotine air sampling,[6-8] and cotinine as a biomarker.[7,12,30] Our findings support the recommendations of others that a combination of questionnaire data and exposure monitoring is most appropriate when evaluating exposure to ETS.[9,10]

A limitation of this study is that the participation rate for the target group (all non-smoking dealers and supervisors) is unknown, since the percentage of the work force who were active smokers is unknown. Information about non-participants was not gathered. Factors which likely affected the participation rate include insufficient employee notification regarding the HHE, concern over medical testing, and reluctant support by management. The fact that the participation rate is unknown does not alter our ability to characterize the exposure of a representative group of non-smoking casino employees. Attempting to interpret data representing ETS exposure in the context of potential health effects associated with ETS was not an objective of the current study.[11]

RECOMMENDATIONS

NIOSH recommends that workers not be involuntarily exposed to tobacco smoke. The best method for controlling worker exposure to ETS is to eliminate tobacco use from the workplace and to implement a smoking cessation program for employees. The 'non-smoking' tables, as currently situated, did not measurably decrease employee exposure to ETS. Until tobacco use can be completely eliminated, Ballys should make efforts to protect employees from ETS by isolating areas where smoking is permitted. Separate smoking areas with dedicated ventilation are a means to accomplish this. Restricting smoking to the outdoors (away from building entrances and air intakes) is another method to protect employees from ETS.

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Table 1
Full-Shift Personal Breathing Zone (PBZ) Concentrations of Nicotine Vapor
and Area Sampling Results for Nicotine Vapor & Respirable Dust
Bally's Casino, HETA 95-0375, March 14-15, 1996.

PBZ Samples (Pit #, Game)	Job Title	Sample Time (minutes)	Nicotine Vapor Concentration ($\mu g/m^3$)[1]
2B, Roulette[2]	Dealer	472	7
2B, Roulette	Supervisor	505	6
2C, Blackjack	Dealer	551	6
3A, Pai gow Poker	Dealer	502	10
3A, Caribbean Stud Poker	Dealer	534	12
4A, Craps	Dealer	463	9
4A, Craps[2]	Dealer	516	9
4A, Craps	Supervisor	521	6
4A, Craps[3]	Dealer	479	8
Area Location (Pit #)	**Substance**	**Sample Time**	**Concentration ($\mu g/m^3$)**
2A	nicotine vapor	449	7
	respirable dust[4]	441	*ND*
2B	nicotine vapor	447	6
	respirable dust	392	90
3A	nicotine vapor	445	12
	respirable dust	444	80
4A	nicotine vapor	445	8
	respirable dust	210	*ND*
Poker Registration	nicotine vapor	441	10
	respirable dust	438	80

[1] $\mu g/m^3$ = micrograms per cubic meter, mg/m^3 = milligrams per cubic meter. The limits of detection and quantitation for nicotine were 1.3 $\mu g/m^3$ and 4 $\mu g/m^3$, respectively (assumes 75 liter air sample). The limit of detection for total respirable particulate mass was approximately 30 $\mu g/m^3$ for the ND (non-detected) samples in this table (laboratory reported a limit of detection of 20 µg/sample).
[2] Worked at non-smoking table
[3] Worked a non-smoking table except for the last 2½ hours of shift
[4] Total mass of respirable dust fraction.

Table 2
Full-Shift Personal Breathing Zone (PBZ) Concentrations of Nicotine Vapor
and Area Sampling Results for Nicotine Vapor & Respirable Dust
Bally's Casino, HETA 95-0375, March 15-16, 1996.

