Influence of Maternal Health Literacy on Child Participation in Social Welfare Programs: The Philadelphia Experience

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We examined the influence of maternal health literacy on child participation in social welfare programs. In this cohort, 20% of the mothers had inadequate or marginal health literacy. Initially, more than 50% of the families participated in Temporary Assistance for Needy Families (TANF), the Food Stamp Program, and Special Supplemental Nutrition Program for Women, Infants, and Children, whereas fewer than 15% received child care subsidies or public housing. In multivariate regression, TANF participation was more than twice as common among children whose mothers had adequate health literacy compared with children whose mothers had inadequate health literacy. (*Am J Public Health.* 2010;100:1662–1665. doi:10.2105/AJPH.2009.172742)

Reports have documented underenrollment in public programs known to improve child health (e.g., food or cash assistance, housing).[1–8] Although the mechanisms underlying this phenomenon are complex, one possible explanation is that participation is hampered by the literacy demands of the application process. Low health literacy ("an individual's ability to read, understand and use healthcare information to make decisions and follow instructions for treatment"[9]) affects more than 90 million American adults (approximately 20% of the adult population).[10] In a prospective, longitudinal cohort study of Medicaid-eligible mothers and infants, we hypothesized that mothers with adequate health literacy would be more likely than those with inadequate health literacy to participate in public programs.

METHODS

We analyzed data from the Health Insurance Improvement Project,[11,12] a prospective cohort study of Medicaid-eligible mothers and their infants. Between June 2005 and August 2006, mother-infant dyads were recruited from a large Philadelphia, Pennsylvania, hospital's postpartum wards. Inclusion criteria were maternal Medicaid eligibility and maternal English proficiency. Exclusion criteria were gestational age younger than 36 weeks, birth weight less than 2500 g, and infants entering foster care or adoption.

Primary outcomes were self-reported participation in 5 social welfare programs: (1) Temporary Assistance for Needy Families (TANF); (2) Food Stamp Program; (3) Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); (4) child care subsidies, and (5) public housing, measured with survey items adapted from the National Health Interview Survey. Covariates included child's sex and birth order; maternal age, education, marital status, and employment status; and household income. Maternal health literacy was measured with the short-form Test of Functional Health Literacy in Adults. Scores range from 0 to 36 and are categorized as follows: 16 or lower (limited); 17 to 22 (marginal); and 23 or higher (adequate).[13,14]

We used the χ^2 test to compare the rate of participation in each social welfare program among the literacy levels. We used best subsets multivariate logistic regression to estimate the relation between maternal health literacy and program participation. We assessed associations between explanatory variables to exclude multicollinearity.

RESULTS

Our study enrolled 744 participants (53.3% of eligible mother–infant dyads). No significant or clinically relevant differences were seen between participants and nonparticipants. Analytic sample sizes were 626 (of 744) at birth and 499 (of 580) at 6 months.

At baseline, 8% had inadequate (n=50) and 12% had marginal (n=75) health literacy. Most mothers were African American (80%), were single (87%), had more than 1 child (63%), and had annual household incomes lower than $12 000 (77%). No significant differences in health literacy were related to race/ethnicity (P=.16), marital status (P=.2), income (P=.44), or employment status (P=.26). Health literacy was related to education (P=.004; 38% with inadequate health literacy had an education beyond high school) and number of children (P=.019).

At birth, more than half of the families participated in TANF, the Food Stamp Program, or WIC, and fewer than 15% received child care benefits or public housing (Table 1). At birth and 6 months, children whose mothers had adequate or marginal health literacy were more likely (P<.05) to receive TANF. At birth, children of mothers with adequate or marginal health literacy were more likely to receive food stamps. No significant differences in participation in WIC, child care, or housing were related to health literacy levels.

In multivariate analysis (Table 2), children whose mothers had adequate or marginal health literacy were more than twice as likely to participate in TANF as were children whose mothers had inadequate health literacy at baseline and 6 months. Other significant predictors were number of children, income, and age. For food stamps participation, the association with maternal health literacy at birth was not statistically significant.

