

From Concept to Application: The Impact of a Community-Wide Intervention to Improve the Delivery of Preventive Services to Children

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ABSTRACT. *Objective.* To improve health outcomes of children, the US Maternal and Child Health Bureau has recommended more effective organization of preventive services within primary care practices and more coordination between practices and community-based agencies. However, applying these recommendations in communities is challenging because they require both more complex systems of care delivery within organizations and more complex interactions between them. To improve the way that preventive health care services are organized and delivered in 1 community, we designed, implemented, and assessed the impact of a health care system-level approach, which involved addressing multiple care delivery processes, at multiple levels in the community, the practice, and the family. Our objective was to improve the processes of preventive services delivery to all children in a defined geographic community, with particular attention to health outcomes for low-income mothers and infants.

Design. Observational intervention study in 1 North Carolina county (population 182 000) involving low-income pregnant mothers and their infants, primary care practices, and departments of health and mental health. An interrupted time-series design was used to assess rates of preventive services in office practices before and after the intervention, and a historical cohort design was used to compare maternal and child health outcomes for women enrolled in an intensive home visiting program with women who sought prenatal care during the 9 months before the program's initiation. Outcomes were assessed when the infants reached 12 months of age.

Interventions. Our primary objective was to achieve changes in the process of care delivery at the level of the clinical interaction between care providers and patients that would lead to improved health and developmental outcomes for families. We selected interventions that were directed toward major risk factors (eg, poverty, ineffective care systems for preventive care in office practices) and for which there was existing evidence of efficacy. The interventions involved community-, practice-,

and family-level strategies to improve processes of care delivery to families and children. The objectives of the community-level intervention were: 1) to achieve policy level changes that would result in changes in resources available at the level of clinical care, 2) to engage multiple practice organizations in the intervention to achieve an effect on most, if not all, families in the community, and 3) to enhance communication between, among, and within public and private practice organizations to improve coordination and avoid duplication of services. The objective of the practice-level interventions was to overcome specific barriers in the process of care delivery so that preventive services could be effectively delivered. To assist the health department in implementing the family-level intervention, we provided assistance in hiring and training staff and ongoing consultation on staff supervision, including the use of structured protocols for care delivery, and regular feedback data about implementation of the program. Interventions with primary care practices focused on the design of the delivery system within the office and the use of teamwork and data in an "office systems" approach to improving clinical preventive care. All practices ($N = 8$) that enrolled at least 5 infants/month received help in assessing performance and developing systems (eg, preventive services flow sheets) for preventive services delivery. Family-level interventions addressed the process of care delivery to high-risk pregnant women (<100% poverty) and their infants. Mothers were recruited for the home visiting intervention when they first sought prenatal care at the community health center, the county's largest provider of prenatal care to underserved women. The home visiting intervention involved teams of nurses and educators and involved 2 to 4 visits per month through the infant's first year of life to provide parental education on fetal and infant health and development, enhance parents' informal support systems, and link parents with needed health and human services. We included training in injury prevention and discipline, and home visitors assisted mothers in obtaining care from one of the primary care offices.

Results. There were high levels of participation, changes in the organization of the delivery system, and improvements in preventive health outcomes. Agencies cooperated in joint contracting, staff training, and defining program eligibility. All 8 eligible practices agreed to participate and 7/8 implemented at least 1 new office system element. Of eligible women, 89% agreed to participate, and outcome data were available on 80% (180/225). After adjusting for differences in baseline characteristics, intervention group women were significantly more likely than comparison group women to use contraceptives (69% vs 47%), not smoke tobacco (27% vs 54%) and have a safe and stimulating home environment for

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their children. Intervention group children were more likely to have had an appropriate number of well-child care visits (57% vs 37%) and less likely to be injured (2% vs 7%). Intervention mothers also received Aid to Families with Dependent Children for fewer months after the birth of their child (7.7 months vs 11.3 months).

Conclusions. We observed a number of positive effects at all 3 levels of intervention. Policy-level changes at the state and community led to lasting changes in the organization and financing of care, which enabled changes in clinical services to take place. These changes have now been expanded beyond this community to other communities in the state. We were also able to engage multiple practice organizations, reduce duplication, and improve the coordination of care. Changes in the process of preventive services delivery were noted in participating practices. Finally, the outcomes of the family-level intervention were comparable in direction and magnitude to the outcomes of previous randomized trials of the intervention. All the changes were achieved over a relatively brief 3-year study period, and many have been sustained since the project was completed. Tiered, inter-related interventions directed at an entire population of mothers and children hold promise to improve the effectiveness and outcomes of health care for families and children. *Pediatrics* 2001;108(3). URL: <http://www.pediatrics.org/cgi/content/full/108/3/e42>; children, preventive services, quality improvement.

ABBREVIATIONS. WIC, Women, Infant's and Children; AFDC, Aid to Families With Dependent Children.