PBZ Samples (Pit #, Game)	Job Title	Sample Time (minutes)	Nicotine Vapor Concentration ($\mu g/m^3$)[1]
2A & 3B, Blackjack	Dealer	494	10
2C, Blackjack	Dealer	464	11
2C, Blackjack	Dealer	511	9
3A, Paigaw Poker	Dealer	400	12
3A, Caribbean Stud	Dealer	519	15
4A, Craps	Supervisor	494	10
4A, Craps	Dealer	479	12
4A, Craps	Supervisor	491	4
4A, Craps	Dealer	466	14

Area Location (Pit #)	Substance	Sample Time	Concentration ($\mu g/m^3$)
2A	nicotine vapor	500	10
	respirable dust[2]	500	*ND*
2B	nicotine vapor	499	8
	respirable dust	499	*ND*
3A	nicotine vapor	499	11
	respirable dust	*Not analyzed due to sampling pump failure*	
4A	nicotine vapor	498	10
	respirable dust	496	90
Poker Registration	nicotine vapor	496	16
	respirable dust	493	60

[1] $\mu g/m^3$ = micrograms per cubic meter, mg/m^3 = milligrams per cubic meter. The limits of detection and quantitation for nicotine were 1.3 $\mu g/m^3$ and 4 $\mu g/m^3$, respectively (assumes 75 liter air sample). The limit of detection for total respirable particulate mass was approximately 20 $\mu g/m^3$ for the ND (non-detected) samples in this table (the laboratory reported a limit of detection of 20 µg/sample).
[2] Total mass of respirable dust fraction.

Table 3
Carbon Dioxide, Temperature, Relative Humidity Measurements
Bally's Casino, Atlantic City, New Jersey
HETA 95-0375, March 14-15, 1996, Second Shift

Location	Time (± 15 minutes)	Carbon Dioxide (ppm)[1]	Temperature (°F)[2]	Relative Humidity (%)
Versaille Room	7:30 pm	575	70	31
	10:30 pm	575	71	31
	12:30 am	425	70	31
Pit 2A	7:30 pm	500	72	31
	10:30 pm	450	71	32
	12:30 am	450	72	31
Pit 2B	7:30 pm	500	73	31
	10:30 pm	450	71	32
	12:30 am	450	72	31
Pit 3A	7:30 pm	575	71	31
	10:30 pm	650	71	32
	12:30 am	525	71	31
Pit 4A	7:30 pm	625	72	32
	10:30 pm	625	71	33
	12:30 am	575	71	32
Poker Registration Area	7:30 pm	525	71	32
	10:30 pm	600	73	33
	12:30 am	500	72	32
Outside	7:30 pm	300	42	68
	10:30 pm	300	44	62
	12:30 am	300	44	59

[1] ppm = parts per million
[2] °F = degrees Fahrenheit

Table 4
Carbon Dioxide, Temperature, Relative Humidity Measurements
Bally's Casino, Atlantic City, New Jersey
HETA 95-0375, March 15-16, 1996, Second Shift

Location	Time (± 15 Minutes)	Carbon Dioxide (ppm)[1]	Temperature (^{O}F)[2]	Relative Humidity (%)
Versaille	8:15 pm	525	71	40
	10:30 pm	500	70	43
	12:30 am	500	71	37
Pit 2A	8:15 pm	475	73	41
	10:30 pm	575	73	43
	12:30 am	525	71	36
Pit 2B	8:15 pm	475	73	41
	10:30 pm	525	71	43
	12:30 am	550	72	35
Pit 3A	8:15 pm	550	73	41
	10:30 pm	650	71	44
	12:30 am	650	71	36
Pit 4A	8:15 pm	575	73	42
	10:30 pm	825	72	44
	12:30 am	850	73	37
Poker Registration	8:15 pm	625	73	45
	10:30 pm	775	73	45
	12:30 am	800	73	36
Outside	8:15 pm	300	55	73
	10:30 pm	300	52	70
	12:30 am	275	47	63

[1] ppm = parts per million
[2] ^{o}F = degrees Fahrenheit

Table 5
Serum and Urine Cotinine and Nicotine Air Sampling Results
Bally's Casino, Atlantic City, New Jersey
HETA 95-0375, March 14- 15, 1996, Second Shift