DISCUSSION

To our knowledge, our study is the first to examine the relation of maternal health literacy to public program participation. We found that mothers with poor health literacy were much less likely to receive TANF than were mothers with adequate health literacy. We also found that although maternal education and health literacy were highly correlated, maternal education was not distinctly associated with participation in any of the social welfare programs examined. Programs with streamlined institutionalized enrollment

TABLE 1—Maternal Health Literacy and Participation in Social Welfare Programs: The Health Insurance Improvement Project, June 2005–August 2006

	Birth (n = 626)					6 Months (n = 499)				
		Health Literacy, No. (%)					Health Literacy, No. (%)			
	Overall Participation, %	Inadequate	Marginal	Adequate	*P*[a]	Overall Participation, %	Inadequate	Marginal	Adequate	*P*[a]
TANF	52	17 (34)	44 (59)	266 (53)	.018	55	15 (36)	38 (62)	206 (55)	.03
Food Stamps	65	23 (46)	50 (67)	333 (67)	.01	71	26 (59)	43 (71)	272 (72)	.19
WIC	66	35 (70)	48 (64)	330 (66)	.78	93	43 (98)	57 (93)	345 (92)	.35
Child care	12	6 (12)	6 (8)	65 (13)	.47	29	8 (18)	24 (39)	108 (29)	.06
Housing	11	6 (12)	8 (11)	55 (11)	.97	14	6 (14)	9 (15)	53 (14)	.99

Note. TANF = Temporary Assistance for Needy Families; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children. Analytic samples were 626 (of 744) at birth and 499 (of 744) at 6 months. No significant differences were found in the distribution of demographic variables (infant birth weight, maternal age, maternal birth country, maternal education, maternal employment) between the analytic sample and the full cohort (data not shown).

[a]*P* value for the χ^2 test of association between maternal health literacy and participation in social welfare programs. All analyses were conducted with SAS (Version 9.1.3; SAS Institute Inc, Cary, NC).

protocols, such as WIC, also appear to have much higher enrollment rates than do those with more complex and fragmented procedures.

These results had some caveats. First, generalizability is limited by the study population composition and single location. Second, self-reported data about public program participation are subject to recall bias. Third, only 53% of the eligible mothers participated; this could result in selection bias. Fourth, we did not analyze the literacy demands of the application process. Fifth, we chose a health literacy measure, which is correlated with but not the same as a more general literacy assessment.[10] Finally, we examined participation at birth and at 6 months of age; multisite observation over a longer period is likely to contribute additional information to assist policymakers in program development.

Our findings indicated that systematic changes in enrollment procedures can be made to promote participation in public programs that benefit children. Initiatives to increase enrollment in public programs might focus on simplifying procedures, whereas welfare-to-work evaluations may focus on promoting

TABLE 2—Multivariate Logistic Regression Results Showing Influence of Maternal Health Literacy on TANF and Food Stamp Program Participation at Birth and 6 Months: The Health Insurance Improvement Project, June 2005–August 2006

	TANF				Food Stamps			
	Baseline (n = 626)		6 Months (n = 499)		Baseline (n = 590)		6 Months (n = 472)	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Maternal health literacy								
Inadequate	1.00		1.00		1.00		1.00	
Marginal	2.41 (1.04, 5.61)	.04	2.61 (0.96, 7.11)	.06	2.13 (0.89, 5.08)	.09	1.59 (0.60, 4.23)	.35
Adequate	2.18 (1.09, 4.35)	.03	3.04 (1.35, 6.84)	.008	1.95 (0.97, 3.92)	.06	1.72 (0.78, 3.77)	.18
Maternal age, y								
≤20	1.00		1.00		1.00		1.00	
21–24	1.36 (0.80, 2.33)	.26	4.22 (2.11, 8.44)	<.001	1.63 (0.94, 2.83)	.08	1.37 (0.74, 2.54)	.31
25–29	1.10 (0.55, 2.21)	.80	3.13 (1.29, 7.62)	.01	2.13 (1.00, 4.55)	.05	0.92 (0.38, 2.23)	.86
30–34	0.59 (0.25, 1.40)	.23	2.49 (0.79, 7.85)	.12	0.86 (0.35, 2.11)	.74	0.50 (0.17, 1.48)	.21
≥35	0.08 (0.02, 0.41)	.003	1.57 (0.36, 6.79)	.55	0.37 (0.12, 1.15)	.09	0.24 (0.06, 0.93)	.04
Income, $								
<250/mo	1.00		1.00		1.00		1.00	
251–500/mo	1.43 (0.86, 2.37)	.16	1.04 (0.55, 2.00)	.9	1.18 (0.68, 2.03)	.56	2.76 (1.35, 5.65)	.005
501–999/mo	0.62 (0.36, 1.07)	.09	0.29 (0.14, 0.59)	.001	0.79 (0.43, 1.42)	.42	1.32 (0.66, 2.66)	.44
1000–1499/mo	0.17 (0.08, 0.36)	<.001	0.11 (0.04, 0.27)	<.001	0.31 (0.15, 0.64)	.001	0.68 (0.28, 1.62)	.38
>1500/mo	0.20 (0.10, 0.41)	<.001	0.07 (0.03, 0.17)	<.001	0.28 (0.14, 0.57)	.001	0.49 (0.22, 1.11)	.09

