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Cost-Benefit Analysis of Two Child Abuse and Neglect Primary Prevention Programs for US States

Cora Peterson¹  · Curtis Florence¹ · Robert Thomas¹ · Joanne Klevens¹

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Abstract We assessed the US state-level budget and societal impact of implementing two child abuse and neglect (CAN) primary prevention programs. CAN cost estimates and data from two prevention programs (Child-Parent Centers and Nurse-Family Partnership) were combined with current population, cost, and CAN incidence data by US state. A cost-benefit mathematical model for each program by US state compared program costs with the future monetary value of benefits from reduced CAN. The models used a lifetime time horizon from government payer and societal perspectives. Both programs could potentially avert CAN among tens of thousands of children across the country. Lower costs from reduced CAN may substantially offset, but not always entirely eliminate, payers' program implementation cost. Results are sensitive to the rate of CAN in each US state. Given the considerable lifetime societal cost of CAN, including victims' lost work productivity, the programs were cost saving from the societal perspective in all US states using base case methods. This analysis represents an overall minimum return on payers' investment because averted CAN is just one of many positive health and educational outcomes associated with these

programs and non-monetary benefits from reduced CAN were not included. Translating cost and effectiveness research on injury prevention programs for local conditions might increase decision makers' adoption of effective programs.

Keywords Cost-benefit analysis · Child abuse

Abbreviations

CAN	Child abuse and neglect
CDC	Centers for Disease Control and Prevention
CPC	Child-Parent Center
GDP	Gross domestic product
NCANDS	National Child Abuse and Neglect Data System
NFP	Nurse-Family Partnership
USD	US dollar

Introduction

The US National Child Abuse and Neglect Data System (NCANDS) indicates an annual incidence of 678,932 victims of child abuse and neglect (CAN), or 9.1 victims per 1000 children, each year in the USA, including 1484 fatalities (US Department of Health and Human Services 2015). These estimates refer to children and youth age 0–21 years for whom the state determined at least one type of CAN—including neglect, physical abuse, psychological maltreatment, or sexual abuse—was substantiated or indicated. The National Survey of Children's Exposure to Violence suggests that far more youth—nearly 25%—have lifetime experience of CAN (Finkelhor et al. 2015). The attributable costs of CAN for victims and society are substantial, estimated at an average of \$210,012 for non-fatal victims and over \$1.3 million

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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(including victims' lost work productivity value) for victim fatalities (2010 USD) (Fang et al. 2012).

Large-scale effectiveness and cost studies of prevention programs can play an important role in policy decision-making. But policymakers outside the immediate context in which such studies are conducted may question the generalizability of such research to their respective areas. In such circumstances, mathematical modeling can provide a low-cost means to address measurable sources of variation. To that end, we compared the program costs and long-term benefits of two programs associated with reduced CAN incidence (or, primary prevention) that had peer-reviewed, per child or family cost estimates, selected from among strategies and approaches highlighted in a recent comprehensive review (Fortson et al. 2016): Child-Parent Centers (CPC) and Nurse-Family Partnership (NFP) (hereafter, prevention programs) (Miller and Hendrie 2015; Reynolds et al. 2011).

Established in 1967, Title 1-funded CPC is an early education intervention in the Chicago public schools, providing services for low-income families beginning at age 3 years through age 9 years (or preschool through third grade) (Reynolds et al. 2011). The program has been evaluated among children who experienced preschool only (hereafter, CPC preschool only, or CPC PO, consisting of up to three CPC years) and also among children who experienced an extended program (hereafter, CPC preschool + school age, or CPC P + S, consisting of four to six CPC years). Comparative data on a variety of educational and health outcomes for program participants versus non-participants through age 26 years has been published, including the finding of reduced substantiated CAN incidence from age 4–17 years among participants (Reynolds et al. 2011). This study projected the impact of CPC in terms of PO and P + S separately.

