The Productivity Cost of Poor Indoor Air Quality in the Hospitality Industry

Abstract

Good indoor air quality is essential for sustainable facilities. This is especially true for the hospitality industry (hotels, motels, restaurants, bars, and casinos) in the United States as people spend significant time in these establishments and there is at least a $4 per square foot impact on productivity due to 60% of the facilities being classified as having poor indoor air quality. This productivity included sales, repeat customers, staff efficiency, and lost wages. Research has shown that by improving the indoor air quality to the level of ASHRAE Standard 62 in hospitality facilities there is a payback of approximately a year.

Study Procedures

The focus of the research was to review existing literature and gather expert opinion on the benefits of upgrading environmental systems and control of the systems in hospitality industry buildings. The basic methodology for determining the impact of indoor air quality in the hospitality industry was:

- Document the hospitality industry – the hospitality industry was classified by type (hotel, motel, restaurant, bar, and casino), size (square footage), number of employees, payroll, and sales. This information was gathered from industry and governmental publications.[1]

- Define wellness categories – the wellness categories were based on past research that reviewed published literature related to case studies and facility evaluations.

- Identify health and medical impacts – the health and medical impacts identified were based on a comprehensive review of literature. The primary health and medical impacts with statistical significance relative to indoor air quality were:

  - SBS/BRI
  - Indoor air contaminants
  - Allergies
  - Occupational asthma
  - Humidifier fever
  - Legionellosis
  - Hypersensitivity pneumonitis
  - Environmental tobacco smoke

- Classify hospitality industry wellness – utilizing the categories and review of literature, the hospitality industry was distributed into the categories.

- Evaluate health costs – the cost of poor indoor air quality on employee and customer health was calculated based on the published research. Conservative estimates were used to make these calculations in order to minimize overestimating the potential savings.

- Evaluate productivity costs – productivity costs calculated included lost worker time (both absenteeism and at work loss), decreased sales, lost repeat sales, and reduced referred sales. These were based on industry estimates, past published and non-published research, and researcher experience.

- Document improvements – the improvements required to improve the indoor air quality in the hospitality industry were based on an understanding of the problems in poor indoor air quality buildings, the requirements of ASHRAE Standard 62, and opportunities to improve the facility and systems.

- Calculate cost of improvements – the cost of the improvements was calculated for typical installations and then translated to other types and sizes of facilities. The costs included planning, design, construction, and operations.

- Calculate net present value of improving the indoor air in the hospitality industry – the overall value of improving the indoor air quality in the hospitality industry was compared to the investment required to improve the indoor air quality to understand the payback and lifetime savings potential.

Unique Indoor Air Quality Challenges

Compared to office buildings and retail, the hospitality industry has unique challenges that must be addressed in achieving acceptable indoor air quality. These include:

- High density of people – in most hospitality facilities there are a large number of people in a relatively small area. There are issues with odors, noise, and transmittal of colds, flu and other transmittable diseases.

- Beyond design conditions – there can be occasional to frequent occupancy rates that are higher than design ventilation rates. This results in poor dilution or removal of pollutants in the space. This is especially true for bars, conference rooms, casinos, and hotel guest rooms.

- Contact changes – the typical hospitality user will be in contact with different people and visitors each day. This provides a greater opportunity for transmittal of flu and cold viruses, with increased absenteeism of employees and resistance of the paying customer of repeated business.

- Higher opportunity for moisture – with the prevalent use of packaged units and the high people density, there are more plumbing fixtures and heating, ventilating, air-conditioning (HVAC) units). This can lead to moisture management problems.

- Pollutant generating activities – Cooking, smoking, off-gassing of materials, and spaces open to outdoors (birds and insects) provide for a greater pollutant generation rate which can tax the systems and result in poor indoor air quality.

- Higher number of HVAC units – a greater use of smaller units increase the higher probability of indoor air quality degradation through the need for more exhaust fans and a higher potential for pressure imbalance.