Despite increasing emphasis on prevention and abundant evidence of ways to improve the delivery of preventive services to children¹⁻³ many Healthy People 2010 goals for children have not been achieved. Traditional approaches to moving evidence into practice have not worked. Therefore, current recommendations for improvement concentrate on changing the system of delivering these services. For example, the US Bureau of Maternal and Child Health and other policy analysts are recommending efforts to improve child health through better integration of clinical and population-based preventive services for children.⁴ The Bureau suggests that primary care practices should strive for "vertical" continuity among physicians, nurses, and office staff, as well as "horizontal" continuity of practices with "community-based health and human service programs such as day care centers, early intervention programs, mental health services, and well-developed public health programs."

Applying these recommendations in communities is challenging because they require both more complex systems of care delivery within organizations and more complex interactions between them. Currently, the health care system is fragmented at the community level. Population-based approaches to the delivery of preventive services have been successful primarily in organizations with responsibility for defined populations, such as closed model health maintenance organizations.⁵ In most communities, managed care plans concentrate on their own subscribers rather than on the health of all children, and the responsibility for coordinating services to fami-

lies is unclear. There are also problems at the level of care provision. Health department programs are organized by type of service or disease category (eg, Women, Infant's, and Children [WIC], immunizations, tuberculosis), making it difficult to combine services for families with multiple needs. In primary care offices, a lack of data on performance and outcomes (eg, home safety, child development, practice-wide preventive service rates) makes it difficult to identify gaps in services and plan improvements. In addition, busy practitioners and health departments may not be aware of emerging evidence on effective interventions or have the support needed to incorporate effective interventions into their settings.⁵⁻⁷ These are problems of the delivery system, not lack of knowledge or technology.

To improve the way that preventive health care services are organized and delivered in 1 community, we developed a health care system-level approach that involved addressing multiple care delivery processes, at multiple levels in the community, the practice, and the family. Our objective was to improve the processes of preventive services delivery to all children in a defined geographic community, with particular attention to health outcomes for low-income mothers and infants. We have reported on the feasibility of the interventions previously.⁸ Here we report on the effects of the interventions.

METHODS

Study Site and Participants

The Linkages for Prevention project was a community-wide health system intervention to improve the delivery of preventive services to all children under 2 years of age in Durham, North Carolina, (population 182 000) between July 1994 and July 1997.⁹ We selected preventive services as a target because they are of central importance to the care of young families. We hoped to accelerate the improvement of health outcomes by addressing specific care delivery processes at the level of the clinical interaction between care providers and patients. Because our primary objective was to achieve process change that would lead to clinically relevant changes in outcomes, we selected interventions that were directed toward major risk factors (eg, poverty, ineffective care systems for preventive care in office practices) and for which there was existing evidence of efficacy.

Community-Level Intervention

The objectives of the community level intervention were: 1) to achieve policy level changes that would result in changes in resources available at the level of clinical care, 2) engage multiple practice organizations in the intervention to achieve an effect on most, if not all, families in the community, and 3) to enhance communication between, among, and within public and private practice organizations to improve coordination and avoid duplication of services.

We formed an advisory board chaired by the director of North Carolina Division of Medical Assistance (Medicaid), with representatives from community agencies, primary care practices, and county government, to provide advice about how the project could fit in among existing community health improvement projects. We sought leadership from state health policy makers to develop needed resources and achieve the cooperation between the health and mental health departments necessary to implement the home visiting program. Because practices and agencies face common barriers to improved care delivery, we sought to increase communication among them about how to overcome specific problems in care delivery. Once the practice-level intervention had begun, meetings of practices were held so that physicians and staff could share new approaches to organizing preventive care. To enhance coordination among groups conducting immunization

outreach, we formed a task force of all the groups to identify and close gaps in immunization outreach activities. Finally, we sought to link practice and family interventions by encouraging home visitors to identify a nurse in each practice with whom they could communicate about the families both served. Our aim was to help build lasting change in the organization of health care in the community.

Practice-Level Interventions

The objective of the practice level interventions was to overcome specific barriers in the process of care delivery so that preventive services could be effectively delivered. To assist the health department in implementing the family-level intervention described below, we provided assistance in hiring and training staff and ongoing consultation on staff supervision, including the use of structured protocols for care delivery, and regular feedback data about implementation of the program. We also assisted the health department in the development of strategies and processes to screen, recruit, and enroll families. Interventions with primary care practices focused on the design of the delivery system within the office and the use of teamwork and data in an "office systems" approach to improving clinical care.¹⁰ We sought to involve all primary care practices in Durham that enrolled at least 5 newborns per month. Eight of the 14 practices in the city met this criterion, and together they cared for >80% of the children in the community. The office systems intervention we used with these practices is described in a companion paper.¹¹

Family-Level Intervention

Family-level interventions provided "intensive" home visiting to poor pregnant women and their infants to address risk factors for adverse health outcomes. The home visiting intervention was selected because it had been shown in randomized trials to have immediate and enduring effects in improving the quality of the care giving environment, improving maternal life course development, reducing dependence on government programs, and decreasing childhood injury.^{12,13} Women (regardless of parity) whose incomes were 100% or less of the federal poverty level and who presented consecutively for prenatal care at the community health center were eligible for the intervention. At the time the study was conducted, this clinic served approximately 50% of the low-income pregnant women in the county.