NFP is a home visitation program by registered nurses to first-time mothers from the prenatal period through the child's second birthday. The program has been tested in multiple sites, including three randomized trials, and reported in several studies (Miller 2015). The program is associated with reduced CAN incidence (i.e., a child experiencing any CAN), as well as reduced CAN reports per child, age 0–15 years (Eckenrode et al. 2000; Olds et al. 1997; Zielinski et al. 2009), particularly among children born to first-time, unmarried, low-income mothers (Zielinski et al. 2009).

Other programs that potentially could have been included in our cost-benefit analysis of CAN prevention programs—such as Triple P, Parent-Child Interaction Therapy, and others (Fortson et al. 2016)—had one or more of the following: insufficient peer-reviewed effectiveness or cost evidence (including evidence limited to indirect program effects on CAN, rather than CAN incidence) or a focus on secondary prevention (i.e., recidivism) (Chaffin et al. 2011; Coyne and Kwakkenbos 2013; Wilson et al. 2012).

This study focused exclusively on the cost-benefit of the programs' effectiveness to reduce CAN, although these programs have demonstrated effectiveness to improve multiple indicators of children's healthy development. This study therefore represents a CAN-specific—and overall minimum—return on payers' potential investment in these programs. We focused exclusively on CAN for two reasons. First, prevented CAN might be a primary cost savings driver for multiple outcomes such as reduced special education and crime that have been separately measured—and valued—in previous studies (Karoly et al. 1998; Karoly et al. 2005; Reynolds et al. 2011; Washington State Institute for Public Policy 2012). Second, we focused on CAN because there now exists a comprehensive, attributable lifetime incidence cost of CAN from a recent study (Fang et al. 2012).

This study aimed to combine existing effectiveness and cost data on CAN prevention programs with current state-level data to model the lifetime cost-benefit of program implementation in each US state in terms of government budget impact (i.e., payer perspective) and economic impact (i.e., societal perspective).

Methods

Economic Evaluation Details

Comprehensive information on reference data sources, resulting model inputs, calculations, and all results by state are presented in a supplemental file (eTables 1–8, available online). Study information is reported in accordance with Consolidated Health Economic Evaluation Reporting Standards (CHEERS) (Husereau et al. 2013). The primary outcome measures were as follows: (1) the net present value (i.e., benefits less costs) of program implementation from a government payer perspective and (2) the net present value of program implementation from a societal perspective, which included costs and benefits outside of those accruing to a payer, such as the cost of parents' time to attend program sessions and lifetime work productivity gains from reduced CAN among participating children. We also report estimated benefit-cost ratios (or monetary benefit per dollar invested) by state to facilitate comparison of this study's results with previous estimates (Karoly et al. 2005; Reynolds et al. 2011; Washington State Institute for Public Policy 2012). The health outcome measure was substantiated CAN incidence from ages 4 to 17 years (CPC analysis) or 0 to 15 years (NFP analysis) (age ranges were based on available data from previous studies). The intervention cost measure was the total program cost per modeled cohort. Programs were assessed individually; results by program should not be summed and in this study,

and we did not aim to compare the merits of these programs on the basis of benefit-cost results presented here.

Non-monetary measures such as quality-adjusted life years were not investigated and we did not assign a value for intangible costs or quality of life decrements. Costs are presented in 2013 USD. Based on available inflation indices at the state level, inflation adjustments reflected gross domestic product (GDP) sector-specific growth by state over time relative to the state where program costs were originally assessed (US Bureau of Economic Analysis 2015, 2017) (eTable 1). This analysis used a lifetime time horizon (i.e., program costs were incurred during a participant's childhood, and the value of averted CAN was applied as estimated in the reference source—with a lifetime horizon). Costs after the first year were discounted by 3% in CPC cost reference sources, but there was no discounting applied to NFP program costs in the reference study; this is a minor limitation, as the duration of NFP per family is <3 years (eTable 2). The lifetime average value of averted CAN in the reference source was discounted to present value assuming an average age of CAN incidence of 6 years old (Fang et al. 2012).