Continued

TABLE 2—*Continued*

No. of children								
1	1.00		1.00		1.00		1.00	
2	1.65 (1.02, 2.67)	.04	1.33 (0.74, 2.38)	.34	2.10 (1.29, 3.41)	.003	2.90 (1.61, 5.19)	<.001
≥3	3.05 (1.78, 5.22)	<.001	2.62 (1.36, 5.04)	.004	5.53 (3.07, 9.96)	<.001	9.37 (4.44, 19.77)	<.001
Education								
Less than high school	1.00		1.00		1.00		1.00	
High school	0.81 (0.49, 1.34)	.41	0.67 (0.35, 1.29)	.23	0.72 (0.43, 1.23)	.23	1.00 (0.52, 1.92)	.99
High school or greater	0.80 (0.49, 1.29)	.36	0.42 (0.22, 0.77)	.006	0.89 (0.53, 1.50)	.66	0.74 (0.39, 1.39)	.35
Race								
Black	. . .	. . .	1.00		. . .	. . .	1.00	. . .
Other	. . .	. . .	0.44 (0.23, 0.84)	.01	0.62 (0.38, 1.02)	.06	0.53 (0.29, 0.99)	.05
Employment								
Student	. . .	. . .	1.00		. . .	. . .	. . .	. . .
Full time	. . .	. . .	1.49 (0.78, 2.84)	.23	. . .	. . .	. . .	. . .
Unemployed, looking for work	. . .	. . .	0.66 (0.27, 1.59)	.35	. . .	. . .	. . .	. . .
Unemployed, not looking for work	. . .	. . .	2.39 (0.96, 5.92)	.06	. . .	. . .	. . .	. . .
Missing	. . .	. . .	0.60 (0.30, 1.21)	.15	. . .	. . .	. . .	. . .
Baseline housing situation								
Living alone	. . .	. . .	. . .	. . .	1.00		1.00	
Living with friends or relatives	. . .	. . .	. . .	. . .	0.71 (0.46, 1.10)	.12	0.68 (0.39, 1.17)	.16

Note. OR = odds ratio; CI = confidence interval; TANF = Temporary Assistance for Needy Families. Multivariate logistic regression was performed to obtain the best estimate of the relation between maternal health literacy and participation with a best subsets approach to arrive at final models separately for birth and 6 months of age. Analytic samples for TANF participation were 626 (of 744) at birth and 499 (of 744) at 6 months; for Food Stamp Program participation, samples were 590 (of 744) at birth and 472 (of 744) at 6 months. No significant differences were found in the distribution of demographic variables (infant birth weight, maternal age, maternal birth country, maternal education, maternal employment) between the analytic samples and the full cohort (data not shown). ORs present estimates for all predictors included in each of the 4 best models. Associations between explanatory variables were assessed to exclude multicollinearity. Although health literacy was related to maternal education, 38% of the mothers with inadequate health literacy had an education greater than high school. Although income and employment were significantly related ($P < .001$), they were not collinear, and both contributed to the model. All analyses were conducted with SAS (Version 9.1.3; SAS Institute Inc, Cary, NC).

educational attainment. Further research into solution-oriented approaches to these problems is warranted. ■

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Contributors

S. Pati led the conceptualization, design, and implementation of the study; wrote the brief; and revised subsequent drafts. Z. Mohamad and A. Cnaan conducted the analyses, helped implement the study, and helped write the draft of the brief. J. Kavanagh helped implement the study, helped interpret the results, and provided critical revision of the brief. J.A. Shea helped interpret the results and provided critical revision of the brief. All authors helped interpret findings and reviewed drafts of the brief.

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Human Participant Protection

All study activities were approved by the institutional review boards at the Children's Hospital of Philadelphia and the University of Pennsylvania. Participants provided written consent and were remunerated according to the study protocol.