Current State of Indoor Air Quality

Utilizing past indoor air quality studies completed on a variety of building types, a national average classification of wellness can be determined.[2] The wellness categories are:

- Healthy
  - Always meets ASHRAE Standards 62-1999 and 55-1992 during occupied periods
  - 80% or more of the occupants do not express dissatisfaction with indoor air
  - Building systems are well maintained
  - Building health management practices exists

- Generally healthy

  - Meets ASHRAE Standards 62-1999 and 55-1992 during most occupied periods. Examples of items which lead a building to be classified as generally healthy include:

    - Buildings in northern climates that temporarily fall below recommended minimum 30% rh during winter days due to inadequate humidification.

    - Buildings in southern climates that temporarily rise above recommended maximum 60% rh during summer days due to inadequate dehumidification.

    - Buildings where crowding results in per-person rate of outdoor air ventilation to temporarily drop below recommended minimum range.

    - Lack of maintenance leads to periodic IAQ degradation.

    - The HVAC system does not operate during low occupancy.

- Unhealthy, source unknown

  - Fails to meet ASHRAE Standards 62-1999 and 55-1992 during most occupied periods.

- More than 20% of the building occupants consistently express dissatisfaction with the indoor air.

- Increased occurrence of SBS symptoms but with a complaint rate less than 20% of the occupants.

- Problems exist in the HVAC system and the specific system components with problems can be identified. However, the source of the IAQ and SBS problems cannot be linked to a specific HVAC component.

- Occasional high levels of IAQ related complaints or symptoms.

- Unhealthy, source known

  - Fails to meet ASHRAE Standards 62-1999 and 55-1992 during most occupied periods.

  - More than 20% of the building occupants consistently express dissatisfaction with the IAQ.

  - Increased occurrence of SBS symptoms but with a complaint rate less than 20% of the occupants.

  - Problems exist in the HVAC system, but specific system components with the problems have not been identified.

  - Occupants have SBS symptoms and illness related to the IAQ, but which cannot be related specifically to the building.

    Examples of items that cause a building to be classified as unhealthy include:

    - Buildings designed/operated using out-of-date ventilation rate standards
    - Inadequate maintenance leading to dirty coils, dirty ducts, moisture, and mold growth
    - Cross-contamination between occupied zones and sources of chemical pollution
    - Poorly sized or inoperable HVAC equipment
    - Uncontrolled contaminant generation and containment

- Sick building syndrome and building related illness

  - More than 20% of the building occupants complain of SBS symptoms
  - One or more cases of BRI have been documented
  - Occupants report daily symptoms of IAQ related illness while in the building

The results of this categorization for an overall national building wellness (all commercial facilities) and that for the hospitality industry are shown in Table 1.

Table 1: Hospitality Industry Wellness Percentage Distribution

Building Wellness Category	National Building Wellness	Restaurants	Bars	Lodging (humid climate)	Lodging (non-humid climate)	Casinos
Healthy Buildings	20	15	10	12	15	15
Generally Healthy	40	35	10	18	30	25
Unhealthy, Source Unknown	20	30	25	40	35	20
Unhealthy, Source Known	10	12	45	15	10	30
SBS and BRI Building	10	8	10	15	10	10

The differences between the national values and the various hospitality industry categories are due to the unique challenges faced in the hospitality facilities.

How to Improve the Indoor Air Quality

There are multiple opportunities to improve the indoor air quality in hospitality facilities. For ease of discussion, these opportunities can be divided into two categories of upgrade opportunities:

1) Meet or exceed the requirements of ASHRAE Standard 62-1999
   a) Change the rate of outdoor air
   b) Install demand control
   c) Develop smoke and odor control and separation systems
   d) Monitor outdoor air quantity to meet ventilation requirements
   e) Install local exhaust
   f) Increase ventilation effectiveness
   g) Maximize economizer cycle
   h) Relocate air vents
   i) Change the air filtration method
   j) Reduce unwanted infiltration/exfiltration

2) Improve space control to meet the health needs of Standard 62-1999 and meet or exceed the generally accepted requirements of ASHRAE Standard 55-1992
   a) Improve space temperature control
   b) Improve control or provide positive control of humidity (dehumidification)
   c) Install humidification, self-contained steam humidifiers

Cost to Implement

The estimated capital cost of all the potential IAQ improvements is $20.2 billion with an annual recurring cost of $1.1 billion. The cost breakdown is presented in Table 2.