Lifetime Cost of Child Abuse and Neglect

We assumed that 61% of healthcare costs for CAN victims (\$210,012 for non-fatal victims and over \$1.3 million for fatal victims) were paid by government sources (Fang et al. 2012; Florence et al. 2013) (eTable 3). In the payer perspective analysis, we included as a benefit of reduced CAN the estimated state tax revenues generated from increased work productivity among children who avoid CAN, measured as the average proportion of per capita income paid in state and local taxes (The Tax Foundation 2011) (eTable 4).

CAN outcomes in program effectiveness studies of CPC and NFP reference studies were not reported with a fatality distinction. In the absence of other guiding data, we calculated the average lifetime cost per incident CAN case (whether fatal or non-fatal) by US state as the average of the reference study's estimates of lifetime costs for fatal and non-fatal CAN (Fang et al. 2012), weighted by each state's proportion of substantiated fatal and non-fatal annual incident CAN cases in the most recent annual data (Fang et al. 2012; US Department of Health and Human Services 2015) (eTable 1). At the national level, the estimated 2013 USD (i.e., including inflation) weighted average lifetime costs of CAN for the payer and societal perspective assessments were \$62,781 and \$222,800, respectively (Table 1). These estimates by US state ranged from \$47,120 (Louisiana) to \$76,352 (New York) for the payer perspective and from \$179,179 (Louisiana) to \$261,536 (North Dakota) for the societal perspective (Table 1; eTable 1 for all states).

Modeled Program Cohorts by US State

Child-Parent Centers

The hypothetical annual CPC program cohort (meaning, the cohort that might each year commence with CPC) in each US state was estimated as each state's low-income age 3-year resident population (eTable 1 for data and calculations) (US Bureau of the Census 2009–2013, 2014). At the national level, this cohort consisted of 1,472,116 children (Table 1), based on 36.9% of families with young children classified as low-income. By state, the CPC-modeled cohort size ranged from 1801 (Vermont) to 184,774 (California) (Table 1; eTable 1 for all states).

Nurse-Family Partnership

The hypothetical annual NFP cohort in each US state was estimated as the number of first-time births to low-income, unmarried mothers, who used Medicaid as the primary payer at the time of delivery (US Centers for Disease Control and Prevention, US Centers for Disease Control and Prevention 2003). By state, the modeled cohort size ranged from 589 (Wyoming) to 49,001 (California) (Table 1, eTable 1, and eTable 5 for all states).

Child Abuse and Neglect Incidence and Program Effect

In the base case analysis, we assumed that the observed rate of CAN in reference studies' control groups (i.e., 17.4% in the CPC cohort and 42.0% in the NFP cohort) was the existing rate of substantiated CAN in all states (eTable 2). Control groups' CAN rates in reference studies were drawn from substantiated CAN records in state administrative data where the studies were conducted. Reductions in CAN incidence associated with prevention programs (for example, a reduction of 54.8% in the NFP treatment group relative to a control group, described below) were also applied uniformly to all states (Table 1, eTable 1, and eTable 2).

Child-Parent Centers

A matched case evaluation reported that children who were enrolled in CPC PO ($n = 950$) had a significantly lower rate of substantiated CAN from ages 4 to 17 years compared to a control group enrolled in usual preschool ($n = 523$) (9.9 versus 17.4%, or a relative reduction of 43.1%) (Table 1, details from program reference studies in eTable 2) (Reynolds et al. 2011). In a separate analysis restricted to children who had experienced CPC, children enrolled in CPC P + S ($n = 543$) demonstrated a significantly lower CAN incidence compared to those that only experienced CPC PO ($n = 567$) (8.4 versus 14.4%), suggesting that approximately a third of children

Table 1 Model inputs: national estimates and state ranges, including details of state-level variation