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Effects of Green Buildings on Employee Health and Productivity

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We investigated the effects of improved indoor environmental quality (IEQ) on perceived health and productivity in occupants who moved from conventional to green (according to Leadership in Energy and Environmental Design ratings) office buildings. In 2 retrospective–prospective case studies we found that improved IEQ contributed to reductions in perceived absenteeism and work hours affected by asthma, respiratory allergies, depression, and stress and to self-reported improvements in productivity. These preliminary findings indicate that green buildings may positively affect public health. (*Am J Public Health.* 2010;100:1665–1668. doi:10.2105/AJPH.2009.180687)

The effect of indoor environmental quality (IEQ) in office buildings on employee health, well-being, and productivity is an important topic in occupational health and public health research and practice. IEQ can negatively affect occupants' physical health (e.g., asthma exacerbation and respiratory allergies) through poor air quality, extreme temperatures, excess humidity, and insufficient ventilation and psychological health (e.g., depression and stress) through inadequate lighting, acoustics, and ergonomic design.[1–12] Studies have shown that employees with such adverse health conditions are absent more often, lose more work hours, and are less productive than employees without these conditions.[13–18] The green building movement is attempting to address IEQ and employee health concerns by providing healthier building environments. Although the claim that improved IEQ also improves health and productivity is made in many qualitative studies[19–29] and has provided substantial motivation to build green,[30,31] quantitative studies are needed to validate these relationships.[15,32]

We evaluated changes in employee-perceived asthma and respiratory allergy symptoms and depression and stress conditions and the effect of these perceived changes on self-reported absenteeism, work hours affected, and productivity changes, following the movement from traditional to green (according to Leadership in Energy and Environmental Design [LEED] ratings) office buildings.[33] We focused on LEED-rated buildings because they dominate the US green building market,[34] and they are designed and constructed to optimize IEQ.

We carried out 2 case studies in the area of Lansing, Michigan, with a retrospective–prospective cohort design to evaluate the effects of moves to green buildings on perceived employee outcomes. The preliminary findings from these longitudinal studies will provide substantive direction for future occupational and public health initiatives, researchers, and public health policymakers.

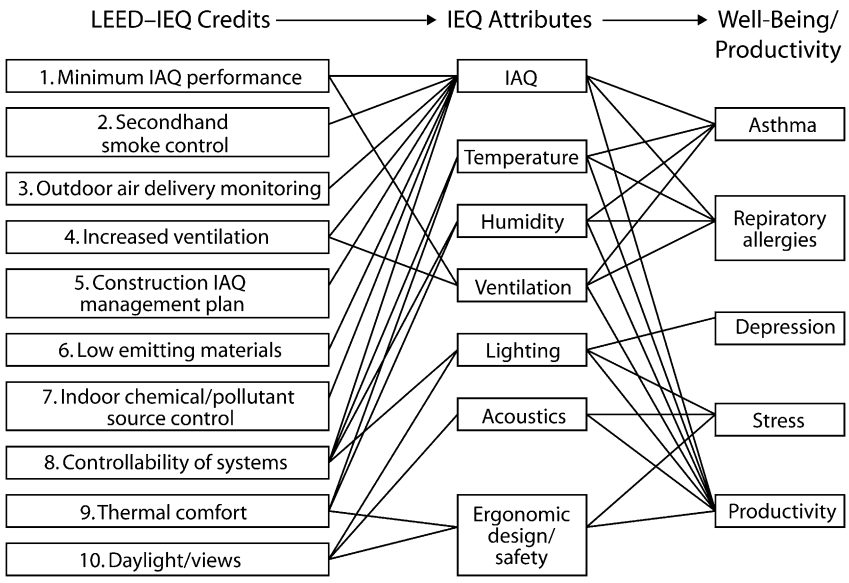
METHODS

We conducted 2 case studies in which we followed employees (study 1, n=56; study 2, n=207) who moved from conventional office buildings to LEED-rated buildings in Lansing, Michigan. LEED ratings range from Certified (lowest) to Silver, Gold, and Platinum, according to a system of LEED–IEQ credits defined by 7 attributes: indoor air quality, temperature, humidity, ventilation, lighting, acoustics, and ergonomic design and safety.[8] Figure 1 links these attributes with LEED–IEQ credits and selected health and productivity outcomes. The study 1 building was awarded the platinum LEED rating, and the study 2 building received a gold rating.[35]

Premove and postmove surveys were conducted with Web-based survey instruments that took employees approximately 20 minutes each to complete. We developed the surveys after reviewing the literature assessing other relevant health questionnaires.[21,33–36] We pretested the surveys and finalized them after receiving feedback from industry and academic experts. We conducted the premove survey for study 1 employees 3 to 4 months after their move; it was therefore retrospective. The study 2 employees responded to the premove survey while they still occupied the conventional building. The premove survey response rate for study 1 was 58.9% (n=33) and for study 2, 68.5% (n=142).