Participant #	Job[1]	Nicotine[2] (ug/m^3)	Pre-shift Serum Cotinine (ng/ml)	Post-shift Serum Cotinine (ng/ml)	Pre-shift Urine Cotinine (ng/ml)	Post-shift Urine Cotinine (ng/ml)
1[3]	D	7	2.74	2.62	159	197
2	D	9	NA[4]	NA	47.6	54.0
3	S	6	0.926	1.47	16.2	23.6
4[3]	D	9	2.72	2.56	21.2	45.3
5	D	NA	1.19	1.45	37.7	54.4
6	D	10	1.58	2.22	16.7	39.1
7	D	12	2.78	2.91	42.4	58.6
8[5]	D	6	113	73	4664	4137
9	S	6	0.885	1.36	21	28.4
10	S	NA	1.07	1.21	5.76	20.7
11[3]	D	8	1.30	1.57	14	7.21
12	D	NA	0.967	1.32	23.7	26.7

[1] Job titles: D = dealer, S = supervisor
[2] Personal breathing zone sampling for nicotine vapor (TWA).
[3] Some or all of workshift on day of sampling was spent at non-smoking table.
[4] NA = test not performed.
[5] Based on high cotinine levels, this participant was determined to be an active smoker; his/her results are excluded from all analyses.

Table 6 -- Serum and Urine Cotinine and Nicotine Air Sampling Results
Bally's Casino, Atlantic City, New Jersey -- HETA 95-0375, March 15-16, 1996, Second Shift

Participant #	Job[1]	Nicotine[2] (ug/m^3)	Pre-shift Serum Cotinine (ng/ml)	Post-shift Serum Cotinine (ng/ml)	Pre-shift Urine Cotinine (ng/ml)	Post-shift Urine Cotinine (ng/ml)
13	S	NA[3]	2.81	2.61	51.4	50.5
14	S	NA	4.24	3.52	61.1	59.3
15	S	10	1.14	1.95	27.3	35.9
16	D	10	1.37	1.77	28.4	33.9
17	D	11	1.39	1.16	23.4	25.3
18	D	15	0.23	2.70	7.63	58.0
19	S	NA	1.49	2.03	7.98	28.1
20	D	12	0.768	1.54	16.4	22.6
21	S	4	1.15	1.41	37.0	43.2
22	D	12	1.05	2.33	17.4	32.5
23	D	9	2.19	2.57	44.9	52.6
24	S	NA	0.516	0.959	2.54	3.87
25	D	14	1.35	1.96	35.6	51.2
26	S	NA	2.38	2.56	26.8	31.2
27[4]	D	NA	2.89	3.19	19.5	21.7
28	S	NA	0.659	0.917	23.0	24.1
29	D	NA	1.16	1.42	27.2	33.3

[1] Job titles: D = dealer, S = supervisor
[2] Personal breathing zone sampling for nicotine vapor (TWA).
[3] NA = test not performed.
[4] Some or all of workshift on day of sampling was spent at non-smoking table.

Table 7
Summary of Serum and Urine Cotinine Measurements
Bally's Casino, Atlantic City, New Jersey
HETA 95-0375, March 14-16, 1996

	Pre-shift Serum Cotinine (ng/ml)	Post-shift Serum Cotinine (ng/ml)	Pre-shift Urine Cotinine (ng/ml)	Post-shift Urine Cotinine (ng/ml)
Geometric Mean	1.34	1.85	23.0	33.3
Geometric Standard Deviation	1.9	1.4	2.2	2.0

Table 8
Results of Split Samples for Serum Cotinine Measurements
Bally's Casino, Atlantic City, New Jersey
HETA 95-0375, March 14-16, 1996

Duplicate Serum Cotinine Levels (ng/ml)
2.72; 2.68
1.07; 1.08
1.14; 1.18
1.37; 1.34
2.56; 2.5
2.22; 2.26
2.7; 2.72
2.61; 2.67

Table 9
Results of Split Samples for Urine Cotinine Measurements
Bally's Casino, Atlantic City, New Jersey
HETA 95-0375, March 14-16, 1996

Duplicate Urine Cotinine Levels (ng/ml)
105.9; 86.5
185.1; 181.9
28.9; 28.6
216.5; 214.4
206.5; 205.5
100.8; 98.6
101.5; 103.7
218.6; 216