Measure by program	Payer or societal perspective ^a	National estimate	State range				Basis for variation in US state estimates and source	
			Low	State	High	State		
All programs								
LifETIME cost of child abuse and neglect	Payer	\$62,781	\$47,120	Louisiana	\$179,179	Louisiana	Number of substantiated fatal and non-fatal CAN cases by state in most recent annual data (2013) (US Department of Health and Human Services 2015). Also, inflation by state since cost estimated in reference study (Fang et al. 2012; US Bureau of Economic Analysis 2015b), as well as state income tax per capita gained from averted lost productivity (affects payer perspective analysis only).	
	Societal	\$222,800	\$76,352	New York	\$261,536	North Dakota		
Child-Parent Centers								
Program population (<i>n</i>)	Both	1,472,116	1801	Vermont	184,774	California	Number of resident children age 3 years from low-income families by state (US Bureau of the Census 2009–2013, 2014).	
Substantiated child abuse and neglect incidence								
• No program								
- Base case	Both	All states: 17.4%					No state variation applied in base case analysis; a sensitivity analysis reports results that include state variation based on the population rate of CAN per 1000 population by state compared to CPC reference study location (Illinois) in most recent annual data (2013) (Reynolds et al. 2011; US Department of Health and Human Services 2015).	
- Sensitivity analysis	Both	16.2%	2.1%	Pennsylvania	34.9%	Kentucky		
• Relative reduction associated with program:								
- Preschool only	Both	-43.1%	–	–	–	–		
- Preschool + school age	Both	-66.8%	–	–	–	–		
Program cost per child								
• Preschool only	Payer	\$8,878	\$7,332	Mississippi	\$10,977	Alaska	Inflation by state since cost estimated in reference study (Reynolds et al. 2002; A. J. Reynolds et al. 2011; US Department of Health and Human Services 2015). Cost originally assessed in Illinois, presented as 2007 USD.	
• Preschool only	Societal	\$9,635	\$7,957	Mississippi	\$11,912	Alaska		
• Preschool + school age	Payer	\$13,237	\$10,931	Mississippi	\$16,365	Alaska		
• Preschool + school age	Societal	\$14,397	\$11,889	Mississippi	\$17,800	Alaska		
Nurse-Family Partnership								
Program population (<i>n</i>)	Both	370,211	589	Wyoming	49,001	California	Number of first-time births to low-income, unmarried mothers (US Centers for Disease Control and Prevention 2013).	
Substantiated child abuse and neglect incidence								
• No program								
- Base case	Both	All states: 42.0%					No state variation applied in base case analysis; a sensitivity analysis reports results that include state variation based on the population rate of CAN per 1000 population by state compared to NFP reference study location (New York) in most recent annual data (2013) (Olds et al. 1997; US Department of Health and Human Services 2015; Zielinski et al. 2009).	
- Sensitivity analysis	Both	25.2%	3.3%	Pennsylvania	54.4%	Kentucky		
• Relative reduction associated with program	Both	-54.8%	–	–	–	–		

Table 1 (continued)

Measure by program	Payer or societal perspective ^a	National estimate	State range				Basis for variation in US state estimates and source
			Low	State	High	State	
Program cost per child	Both ^b	\$8,046	\$6,750	Mississippi	\$9,498	California	Inflation by state since cost estimated in NFP reference study (Miller and Hendrie 2015). Cost originally assessed in six states and presented as national estimates in 2010 USD.

CAN Child abuse and neglect, CPC Child-parent centers. Costs are 2013 USD. See text for details of state-level variation in estimates. See eTable 1 for comprehensive inputs by state and calculations

^a Payer perspective analysis refers to the government payer perspective; societal perspective analysis includes program cost and benefit values that do not appear in a payer's program budget (e.g., parents' time off from work for program activities and value of increased work productivity among adults estimated to have avoided CAN during childhood due to these programs). See text for details of program costs based on cited cost reference studies and eTable 2 for reference study data and our calculations

^b Program cost estimate in reference study did not contain elements separately relevant to a payer and societal perspective analysis

who participated in CPC P + S suffered CAN over the assessment period compared to peers who had experienced no CPC in the control group (or an estimated relative reduction of 66.8%) (Table 1 and eTable 2).