Mothers were recruited for the home visiting intervention when they first sought prenatal care at the community health center, the county's largest provider of prenatal care to underserved women. The home visiting intervention began when the mother presented for prenatal care and involved 2 to 4 visits per month through the infant's first year of life to provide parental education on fetal and infant health and development, enhance parents' informal support systems, and link parents with needed health and human services. We included training in injury prevention and discipline,¹⁴ and home visitors assisted mothers in obtaining care from one of the primary care offices. The home visiting intervention was provided by a public health nurse from the health department and an early childhood educator from the mental health department. Based on our experience in a feasibility study, an early childhood educator was added to the nurse visitor to enhance the emphasis on early childhood development.⁸ Educators were hired through the county Department of Mental Health, which allowed us to take advantage of additional sources of governmental funding.

Study Design and Data Collection

Outcomes of the program were evaluated at all 3 levels of the intervention to assess the degree to which we achieved our objectives. Because there is already evidence that the preventive services we targeted are effective in improving the health of children, we focused on changes in the rates of delivery of care. We were interested in evidence of change in the organization of the delivery system and outcomes of care.

We measured the community-level impact by documenting changes in the participation, financing, and organization of services delivered by participating organizations. We assessed the practice-level intervention by measuring rates of preventive services before and after the intervention, using a random sample of charts abstracted from each practice. (This is described in detail in

the companion paper.¹¹) We assessed the family-level intervention by comparing the extent to which we achieved outcomes comparable to those achieved in earlier randomized trials. We used a historical cohort design that compared maternal and child health outcomes in 2 groups: women enrolled in the intensive home visiting program and women who had sought prenatal care during the 9 months before the program's initiation. Enrollment in the comparison group took place between November 1994 and March 1995. Enrollment in the intervention group occurred between April 1995 and March 1996. Funding for home visiting competent at the intervention was provided by the North Carolina Division of Medical Assistance, but only through the infant's first year. Therefore, we focused on outcomes that could be influenced during this period.

Our measurement approach was based on the work of Kitzman et al¹⁵ In brief, participating women were interviewed by trained interviewers at the time of enrollment and when the child reached 12 months of age. The enrollment interview collected data on demographic,⁵ obstetrical, and medical histories, and data on health-related behaviors (eg, smoking, alcohol use), stress, self-efficacy, and social support. Twelve-month interviews with mothers and/or guardians were used to reassess socioeconomic conditions, medical and reproductive history, health-related behaviors, parenting knowledge and attitudes, and social support. This interview also involved an assessment of the home environment and home safety.

Prenatal, obstetrical, and newborn records were abstracted to measure use of prenatal care and pregnancy outcomes. Birth certificates were obtained from the North Carolina Center for Health Statistics. Social services records were searched for reported child abuse and neglect. Medical records of all hospitals in the region were searched to identify emergency department visits and hospital admissions, and the total number of visits for injuries and ingestions was recorded. The North Carolina Immunization Registry was searched for any record of immunization among children found to be underimmunized. Abstracters and interviewers were unaware of the mothers' treatment assignment.

Prenatal care and pregnancy outcomes included the number of prenatal visits, pregnancy weight gain, gestational age, and complications of pregnancy. The adequacy of prenatal care was measured using the Kotelchuck Index.¹⁶ Hospital records were used to create the index and to measure gestational weight gain, prenatal care, and neonatal problems when birth certificates were unavailable.

Behavioral outcomes included reported use of birth control, and tobacco, alcohol, and illicit drugs. Alcoholic abuse was measured with the CAGE questions.¹⁷ Maternal depression was measured with the Beck Depression Inventory.¹⁸ Rates of preventive services, including immunizations and screening for lead, anemia, tuberculosis, blood pressure, and vision, were measured by chart abstractions in the primary care practices in which mothers sought care. Children were determined to be up-to-date for immunizations if they had received 3 diphtheria, pertussis, and tetanus vaccines; 2 oral poliovirus vaccines; 2 *Haemophilus influenzae* type b vaccines; and 3 hepatitis B vaccines by 12 months of age. The total number of visits and the number of well-child visits were also recorded. Because 4 or 5 well-child visits are recommended by 12 months of age, the number of well-child visits was dichotomized at 4 or more visits. Access to care and satisfaction with care were measured with questions from the National Health Interview Survey.¹⁹ Mothers were also asked if they had had a prenatal visit with the infant's physician and if they knew the date when the child's next immunization was due.

Home safety outcomes were assessed by direct observation using a home safety checklist.¹⁴ The characteristics of the home environment were measured with the infant/toddler version of Home Observation for Measurement of the Environment.²⁰ Mothers' beliefs associated with child abuse were measured by the Adult Adolescent Parenting Inventory.²¹ Parenting knowledge and skills were assessed using a modified 19-item version of the Knowledge of Infant Development Index.²² Satisfaction with parenting was measured by the Parenting Satisfaction Scale.²³ Social Support was measured using the Maternal Social Support Inventory.²⁴

In the 12-month interview, mothers were asked about their postnatal work and educational history, as well as the type of child-care arrangements and the number of hours per week the child used them. Use of human services was measured by asking

mothers about their current receipt of WIC and Aid to Families With Dependent Children (AFDC), an approach found comparable to secondary data collection.¹⁵

Statistical Analysis

To assess the effects of the family-level intervention, we compared the intervention and comparison groups on maternal, parenting, and child outcomes. The analysis of the practice-level intervention is reported in the companion paper. The community level intervention was not amenable to statistical testing.