Table 2: National Cost of All IAQ Improvements

IAQ Improvement	Total Potential Economics ($ millions)		
	Labor	Materials	Combined
Meet ventilation standards (ASHRAE 62-1999)			
Change the rate of outdoor air to 20 cfm or more	$655.9	$1,881.6	$2,537.5
Monitor outdoor air quality to meet ventilation requirements	$353.6	$1,020.1	$1,373.7
Install local exhaust	$0.9	$4.3	$5.2
Increase ventilation effectiveness	$36.0	$136.3	$172.3
Maximize economizer cycle	$132.9	$0.0	$132.9
Relocate air vents	$196.2	$62.9	$259.1
Change air filtration method	$689.4	$1,979.7	$2,669.1
Reduce unwanted infiltration/or exfiltration	$145.4	$27.0	$172.4
Total for meeting ASHRAE 62-1999	$2,210.2	$5,111.9	$7,322.1
Improve space control (ASHRAE 55-1992)			
Improve space temperature control	$1,641.4	$4,734.9	$6,376.3
Improve control or provide positive control of humidity (dehumidification)	$1,154.0	$5,368.3	$6,522.3
Install humidification, self generated steam humidifiers	$0.8	$12.4	$13.2
Total for meeting ASHRAE 55-1992	$2,796.2	$10,115.6	$12,911.8
TOTAL	**$5,006.4**	**$15,227.5**	**$20,233.9**
Maintenance/on-going costs			$1,112.87

Savings due to Improved Indoor Air Quality

Accomplishing the improvement of the indoor air quality to ASHRAE Standard 62-1999 levels is economical for all buildings in the hospitality industry which currently do not meet Standard 62. A summary of the demographics, costs, and benefits calculated in this study are shown in Table 3.

Table 3: Summary of Key Data

	Bars	Restaurants	Lodging (humid)	Lodging (non-humid)	Casinos	Total
Demographics						
Number of buildings	52,825	434,081	105,148	52,852	651	645,557
Total space (million ft^2)	252	1,101	2,408	1,210	40.6	5,012
Number of employees	321,294	7,430,000	885,108	444,892	398,695	9,479,989
Annual payroll (million)	$3,552	$90,739	$17,179	$8,635	$11,053	$131,158
Total sales (million)	$13,187	$257,020	$51,252	$25,762	$31,629	$378,850
Benefits of Improved IAQ						
Reduced health and medical cost (million)	$56	$1,296	$154	$78	$70	$1,654
Reduced classical absenteeism (million)	$98	$1,738	$454	$181	$246	$2,717
Reduced turnover costs (million)	$20	$307	$42	$17	$20	$ 406
Increased productivity (million)	$50	$948	$234	$97	$130	$1,459
Reduced sick leave costs (million)	$17	$343	$81	$35	$46	$ 522
Increased sales (million)	$132	$2,570	$513	$258	$316	$3,789
Improved sales (million)	$264	$5,140	$1,025	$515	$633	$7,577
Reduced complaint resolution (million)	$201	$881	$241	$121	$32	$1,476
Annual total benefits (million)	$837	$13,223	$2,744	$1,302	$1,492	$19,598
Annual total benefits (per employee)	$2,605	$1,780	$3,100	$2,927	$3,742	$2,067
Annual total benefits (per ft^2)	$3.33	$12.01	$1.14	$1.08	$36.73	3.91
Cost to Implement						
Implement all identified IAQ improvements (million)	$631	$13,860	$4,096	$1,536	$111	$20,234
Average cost per square foot (per ft^2)	$2.51	$12.58	$1.70	$1.27	$2.73	4.04
Average cost per worker (per employee)	$1,964	$1,865	$4,628	$3,452	$278	$2,134
Initial average economic simple payback (yrs)	0.75	1.05	1.49	1.18	0.07	1.03
Annual cost to sustain all improvements (million)	$35	$762	$225	$84	$6	$1,112
Net 20-year present value of benefits less cost*						
For all improvements (million)	$11,307	$171,526	$33,370	$16,578	$21,993	$254,774
Per ft^2 for all improvements	$44.93	$155.74	$13.86	$13.70	$541.50	$50.84
Per worker for all improvements	$35,191	$23,086	$37,702	$37,263	$55,163	$26,875