Nurse-Family Partnership

There were significantly fewer substantiated CAN victims from ages 0 to 15 years among high-risk children (born to first-time, unmarried, low-income mothers) who were randomized to receive nurse home visits during pregnancy through the child's second birthday ($n = 39$) compared to a control group randomized to receive a version of usual medical services (including sensory and developmental screening for the child at 12 and 24 months of age and paid transportation to prenatal and well-child visits through the child's second birthday) ($n = 62$) (19 versus 42%, or a relative reduction of nearly 55%) (Table 1 and eTable 2) (Zielinski et al. 2009). Though NFP has been evaluated in multiple locations, the New York state (Elmira) location is the only US study site where participant outcomes were reported in terms of CAN incidence (Miller 2015).

Program Costs

Child Parent Centers

Average CPC program costs per child were \$8512 for CPC PO and \$12,719 for CPC P + S (2007 USD) (eTable 2) (Reynolds et al. 2011). These average costs per child included program staff, program administration, operations and maintenance, instructional materials, capital outlays and equipment, transportation, food, and community services, school-wide services, school district support, capital depreciation, and interest (eTable 2). Incremental program costs, or the cost of CPC beyond the cost for existing alternative preschool services in the

target population, were not available. Parents' program participation, valued at an estimated wage rate in the reference study, was included in our societal perspective assessment but excluded from the payer perspective assessment. The estimated payer and societal perspective program costs per child for CPC PO in our model ranged from \$7,332 (Mississippi) to \$10,977 (Alaska) and \$7,957 (Mississippi) to \$11,912 (Alaska), respectively (Table 1) (2013 USD). The corresponding estimates for CPC P+S ranged from \$10,931 (Mississippi) to \$16,365 (Alaska) and from \$11,889 (Mississippi) to \$17,800 (Alaska), respectively (Table 1; eTable 1 for all states)

Nurse-Family Partnership

The average per-child NFP cost was calculated from an undiscounted estimated average cost per nurse visit (i.e., \$354 in 2010 USD) multiplied by the average number of visits from a recent evaluation (i.e., 25 visits) (Miller and Hendrie 2015). The estimated cost per visit in the reference study included nurse salaries, fringe benefits, administration and supervision, offices, supplies, travel, and NFP National Services Office fees in six unnamed states and is assumed to represent only a payer perspective (eTable 1). The estimated 2013 USD payer and societal perspective program costs per child for NFP (payer and societal perspective program costs were the same for this program based on available data) in our model ranged from \$6,750 (Mississippi) to \$9,498 (California) (Table 1; eTable 1 for all states).

Analysis

To estimate the number of CAN cases each program could avert per cohort, we multiplied each US state's estimated program cohort size by the estimated CAN incidence rate in that cohort, with and without each program. To estimate the total cost of each program per cohort, we multiplied each state's

estimated program cohort size by the estimated program cost per child, separately for payer and societal perspective assessments. To estimate the total monetary benefit of each program per cohort, we multiplied each state's estimated number of incident CAN cases averted due to the program by the estimated average lifetime cost of incident CAN, separately for payer and societal perspective assessments. The net present value of each program by US state from both payer and societal perspectives was calculated as the total program cost less total program benefits (i.e., value of averted incident CAN cases); a negative value therefore indicates cost savings. The average program cost per averted CAN case was calculated as the net present value divided by the total number of incident CAN cases averted per cohort. The benefit-cost ratio was calculated as the total monetary benefit value of the program divided by the total cost.