All family-level analyses used an "intention-to-treat" approach, in which all women enrolled in the project were included regardless of how long they participated in the intervention. We assessed the potential confounding effects for a number of independent variables, selected based on differences between treatment and comparison groups at the time of enrollment, previous evidence, and theory. We used logistic regression to model dichotomous variables and analysis of variance models (analysis of variance) for continuous variables. The following covariates were included in every model: mother's age, education, ethnicity, child order, marital status, baseline smoking status, and alcohol use. In modeling outcomes for alcohol use, drug use, postnatal work outside the home, and school attendance, baseline values were included in the model as well. For instance, to model alcohol use at the end of the intervention, we adjusted for reported alcohol use at enrollment in addition to the basic set of covariates. Models for outcomes that were time-dependent, including parental knowledge, number of well-care visits, and use of WIC and AFDC, were adjusted for the child's age at follow-up. For dichotomous outcomes, we present the adjusted proportion, as well as the measures of effect. For proportions, the adjusted value is the predicted probability of an event when the intervention and control groups both had the same mean values for each of the covariates.

Because of concern that the intervention might have variable effects depending on whether the mother was bearing her first child, a treatment-by-birth order (first child vs not first child) interaction term was included in all adjusted analyses. An interaction term was included if this was significant at the 0.10 level. When significance was detected, group comparisons were done separately for each level of child order.

We collected substantial amounts of data to be able to compare our results to previous randomized trials of the intervention model. However, because of the shorter duration of the intervention (1 year as opposed to 2 years in the randomized trials) and because our emphasis was on translating evidence into practice, our analyses focused on the direction, pattern, and clinical significance of changes observed, in comparison to the randomized trials.

RESULTS

Implementation

All state and county organizations agreed to participate. All the practices proceeded through the 3 phases of the intervention: measuring current performance and understanding the current office system, designing and implementing office system elements, and monitoring implementation. However, practices varied in the number and types of materials designed and implemented.

When all women who agreed to participate in the program were included, families received an average of 32.5 (standard deviation: 21.2) home visits between the time of enrollment and the time the infants reached 12 months of age. The number of visits completed represented 62.3% of the anticipated number of visits, based on our protocols, and is similar to other reported results.¹² Of women in the comparison group, 34.6% (28/81) reported having had at least 1 home visit during their pregnancy by a public health nurse or social worker.

Community-Level Outcomes

Table 1 lists the organizations that participated in the project at state, county, and local levels and changes that took place that may have been related to the interventions. The North Carolina Division of Medical Assistance and the North Carolina Division of Women and Children's Health collaborated to provide start-up funding and Medicaid reimbursement for the intensive home visiting services. With the assistance of the North Carolina Divisions of Medical Assistance and Mental Health, the county departments of health and mental health developed a joint contract that enabled them to hire and fund the home visitors. During the course of the study, the intensive home visiting program was adopted as an ongoing service of the health department. The health department also worked with other community home visiting projects to define eligibility criteria for each program and share staff training. These home visiting programs have continued to coordinate their services to maximize the number of children in the community who can be served. As a result of the practice level intervention, the primary care practices involved in the study met twice to share improvement ideas with each other and are continuing work to measure and improve the quality of their care. Finally, the health department, community health center, volunteers, and the North Carolina Immunization Section participated in joint planning of immunization outreach services. However, despite uncovering ways in which outreach could be improved, the planning effort did not result in changes in outreach services during the study period.

Practice-Level Outcomes

The 8 pediatric and family practices that met the eligibility criterion for the study included an academic pediatric practice, community health center, staff model health maintenance organization, 3 private pediatric practices, and 2 private family practices. All agreed to participate and 7 of 8 practices implemented new office systems. The effects of the practice-level intervention are described in detail in the companion paper on the effectiveness of the office systems intervention in improving preventive services delivery.

Family-Level Outcomes

During the recruitment period for the comparison group, a total of 274 women sought prenatal care. Of these women, 249 (91%) were screened for eligibility (screening was not done when no research assistant was present in the clinic). Of the 121 eligible women, 116 (96%) agreed to participate. Of the 557 women who sought prenatal care during the recruitment period for the intervention group, 449 (81%) were screened for program eligibility. Of the 225 women who were eligible, 201 (90%) agreed to participate. At the end of the study, 110 women had children old enough for the 12-month follow-up interview. Mothers who refused to participate said the program was too time consuming (5%), they already had parenting skills (2%), or they gave other unrelated reasons

TABLE 1. Summary of Major Activities and Changes Observed Among State, County, and Community Organizations Participating in the Health System Intervention