For study 1, we conducted the postmove survey 3 months after the premove survey (i.e., 6–7 months after the move); the response rate was 57.1% (n=32). The postmove survey for study 2 occurred 1 to 2 months after the premove survey (i.e., 4–6 weeks after the move); the response rate was 54.5% (n=113). The total study period was approximately 8 months. We downloaded both survey data sets into Excel spreadsheets (Microsoft Corp, Redmond, WA) and analyzed them in Excel and Minitab15[36] software programs.

We used the lower-tailed paired *t* test to determine the mean difference in perceived work hours affected and productivity change between paired observations (i.e., employees who completed both the pre- and postmove surveys). The paired *t* test computes a confidence interval and performs a hypothesis test of the difference between 2 population means when observations are paired and the paired differences follow a normal distribution. The paired differences in the pre- and postmove survey of outcomes reported by employees were normally distributed and therefore met



Note. IAQ = indoor air quality. The LEED credits listed here represent typical IEQ-related concerns covered in LEED rating systems; however, different rating systems may use minor variations of these credits. Case study project 1 pursued all credits 1-10, and case study project 2 pursued all credits except credit 9.

FIGURE 1—Leadership in Energy and Environmental Design (LEED)–indoor environmental quality (IEQ) occupant well-being and productivity structure.

the criteria for performing the paired *t* test on the paired observations in our studies.

RESULTS

Demographic information collected during the premove survey (n=175 for both studies) showed that a majority of respondents were female (68.0%), White (86.8%), non-Hispanic (82.2%), college educated (64.0%), and married (64.6%). Respondents' ages were younger than 20 years (1.2%), 20 to 29 years (34.3%), 30 to 39 years (29.7%), 40 to 49 years (20.3%), and older than 49 years (14.5%). Employees described their positions and responsibilities as managerial–executive (22.9%), supervisory (15.4%), support staff (58.3%), or other (3.4%). Overall, 14.9% of employees reported a medical history of asthma; 28.6%, respiratory allergies; 14.9%, depression; and 33.7%, stress-related conditions.

The mean number of self-reported hours absent per month from asthma and respiratory allergies in the premove survey was 1.12 (range=0–18; n=49); in the postmove survey, it declined to 0.49 (range=0–8; n=34). The premove mean for self-reported hours absent per month for depression and stress-related conditions was 0.93 (range=0–13); after the move, it was 0.47 (range=0–12). The mean number of self-reported work hours affected per month by asthma and respiratory allergies was 16.28 (range=0–88; n=46) before the move and 6.32 (range=0–28; n=33) afterward. The mean number of self-reported work hours affected per month by depression and stress was 20.21 (range=0–88) before the move and 14.06 (range=0–88) afterward. Before the move, the mean perceived productivity (i.e., self-reported effect of IEQ on typical productivity) was –0.80% (range=–10.0% to 10.0%; n=128); afterward it was 2.18% (range=–10.0% to 10.0%; n=141).

Overall, we found substantial reductions in self-reported absenteeism and affected work hours as a result of perceived improvements in health and well-being. The employees also perceived a positive effect of their new work environment on their productivity.

Our paired *t* test results for mean differences in perceived work hours affected and productivity change for employees who completed the pre- and postmove surveys are shown in Table 1, as perceived annual work hours gained. These findings suggested that perceived improvements in asthma and respiratory allergies could provide 1.75 additional work hours per year (e.g., 0.41+1.34) to each employee with a medical history of these conditions. Similarly, employees with a medical history of depression or stress might gain 2.02 additional work hours per year because of reductions in their perceived work hours affected by these conditions. Finally, the improvements in perceived productivity were fairly substantial and could result in an additional 38.98 work hours per year for each occupant of a green building.

DISCUSSION

The literature on the health effects of green buildings claims that improved IEQ has a positive effect on health and well-being. Our findings in these preliminary studies lend support to expectations of improved IEQ and occupational health and public health outcomes from expanded use of green office buildings. Our case studies employed a longitudinal study design and collected data from employees who moved from conventional to LEED-rated buildings about their productivity and health symptoms before and after the moves. These quantitative data supplement previous qualitative studies about the benefits of green office buildings.