Sensitivity Analysis

In a sensitivity analysis, we incorporated each state's current actual substantiated CAN incidence relative to the state in which the program reference study was conducted. For example, to estimate the extant substantiated CAN incidence among the CPC modeled cohort (i.e., low-income 3-year olds) in New York in the sensitivity analysis, we multiplied the CAN incidence rate observed in the reference study's control group (i.e., 17.4%) by the ratio of the current all-ages substantiated CAN rate in New York relative to current rate in the reference study state, Illinois (15.2 per 1000 in New York/9.83 per 1000 in Illinois (US Department of Health and Human Services 2015a)), resulting in an estimated 27.0% CAN incidence among the modeled New York CPC cohort (eTable 1). Reductions in CAN incidence associated with prevention programs (for example, a reduction of 54.8% in the NFP treatment group relative to a control group) were still uniformly applied to all states.

Threshold Analyses

Using base case inputs we undertook a series of threshold analyses for key input measures—maximum program cost per child, minimum program participant completion rate, minimum reduction in CAN incidence—and assessed for each state the values of these inputs that would be required to return at least a neutral long-term net present value by program.

Results

Base Case: Victims Averted

In all states combined, the programs could potentially avert an estimated 110,457 (CPC PO), 171,208 (CPC P + S), or 85,149

(NFP) incident CAN victims per cohort (Table 2). The estimated number of averted CAN victims by program and state ranged from 135 (NFP) in Wyoming to 21,480 (CPC P + S) in California (Table 2; eTable 6 for calculations).

Base Case: Net Present Value per Averted Victim and Benefit-Cost Ratios

All states were estimated to have a negative average net cost per CAN victim averted from the societal perspective for both CPC PO and CPC P + S, indicating societal cost savings over the lifetime of the program cohorts (Table 2; eTable 6 for calculations). From the payer perspective, lower costs from reduced CAN in the years following program implementation may substantially offset, but often not entirely eliminate, payers' cost to implement CPC PO and CPC P + S. NFP estimates suggested a negative net cost per CAN victim averted, or cost savings, for all states using a payer or societal perspective (Table 2; eTable 6 for calculations). For comparison of this study's results with previous studies, societal perspective benefit-cost ratios assessed for all states combined were \$1.73 for CPC (\$1.73 of benefits for every \$1 of program costs) and \$6.37 for NFP (eTable 8).

Child-Parent Centers

From the payer perspective, Michigan had the lowest estimated net average cost per averted CAN victim from CPC (at a cost of \$42,572 and \$38,665 per averted CAN victim for CPC PO and CPC P+S, respectively), while Alaska had the highest net average cost per CAN victim averted from CPC (at a cost of \$85,742 and \$80,164 per averted CAN victim for CPC PO and CPC P+S, respectively) (Table 2).

However, from the societal perspective, both CPC programs were cost saving (i.e., negative net cost) in all states using base case methods. North Dakota was estimated to have the lowest net program cost (-\$134,721 for CPC PO and -\$139,283 for CPC P+S) per CAN victim averted using a societal perspective and Louisiana was estimated to have the highest (-\$59,782 for CPC PO and -\$64,077 for CPC P+S). Across all states, CPC PO could save an estimated \$10.4 billion and CPC P+S \$16.9 billion, over the lifetime of each annual participating cohort of children from the societal cost perspective (eTable 6).

Nurse-Family Partnership

From the payer perspective, net average cost per CAN victim averted through NFP by state ranged from -\$37,962 (North Dakota) to -\$16,203 (Louisiana). From the societal perspective, net savings from program

Table 2 Estimated number of children that could avoid child abuse and neglect per annual cohort and net present value per child abuse and neglect victim averted from payer and societal perspectives by program and state