Organization	Intervention Activities	Changes Observed
State government		
Division of Medical Assistance	State and community level leadership Coordinated interactions with other state divisions	Established reimbursement procedures for home visitation services
Division of Mental Health	State and community level leadership Participation in intervention planning	Encouraged collaboration of county health and mental health departments Established reimbursement procedures for home visitation services
Maternal and Child Health Section	State and community level leadership Participation in intervention planning	Provided start-up funds Expanded program following completion of research
Immunization Section	Leadership of immunization task force Coordinated outreach activities with county agencies	Pilot-tested immunization registry in participating primary care practices
County government		
Department of Health	Community leadership Participated on advisory board Program implementation	Developed joint contract with Department of Mental Health to provide home visiting Agreed on target populations with other community home visiting agencies thus expanding availability of services Adopted program as ongoing service
Department of Mental Health	Community leadership Participated in advisory board Program implementation	Developed joint contract with county Health Department
Community organizations		
Community Health Center	Recruited study participants Participated in practice interventions	
Community home visiting agencies	Participated on advisory board	Joint training of agency and county home visiting staff Joint planning of target populations among programs led to expanded availability of service
United Way	Participated on advisory board Community leadership	
Primary care practices	Met to share improvement ideas	Continue working on improvement projects
Volunteer immunization program	Participated in needs assessment of immunization outreach	

(3.5%). Of women in the intervention group, 5% moved out of Durham County and 17% had fewer than 5 home visits.

A high proportion of follow-up assessments were completed among eligible participants: 94% of newborn and delivery records were abstracted, and 96% of birth certificates were matched. Among those

women enrolled who experienced no fetal or child death, 83% completed the 12-month home interviews, and 89% of primary care records and 97% of emergency department and hospital records were abstracted.

Table 2 shows the characteristics of mothers in the intervention and comparison groups at enrollment.

TABLE 2. Characteristics of Intervention and Control Group Mothers at Enrollment

	Intervention		Control	
	%	n/N	%	n/N
Age ≤18 y	18.5	19/103	9.5	10/105
Mean age	22.8	(5.4 standard deviation)	24.1	(5.5 standard deviation)
Ethnicity				
White	4.9	5/103	14.3	15/105
Black	90.3	93/103	80.0	84/105
Education				
<High school	47.6	49/103	40.0	42/105
High school	31.1	32/103	29.5	31/105
Unmarried	89.3	92/103	87.6	92/105
Birth is first child	54.4	56/103	45.7	48/105
Tobacco use	32.0	33/103	34.3	36/105
Alcohol use	20.4	21/103	17.1	18/105
Alcohol abuse	21.1	15/71	14.1	12/85
Drug use	11.3	8/71	8.8	7/80

Differences between the intervention and control in the groups were small. Intervention mothers were younger, more often black, less educated (nearly half had not completed high school), more likely to use alcohol, and more likely to be bearing their first child than comparison group mothers. As noted earlier, we adjusted for baseline differences in these and other potentially confounding factors in the analyses.

Prenatal and Birth Outcomes

There were no overall differences between the intervention and comparison groups in utilization of prenatal care, as measured by the Kotelchuck index, or in urinary infections or sexually transmitted diseases (Table 3). No differences were observed in gestational weight gain, birth weight, or gestational age.

Child Abuse and Injuries and Use of Preventive Services

Although there were no substantiated cases of abuse in either group, the proportion of infants seen in the emergency department or hospitalized for injuries or ingestions was smaller in the intervention group than in the comparison group (2% vs 7%; crude $P = .11$; Table 4). Among the 103 intervention infants, there were 7 (7%) cases of substantiated neglect, compared with 4 cases among 105 (4%) comparison infants (adjusted $P = .34$). This difference may have reflected home visitors' referrals of at risk infants to family preservation services.

Among intervention group children, we observed a favorable pattern of preventive services outcomes. Intervention mothers were more likely than compar-

ison group mothers to have made 4 or more well-child visits by the time the child was 12 months of age (57% vs 37%; $P = .02$). In addition, more intervention mothers (33% vs 20%) had an introductory visit regarding the infant with a physician ($P = .09$). Although 10% more intervention infants were up-to-date on immunizations (73% vs 62%), this difference was not statistically significant ($P = .16$). We did not observe any difference in mothers' satisfaction with their child's health care, such as whether the physician answered questions, provided enough information, or treated parents with respect. We also did not observe differences in the proportion of families visiting only 1 site of care (80% vs 82%; $P = .86$).

Home Environment: Safety and Parenting

Three of 5 measures of the safety of the child's home environment favored the intervention group (Table 5). Intervention infants' homes were more likely to have a poison control number and syrup of ipecac. Although they also seemed more likely to have the home's hot water temperature set below 120°, this outcome could not be consistently measured because a number of 12-month interviews took place outside the home. There were no differences in the proportion of homes with smoke detectors. Slightly fewer intervention mothers reported that the child always rode in a car seat.