* Assumes a 3% annual interest rate

Conclusions

We have the ability to improve the health and lifestyle of close to 9.5 million workers in the United States and scores more of hospitality facilities. This can be accomplished through the implementation of procedures to maintain the indoor air quality and comfort to ASHRAE standards. For a one-time investment with a year payback, the savings of

over $250 billion dollars net present value for 20 years is staggering. As a nation we must push forward and institute these changes for ourselves and our future.

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References

[1] Energy Information Administration, *Commercial Buildings Energy Consumption & Expenditures for 1995*, United States Department of Energy, Washington, D.C., 1998.

National Restaurant Association, "Foodservice Trends", *Restaurants USA*, March 2000a, pp. 38-42.

National Restaurant Association, *Restaurant Industry Pocket Factbook*, www.restaurant.org/research/pocket/index.htm, 2000b.

United States Census Bureau, *1997 Economic Census*, United States Department of Commerce, Washington, D.C., 2000, "Accommodation and Foodservices, Geographic Area Series", pp. 1-24.

United States Census Bureau, *Statistical Abstract of the United States*, United States Department of Commerce, Washington, D.C., 1999.

United States Department of Labor, *Bureau of Labor Statistics Data*, http://www.bls.gov/sahome.html, 2000.

United States Department of Labor, *Bureau of Labor Statistics Consumer Price Index*, Washington, D.C., 1999, "National U.S. City Average for all Urban Consumers".

[2] Burge, S., A. Hedge, S. Wilson, J.H. Bass, and A. Robertson. 1987. "Sick Building Syndrome: A Study of 4,373 Office Workers," *British Occupational Hygiene Society*, 1987, pp. 493-504.

Putnam, V.L., J.E. Woods and T.A. Bosman, "Objective Measures and Perceived Responses of Air Quality in Two Hospitals", *Proceedings of IAQ '89: The Human Equation: Health and Comfort*, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Atlanta, Georgia, April 1989, pp. 241-250.

Robertson, A.S., P.S. Burge, A. Hedge, J. Simes, F.S. Gill, M. Finnegan, C.A. Pickering and G. Dalton, "Comparison of Health Problems Related to Work and Environmental Measurements in Two Office Buildings with Different Ventilation Systems", *British Medical Journal*, 1985, pp. 373-376.

Skov, P., O. Valbjorn, B.V. Pedersen, and the Danish Indoor Climate Group, "Influence of Personal Characteristics, Job-Related Factors and Psychosocial Factors on the Sick Building Syndrome", *Scandinavian Journal of Work Environmental Health*, 1989, pp. 286-295.

Woods, J.E., "Cost Avoidance and Productivity in Owning and Operating Buildings", *Occupational Medicine: State of the Art Reviews*, Vol. 4 No. 4, Oct.-Dec. 1989, pp. 753-770.

Woods, J.E., G.M. Drewry, and P.R. Morey, "Office Worker Perceptions of Indoor Air Quality Effects on Discomfort and Performance", *Proceedings of Indoor Air '87: Fourth International Conference on Indoor Air Quality and Climate 2*, Berlin, Germany, August 1987, pp. 464-468.