State	Child-Parent Centers: preschool only			Child-Parent Centers: preschool + school age			Nurse-Family Partnership		
	Victims averted	Payer perspective	Societal perspective	Victims averted	Payer perspective	Societal perspective	Victims averted	Payer perspective	Societal perspective
US total	110,409	\$55,593	-\$94,335	171,134	\$51,082	-\$98,956	85,149	-\$27,801	-\$187,820
Alabama	2,010	\$47,390	-\$85,936	3,116	\$43,606	-\$89,811	1,004	-\$21,642	-\$163,430
Alaska	216	\$85,742	-\$70,743	335	\$80,164	-\$76,457	181	-\$20,017	-\$188,978
Arizona	2,828	\$62,770	-\$87,419	4,383	\$58,092	-\$92,211	1,389	-\$25,581	-\$186,233
Arkansas	1,361	\$46,441	-\$85,149	2,109	\$42,561	-\$89,123	666	-\$24,685	-\$164,954
California	13,858	\$68,457	-\$99,894	21,480	\$62,960	-\$105,525	11,270	-\$34,466	-\$215,111
Colorado	1,600	\$60,528	-\$94,966	2,480	\$55,823	-\$99,785	929	-\$27,244	-\$193,261
Connecticut	717	\$62,784	-\$84,798	1,111	\$57,924	-\$89,776	493	-\$27,306	-\$185,758
Delaware	270	\$62,981	-\$85,402	418	\$58,326	-\$90,170	251	-\$22,636	-\$181,430
DC	204	\$64,568	-\$108,096	316	\$59,422	-\$113,367	170	-\$29,559	-\$213,732
Florida	6,520	\$57,503	-\$89,223	10,105	\$53,062	-\$93,771	6,120	-\$24,753	-\$181,409
Georgia	4,306	\$56,116	-\$84,729	6,674	\$51,847	-\$89,103	3,336	-\$22,796	-\$173,191
Hawaii	346	\$66,312	-\$108,719	536	\$61,024	-\$114,135	241	-\$31,442	-\$218,300
Idaho	679	\$60,807	-\$78,060	1,052	\$56,339	-\$82,637	393	-\$23,049	-\$171,909
Illinois	4,106	\$51,594	-\$98,571	6,364	\$47,219	-\$103,051	3,475	-\$28,257	-\$188,205
Indiana	2,469	\$50,291	-\$84,278	3,828	\$46,244	-\$88,422	2,165	-\$23,727	-\$167,345
Iowa	910	\$44,998	-\$89,898	1,411	\$41,164	-\$93,825	786	-\$24,793	-\$168,263
Kansas	1,095	\$49,949	-\$86,228	1,697	\$45,964	-\$90,310	735	-\$23,374	-\$168,465
Kentucky	1,767	\$48,593	-\$81,356	2,740	\$44,681	-\$85,363	1,432	-\$23,208	-\$161,907
Louisiana	1,993	\$62,899	-\$59,782	3,088	\$58,705	-\$64,077	2,485	-\$16,203	-\$148,262
Maine	347	\$48,362	-\$84,648	538	\$44,352	-\$88,757	219	-\$24,201	-\$166,182
Maryland	1,298	\$60,034	-\$101,798	2,012	\$55,114	-\$106,838	1,155	-\$30,767	-\$203,602
Massachusetts	1,317	\$63,314	-\$94,003	2,041	\$58,335	-\$99,103	893	-\$29,331	-\$197,784
Michigan	3,423	\$42,572	-\$101,406	5,306	\$38,665	-\$105,408	2,628	-\$28,060	-\$180,774
Minnesota	1,425	\$51,037	-\$96,692	2,209	\$46,691	-\$101,143	819	-\$29,184	-\$186,631
Mississippi	1,515	\$47,153	-\$80,101	2,349	\$43,427	-\$83,917	1,630	-\$21,256	-\$156,842
Missouri	2,178	\$51,450	-\$85,447	3,376	\$47,496	-\$89,497	1,730	-\$21,038	-\$166,778
Montana	346	\$63,119	-\$77,346	537	\$58,579	-\$81,996	231	-\$22,537	-\$173,156
Nebraska	658	\$48,760	-\$88,832	1,019	\$44,752	-\$92,938	461	-\$24,172	-\$170,729
Nevada	1,033	\$60,479	-\$84,675	1,601	\$56,040	-\$89,221	755	-\$21,951	-\$177,032
New Hampshire	221	\$61,697	-\$98,995	342	\$57,058	-\$103,747	186	-\$24,065	-\$195,131
New Jersey	2,104	\$57,084	-\$107,334	3,261	\$52,152	-\$112,386	1,052	-\$32,634	-\$208,083
New Mexico	1,002	\$57,580	-\$77,066	1,554	\$53,314	-\$81,435	692	-\$21,948	-\$166,134
New York	6,019	\$56,023	-\$108,459	9,329	\$50,978	-\$113,626	4,460	-\$36,885	-\$212,650
North Carolina	3,958	\$48,908	-\$84,116	6,135	\$44,910	-\$88,211	3,109	-\$24,688	-\$166,654
North Dakota	194	\$45,312	-\$134,721	300	\$40,858	-\$139,283	157	-\$37,962	-\$227,956
Ohio	4,108	\$43,905	-\$92,536	6,367	\$40,050	-\$96,485	2,839	-\$25,933	-\$170,995
Oklahoma	1,671	\$46,591	-\$106,653	2,591	\$42,540	-\$110,802	1,498	-\$28,330	-\$190,634
Oregon	1,322	\$54,182	-\$83,649	2,050	\$49,879	-\$88,057	882	-\$23,885	-\$171,341
Pennsylvania	3,465	\$50,275	-\$105,233	5,370	\$45,967	-\$109,645	2,283	-\$28,857	-\$193,999
Rhode Island	275	\$50,231	-\$89,634	427	\$46,056	-\$93,910	189	-\$26,556	-\$175,758
South Carolina	1,977	\$54,439	-\$83,031	3,064	\$50,301	-\$87,270	1,750	-\$22,284	-\$169,009
South Dakota	313	\$58,345	-\$80,830	485	\$54,190	-\$85,086	217	-\$19,315	-\$167,782
Tennessee	2,611	\$59,183	-\$84,166	4,046	\$54,836	-\$88,619	2,287	-\$22,816	-\$175,887