Measurement of parental knowledge of development, parenting satisfaction, and child rearing views at 12 months of age did not reveal differences between the intervention and comparison groups. This lack of effect of the intervention by 1 year of age may

TABLE 3. Impact of Program on Birth Weight, Gestational Age, Prenatal Care Use, and Perinatal Infections

	Intervention		Control		Intervention Versus Control		
	%	n/N	%	n/N	OR	P Value	95% CI
Use of prenatal care*							
Crude	29.6	29/98	29.4	30/102	1.0	.98	(0.55, 1.85)
Adjusted	28.3		27.6		1.0	.91	(0.54, 1.99)
Sexually transmitted diseases							
Crude	28.0	21/75	24.6	20/81	1.2	.64	(0.58, 2.42)
Adjusted	17.2		15.2		1.2	.70	(0.54, 2.49)
Urinary tract infections during pregnancy							
Crude	18.7	14/75	19.8	16/81	0.9	.86	(0.42, 2.07)
Adjusted	15.6		18.9		0.8	.60	(0.34, 1.87)
	Intervention		Control		Mean Difference		
	Mean	(SE) n	Mean	(SE) n	Intervention-Control	(SE) P Value	95% CI
Gestational weight gain (lbs)							
Crude	29.3	(1.5) 99	30.6	(1.5) 96	-1.3	(2.1) .52	(-5.42, 2.74)
Adjusted†							
First child	32.9	(3.1) 99	29.3	(3.2) 96	3.6	(3.0) .24	(-2.36, 9.49)
Not first	28.2	(3.2) 99	34.1	(3.1) 96	-5.9	(3.1) .06	(-11.88, 0.14)
Birth weight (g)							
Crude	3039.4	(58.9) 102	3154.8	(59.7) 99	-115.4	(83.9) .17	(-279.80, 48.91)
Adjusted	3230.5	(106.8) 102	3307.3	(104.2) 99	-76.8	(84.9) .37	(-243.17, 89.63)
Gestational age (mo)							
Crude	38.7	(0.24) 102	38.9	(0.24) 101	-0.2	(0.34) .55	(-0.87, 0.46)
Adjusted	39.3	(0.44) 102	39.4	(0.43) 101	-0.1	(0.35) .75	(-0.80, 0.58)

OR indicates odds ratio; CI, confidence interval; SE, standard error.

* Based on Kotelchuck index: adequate to adequate-plus.

† Significant child order-by-treatment group interaction present: $P = .03$.

TABLE 4. Impact of Program on Child Health Events and Use of Preventive Services

		Intervention		Control		Intervention Versus Control		
		%	n/N	%	n/N	OR	P Value	95% CI
Child health events								
Substantiated abuse	Crude	0.0	0/103	0.0	0/105			
Substantiated neglect	Crude	6.8	7/103	3.8	4/105	1.8	.34	(0.52, 6.49)
Emergency department visits for injury or ingestion	Crude	2.0	2/98	7.1	7/99	0.3	.11	(0.10, 1.40)
Use of preventive services								
Immunization up-to-date	Crude	60.2	62/103	49.5	52/105	1.6	.16	(0.83, 3.03)
	Adjusted	72.8		61.9		1.6	.16	(0.82, 3.30)
≥4 Well-care visits by 12 mo of age	Crude	45.6	47/103	30.5	32/105	1.9	.04	(1.04, 3.58)
	Adjusted	57.2		37.4		2.2	.02	(1.14, 4.36)
Introductory visit to baby's doctor	Crude	31.5	23/73	23.4	18/77	1.5	.27	(0.73, 3.11)
	Adjusted	32.9		20.1		1.9	.09	(0.89, 4.25)

OR indicates odds ratio; CI, confidence interval.

TABLE 5. Impact of Program on Quality of Home Environment: Safety and Home Stimulation

		Intervention		Control		Intervention Versus Control					
		%	n/N	%	n/N	OR	P Value	95% CI			
Home safety											
Poison control center number											
Crude		79.2	38/48	34.3	23/67	7.3	<.001	(3.08, 17.18)			
Adjusted		82.0		32.5		9.5	<.001	(3.56, 25.15)			
Syrup of ipecac											
Crude		49.3	34/69	10.5	8/76	8.3	<.001	(3.45, 19.74)			
Adjusted		51.8		8.3		11.9	<.001	(4.41, 31.83)			
Smoke detector											
Crude		86.1	37/43	85.2	46/54	1.1	.91	(0.34, 3.36)			
Adjusted*		99.7		91.0		0.8	.71	(0.20, 2.95)			
Hot water temperature ≤120°F											
Crude		42.3	22/52	26.3	10/38	2.1	.12	(0.83, 5.09)			
Adjusted*		19.4		9.8		2.2	.16	(0.72, 6.80)			
Child always rides in car seat											
Crude		71.4	50/70	79.8	63/79	0.6	.24	(0.30, 1.35)			
Adjusted*		75.4		82.1		0.7	.34	(0.30, 1.53)			
Home stimulation											
HOME scale (high range)											
Crude†		45.3	24/53	27.7	18/65	2.2	.05	(1.0, 4.7)			
		Intervention		Control			Mean Difference			95% CI	
		Mean	SE	n	Mean	SE	n	Intervention-Control	SE	P Value	
Parenting satisfaction*											
Crude		123.2	3.21	71	124.3	(3.24)	70	-1.1	4.56	.81	(-10.04, 7.83)
Adjusted†		138.4	6.20	71	137.7	(5.94)	70	0.6	4.61	.89	(-8.40, 9.67)
Knowledge of development											
Crude		0.6	0.01	75	0.6	(0.01)	79	0.0	0.02	.37	(-0.02, 0.06)
Adjusted†		0.7	0.03	75	0.7	(0.03)	79	0.0	0.02	.3	(-0.02, 0.06)

OR indicates odds ratio; CI, confidence interval; SE, standard error.