Limitations

Study 1 employees received their premove survey 4 to 6 weeks after their move into the LEED-rated building, so there was the potential for recollection bias. We tried to minimize this bias by asking respondents to rate their level of confidence when reporting their premove outcomes and excluding responses rated less than 50% confident. Previous comparisons of retrospective reporting of sickness and work absences with recorded employer data found minimal discrepancies,[37,38] suggesting that recollection bias in study 1 probably did not significantly affect the results.

We did not evaluate the recollection and perceptual bias of employees reporting their own health effects.[39] For example, employees

TABLE 1—Results From a Paired *t* Test for Well-being and Productivity Benefits Among Employees Who Moved From Conventional to Green Office Buildings: Sustainable Built Environment Project, Greater Lansing area, Michigan, 2008–2009.

Outcome	Mean Difference[a]	*P*[b]	Minimum Average Gains	Total Benefit per Year
Absenteeism attributable to asthma and respiratory allergies, d (n = 25)	0.034	.047	Reduced by 0.034 h/mo for each occupant reporting asthma or allergies	Additional 0.41 work hours/occupant
Work hours affected by asthma and respiratory allergies (n = 27)	2.35	.02	Reduced by 2.35 h/mo for each occupant reporting asthma or allergies	Additional 1.34 work hours/occupant reporting asthma or allergies[c]
Work hours affected by depression and stress (n = 34)	2.86	.02	Reduced by 2.86 h/mo for each occupant reporting depression or stress	Additional 2.02 work hours/occupant reporting depression or stress[d]
Direct effect of IEQ on productivity, hours (n = 86)	2.59	<.001	Productivity improved by 2.6% for all occupants	Additional 38.98 work hours/occupant[e]

Note. IEQ = indoor environmental quality.
[a]Mean difference of (premove – postmove) response for well-being and (postmove – premove) for productivity.
[b]Only statistically significant values (≥ 95% lower-bound confidence) are reported.
[c]The minimum average premove productivity loss as reported by respondents when facing asthma or respiratory allergies was calculated as 4.75%, yielding a postmove gain of 2.35 work hours, or 0.112 h/mo. Calculation performed with the lower-tailed *t* test and both pre- and postmove survey data.
[d]The minimum average premove productivity loss as reported by respondents when facing depression or stress conditions was calculated as 5.90%, yielding a postmove gain of 2.86 work hours, or 0.17 h/mo. Calculation performed with the lower-tailed *t* test and both pre- and postmove survey data.
[e]The minimum average premove productivity loss attributable to all health conditions as reported by all respondents was calculated as 0.565%. Calculation performed with the lower-tailed *t* test and both pre- and postmove survey data. For each month averaging 160 work hours, a 2.03% improvement equals 3.25 additional work hours.

may have perceived and acted upon (or not acted upon) their symptoms of asthma, allergies, depression, and stress differently, and these differences may have biased their recollection and perception of the outcomes reported in the pre- and postmove surveys. Ideally, it would have been beneficial to have observed these behaviors instead of relying on self-reports. In addition, independent data to verify employees' perception of absenteeism, work hours affected, and productivity (e.g., personnel records) were not available for these studies.

The pre- and postmove surveys were taken at different times of the year, so asthma and allergy symptoms reported before and after the moves may have been seasonally biased. The timing of the moves was decided by facility managers, and thus our pre- and postmove surveys were conducted at the beginning and end of the pollen seasons in Michigan. The premove survey for study 1 and study 2, conducted in April and May, obtained retrospective information on outcomes from study 1 in January and from study 2 in March and April. Both postmove surveys were conducted in September and October to obtain retrospective information on outcomes in August. In Michigan, different pollen types are released in early spring (e.g., trees and grasses) and fall (e.g., grasses and weeds), so fall pollen exposures may have resulted in less severe or fewer allergic reactions in our study population than did spring pollen exposures. Ideally, it would have been preferable to conduct the pre- and postmove surveys at the same time of year.

Perceived improvements in stress and depression after the move into the new LEED-rated buildings may have been the result of employees' excitement about their new work environment. The Hawthorne effect[15] explains such temporary bias in occupants' perception of their performance and satisfaction resulting from a change in the work environment. Other studies dispute the Hawthorne effect[40–42]; 1 contention is that increases in productivity after renovations were likely a result of the removal of obstacles that impede productivity.[42] Finally, we assumed that the projections of improvements in perceived work hours affected and productivity gains would be maintained over a year.