* Outcome adjusted for baseline status.

† Outcome adjusted for child's age at follow-up.

reflect the limited ability of measures to discriminate among infants at an age when developmental differences are small and the behavioral challenges of the second year of life have not yet taken place. However, the home environment in which children were raised seemed more stimulating in the intervention group. The proportion of families scoring in the high range of the HOME scale favored the intervention group, as did all but 1 of the subscales. The magnitude of the differences was similar to that reported previously.¹²

Maternal Health, Life Course, and Use of Human Services

We observed a favorable pattern of effects on a wide range of maternal outcomes (Table 6). Intervention mothers were more likely to use effective contraception (69% vs 47%; $P = .007$), and less likely to smoke (27% vs 54%; $P = .04$). They were also more likely to report higher levels of social support. There was no intervention effect on the proportion of women who attempted to breastfeed, the duration of

TABLE 6. Impact of Program on Maternal Health, Life-Course Development, and Use of Social Services

	Intervention		Control		Intervention Versus Control					
	%	n/N	%	n/N	OR	P Value	95% CI			
Maternal health										
Effective contraception										
Crude	66.7	50/75	48.1	39/81	2.1	.02	(1.13, 4.12)			
Adjusted	69.4		46.6		2.6	.007	(1.29, 5.22)			
Smoked tobacco										
Crude	36.0	27/75	47.5	38/80	0.6	.15	(0.33, 1.18)			
Adjusted*	27.4		54.2		0.3	.04	(0.11, 0.92)			
Alcohol user										
Crude	37.3	28/75	43.0	34/79	0.8	.47	(0.41, 1.50)			
Adjusted*	35.4		42.3		0.7	.45	(0.35, 1.59)			
Drug user										
Crude	18.1	13/72	11.5	9/78	1.7	.26	(0.67, 4.23)			
Adjusted*	3.2		2.0		1.6	.41	(0.54, 4.53)			
Attempted breastfeeding										
Crude	41.1	30/73	41.1	30/73	1.0	1.0	(0.52, 1.93)			
Adjusted	38.1		41.8		0.9	.70	(0.39, 1.88)			
	Intervention		Control		Mean Difference			95% CI		
	Mean	SE	n	Mean	SE	n	Intervention-Control	SE	P Value	
Depression										
Crude	8.9	0.90	69	9.0	0.90	69	-0.1	1.27	.96	(-2.57, 2.42)
Adjusted	5.4	1.73	69	6.0	1.65	69	-0.7	1.31	.61	(-3.23, 1.89)
Social support										
Crude	23.0	0.76	73	20.5	0.73	79	2.5	1.05	.02	(0.43, 4.56)
Adjusted	24.2	1.30	73	22.3	1.26	79	1.9	1.02	.07	(-0.11, 3.88)
				Intervention		Control		Intervention Versus Control		
				%	n/N	%	n/N	RR	P Value	95% CI
Maternal life-course										
Working										
Crude				58.7	44/75	56.4	44/78	1.1	.78	(0.58, 2.08)
Adjusted*				62.4		56.7		1.3	.52	(0.61, 2.64)
In school										
Crude				21.3	16/75	16.9	13/77	1.3	.49	(0.59, 3.01)
Adjusted*				9.5		6.9		1.4	.52	(0.48, 4.20)
Use of human services										
Received AFDC after birth of child										
Crude				57.5	42/73	76.0	60/79	0.4	.02	(0.21, 0.86)
Adjusted				55.3		82.2		0.3	.003	(0.11, 0.63)
Received AFDC at 12 months										
Crude				37.8	28/74	45.6	36/79	0.7	.33	(0.38, 1.39)
Adjusted†				33.0		48.7		0.5	.09	(0.25, 1.10)
Received WIC at 12 months										
Crude				64.4	47/73	77.2	61/79	0.5	.08	(0.26, 1.09)
Adjusted†				72.0		89.6		0.3	.006	(0.13, 0.70)

OR indicates odds ratio; CI, confidence interval; RR, risk ratio.

* Outcome adjusted also for baseline status.

† Outcome child's age at follow-up.

breastfeeding, or the proportion using drugs or alcohol. More intervention group women were working or in school. Although a comparable proportion of mothers received Medicaid and WIC for themselves and their children after the birth of the child, fewer mothers in the intervention group reported receiving WIC and food stamps at the time when their infant reached 1 year of age. In addition, the mean duration of the receipt of AFDC was shorter for intervention women (7.7 months vs 11.3 months, $P = .01$).

DISCUSSION

The results of this study suggest that tiered, inter-related interventions directed at an entire population

of children in a community are feasible. We observed a number of positive effects at all 3 levels of intervention. Policy-level changes at the state and community led to lasting changes in the organization and financing of care, which enabled changes in clinical services to take place. These changes have now been expanded beyond this community to other communities in the state. We were also able to engage multiple practice organizations, reduce duplication, and improve the coordination of care. Changes in the process of preventive services delivery were noted in participating practices. Finally, the outcomes of the family-level intervention were comparable in direction and magnitude to the outcomes of previous

randomized trials of the intervention. All the changes were achieved over a relatively brief 3-year study period, and many have been sustained since the project was completed. Although these results are preliminary, they suggest that system-level interventions hold promise to improve the effectiveness and outcomes of care for children.

The interventions were complex and involved introducing multiple changes into the health care delivery system. Because it was not appropriate to use a measurement approach focusing on the effects of individual interventions, we took a systems analysis approach. Although this typically involves the use of an interrupted time series design, we strengthened the approach by including comparison groups at different levels of intervention.

The use of multiple simultaneous interventions also required the use of different evaluation strategies at different levels of intervention. There was no comparison group for the community-level outcomes. However, many community-level changes took place in a community that has had a history of challenges in attempting community collaboration.²⁵ We are encouraged by the amount of collaboration that occurred and by the willingness of community agencies to sustain efforts begun during the project. Furthermore, although the work reported here represents efforts undertaken in a single community, the interventions and measurement approaches may be useful to others as they undertake similar efforts to improve child health outcomes.

The family-level intervention was evaluated with a cohort study design rather than a randomized trial. Although this was a limitation, it enabled us to provide the home visiting intervention to all eligible mothers while still having a comparison group. We observed effects that were similar to those seen in previous randomized trials of the intervention.¹³ Although some effects were more limited, others were greater than observed previously, or were achieved in a shorter period of time (eg, reductions in tobacco use and supplemental assistance). The reductions in the use of AFDC and food stamps may have been attributable to other trends; however, the brief 9-month difference between measurement of the 2 groups makes the effect of secular trends less likely.

There are few examples today of comprehensive, population-based strategies to improve the health and development of all young children in a community (not just those enrolled in particular managed care plans or other closed systems of care). We focused on pregnancy and early childhood because this period provides an opportunity to reach all mothers and children.

Physicians who provide primary pediatric care are in a unique position to improve children's health and development because they encounter virtually every child in a community and are capable of connecting children to needed services. There is also a long tradition of physicians and nurses acting as advocates for children in communities. Linking clinical interventions in physicians' offices and home visits by public health nurses was a concept first developed nearly 100 years ago by Josephine Baker, MD.²⁶

Working in the Hell's Kitchen area of New York in 1907, she implemented a model of well-child care that involved infant examinations in health stations and home visits by nurses to provide education to mothers. The intervention was credited with dramatic reductions in infant mortality attributable to diarrhea, which ravaged the poor sections of the city every summer. Baker had been influenced by the work of Lillian Wald, RN, who pioneered the field of public health nursing by sending nurses into the home. Although Baker's approach was later expanded to other parts of the country, it disappeared with the advent of the private practice of pediatrics.

The model we developed differs from an approach advocated by Zuckerman and Parker,²⁷ which seeks to broaden the scope of care pediatricians provide for families by adding other services (eg, social work, legal assistance) in the medical office. Our approach is based on systems theory, which views care delivery as a series of processes extending from the home to the primary care practice and other community health and social services.²⁸ Systems theory suggests that many opportunities for improvement exist in the interactions between elements of a system (ie, practices, agencies).²⁹ We sought to build capacity and effectiveness at several different levels (the community, the primary care office, and the family) and avoid the need to add resources in any single site by increasing the coordination of existing resources. As illustrated by the cooperative arrangement that developed between the county departments of health and mental health, enhanced cooperation had multiple effects. At a programmatic level, it increased the focus on early childhood development. At a policy level, it has led state policy makers to combine funding streams to support the family-level intervention and expand this model to additional communities in the state.

Many opportunities remain to improve the health and developmental outcomes of young children, especially the socially disadvantaged. Future research should seek to understand how to accelerate and expand the impact of promising interventions like this one. At a community level, we need to understand how factors such as leadership, coordination, and financing can affect the speed and magnitude of change. At a practice level, we need to understand how to implement, spread, and sustain innovative strategies. At a family level, we need to continue to evaluate how enhancing the training and skills of home visitors in particular content areas (eg, home safety, smoking) can magnify their impact. In addition, we need to explore the "dose-response" effects of this intervention and understand how to link in-home and community-based interventions for children.

Future programs must be measured by their impact on the health of all children in a community, not just those who are enrolled in a particular practice or medical care plan. If system-level interventions are feasible and useful, as suggested by this project, the next steps are to determine who is responsible for system-wide improvement, and what resources are

required to achieve the gains in child health and development that are possible.

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