Future Research

Our preliminary analyses identified several limitations to the study design, as well as potential solutions, that could inform future studies. Larger studies, with more sites and participants, would allow for evaluation of the independent and interactive effects of IEQ attributes on employees' perceived health and well-being and productivity outcomes and for the use of triangulation methods to increase the credibility and validity of perceived employee outcomes.

We intend to continue surveying the respondents from these case studies in order to evaluate spring pre- and postmove perceived changes in asthma and allergies, monitor the Hawthorne effect as a potential source of bias in explaining improvements in employee productivity, and evaluate the annual real improvements in perceived employee outcomes to validate these preliminary findings. We will also conduct similar studies at more sites in order to contribute further empirical data to evaluate the hypothetical claims in the IEQ, health, and well-being literature. ■

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All authors helped to design the study and survey instrument and write the article. A. Singh refined the survey instrument and supervised the collection of data and data analysis. M. Syal originated the study and led the development of the survey instrument, data collection, and analysis. S. Grady and S. Korkmaz participated in the data analysis.

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Human Participant Protection

This study was approved by the institutional review board of Michigan State University.

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Family Dog Ownership and Levels of Physical Activity in Childhood: Findings From the Child Heart and Health Study in England

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Dog ownership is associated with higher physical activity levels in adults; whether this association occurs in children is unknown. We used accelerometry to examine physical activity levels in 2065 children aged 9 to 10 years. Children from dog-owning families spent more time in light or moderate to vigorous physical activity and recorded higher levels of activity counts per minute (25; 95% confidence interval [CI]=6, 44) and steps per day (357; 95% CI=14, 701) than did children without dogs. (*Am J Public Health.* 2010;100:1669–1671. doi:10.2105/AJPH.2009.188193)

Adults who own dogs are more physically active (taking approximately 25% more steps per day) than are those who do not own dogs.[1–8] However, the association between dog ownership and physical activity levels in children remains unknown. We therefore examined whether family dog ownership is associated with objectively measured physical activity in a population-based study of 2065 9- to 10-year-old children from different ethnic groups.

METHODS

The Child Heart and Health Study in England (CHASE) was a school-based cross-sectional survey of the cardiovascular health of children of White European, Black African-Caribbean, and South Asian origin in 3 cities (London, Birmingham, and Leicester, UK).[9] Physical activity measurements were carried out in 78 schools studied between February 2006 and February 2007.[10] Children were asked to wear an ActiGraph GT1M activity monitor (ActiGraph, LLC, Pensacola, FL) over the left hip on an elasticized belt during waking hours for 7 complete days. On return of the instrument, ActiGraph data files were downloaded and batch processed with a dedicated program (MAHUffe; MRC Epidemiology Unit, Cambridge, UK; available at http://www.mrc-epid.cam.ac.uk/Research/Programmes/Programme_5/InDepth/Programme%205_Downloads.html).

Outcomes included mean daily activity counts, mean daily steps, and activity counts per minute (cpm) of registered time; days with less than 600 minutes were excluded. Mean daily times (minutes) spent in sedentary (defined as <100 cpm), light (100 to <2000 cpm), and moderate to vigorous (≥2000 cpm) physical activity also were used (equivalent to walking at least 4 km/h).[11,12]

Ethnic origin of the child was based on parentally defined ethnicity and classified as White European, South Asian, Black African-Caribbean, or "other." Child questionnaires asked "Do you have any pets at home?" and, if so, "What kinds of pets?" Children were classified as dog owners or non–dog owners. We compared differences in activity outcomes by dog ownership category with multilevel linear regression adjusted for age, gender, ethnicity, socioeconomic position (based on self-reported parental occupation coded according to the Standard Occupational Classification 2000),[13] allowing for day of the week, day order of recording (i.e., whether it was the first, second, third, and so forth day of recording), and month, with school fitted as a random effect.[10]

RESULTS

In all, 2065 children provided at least 1 complete day of ActiGraph recording and questionnaire data (participation rate=69%), with similar numbers of children and participation rates by ethnic group. Overall, 10% of the participants had family dogs; family dog ownership was more prevalent among White European children (22%) than among other ethnic groups (all<10%; Table 1).

Children with a dog spent more time in light, moderate to vigorous, and vigorous physical activity and recorded more overall activity counts, counts per minute, and steps compared with non–dog owners (Table 2). Associations between dog ownership and physical activity did not differ significantly between weekdays and weekends, summer and winter, boys and girls, or ethnic groups (data not shown). Dog ownership did not account for the ethnic differences in physical activity levels previously described in this study.[10] Although participants who provided a single day of physical activity data (5%) were included in the analysis (to optimize participation rates), most children (89%) provided 3 or more days of physical activity data, and the exclusion of children who contributed fewer days made little difference to the results. Results were not materially affected by exclusion of the few children who reported cycling (not adequately measured by accelerometry) or swimming (when monitors were removed).

DISCUSSION

Our results suggest that children from households with a pet dog have higher levels of physical activity, measured objectively by accelerometry (which provides more accurate assessment of physical activity levels in this age group).[14,15] However, in both adults and children, the extent to which physical activity differences reflected a causal influence of dog ownership or the self-selection of dog owning by more active individuals and families was difficult to establish.[16] Longitudinal studies in adults before and after dog ownership suggest that dog owners become more active[3]; effects in children are unknown. The smaller effect size in children (360 steps/day; 4% difference) compared with that observed in adults (1700 steps/day; 25% difference)[8] is unsurprising and suggests that children's physical activity undertaken with a dog is likely to account for a smaller proportion of total physical activity than that for an adult responsible for exercising a dog.[17]

Our study (in a less affluent urban population) may have underestimated the potential influence of dog ownership on physical activity in a more affluent setting, where there may be better access and proximity to higher-quality

TABLE 1—Dog Ownership Status Overall and by Ethnic Group: Child Heart and Health Study in England, February 2006–February 2007

	Ethnic Group				
	White European	Black African-Caribbean	South Asian	Other	Total
Dog owner, no. (%)	114 (22)	28 (5)	13 (3)	47 (9)	202 (10)
Non-dog owner, no.	393	546	474	450	1863
Total, no.	507	574	487	497	2065

public open space,[18–20] although the independent mobility of children in more affluent areas is not necessarily greater.[21] Further work is needed to examine the influence of dog ownership in different social settings. In adults, the increased physical activity associated with dog ownership primarily reflects walking[1]; the increase in children could reflect active play involving the dog and walking. We could not distinguish between these possibilities; further studies documenting the timing and nature of activities carried out with the pet dog would help to resolve this issue. ■

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Contributors

All authors contributed substantially to the origination and design of this brief. C.G. Owen drafted the brief and led the physical activity assessment with support from U. Ekelund, D.G. Cook, and P.H. Whincup. C.M. Nightingale and A.R. Rudnicka carried out the statistical analyses. P.H. Whincup conceptualized, raised funding for, and directed the Child Heart and Health Study in England with help from D.G. Cook. All authors had access to the data and approved the final version.

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TABLE 2—Summary of Objectively Measured Activity Outcomes, by Child-Reported Pet Ownership, Comparing Non–Dog Owners With Dog Owners: Child Heart and Health Study in England, February 2006–February 2007

	Non-Dog Owners (n = 1606), Mean (95% CI)	Dog Owners (n = 178), Mean (95% CI)	Mean Difference (95% CI)	*P* (Difference)
Time, min, spent sedentary	573 (566, 580)	562 (546, 578)	-11 (-27, 5)	.17
Time, min, spent in light physical activity	176 (172, 180)	181 (175, 187)	5 (0, 10)	.04
Time, min, spent in moderate physical activity	47 (45, 48)	48 (46, 50)	1 (-1, 3)	.18
Time, min, spent in vigorous physical activity	22 (21, 23)	24 (22, 25)	2 (0, 3)	.04
Time, min, spent in moderate to vigorous physical activity	69 (66, 71)	72 (68, 75)	3 (0, 6)	.06
Counts	394 257 (387 611, 400 903)	412 490 (397 264, 427 716)	18 233 (2 969, 33 497)	.02
Counts/min	486 (478, 495)	511 (492, 530)	25 (6, 44)	.01
Steps	9 798 (9 642, 9 953)	10 155 (9 809, 10 501)	357 (14, 701)	.04

Note. CI = confidence interval. Analyses are adjusted for gender, age (in quartiles), ethnicity, socioeconomic position, day order of recording, day of the week, month of the year, and clustering effect of school. Socioeconomic status was available for 1784 children.

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