Table 2 (continued)

State	Child-Parent Centers: preschool only			Child-Parent Centers: preschool + school age			Nurse-Family Partnership		
	Victims averted	Payer perspective	Societal perspective	Victims averted	Payer perspective	Societal perspective	Victims averted	Payer perspective	Societal perspective
Texas	12,448	\$59,345	−\$102,949	19,295	\$54,694	−\$107,714	9,835	−\$28,516	−\$201,214
Utah	1,100	\$60,662	−\$86,037	1,706	\$56,042	−\$90,769	470	−\$24,987	−\$182,019
Vermont	135	\$53,682	−\$88,919	209	\$49,322	−\$93,384	137	−\$26,022	−\$178,373
Virginia	2,068	\$62,060	−\$91,654	3,205	\$57,357	−\$96,471	1,857	−\$25,363	−\$189,594
Washington	2,140	\$62,892	−\$95,757	3,317	\$58,029	−\$100,737	1,475	−\$28,208	−\$197,731
West Virginia	641	\$49,442	−\$79,586	994	\$45,528	−\$83,594	400	−\$21,956	−\$159,736
Wisconsin	1,721	\$48,748	−\$91,130	2,668	\$44,603	−\$95,375	1,200	−\$27,264	−\$176,412
Wyoming	169	\$63,151	−\$72,757	263	\$58,838	−\$77,174	135	−\$17,434	−\$162,987

CAN Child abuse and neglect. Costs are 2013 USD. US totals are different from the sum of all states due to original calculations at the US level, rather than, for example, program cost averages and case sums for all states. See eTable 6 for supporting data (i.e., program cohort size, etc.) by state. Results across programs should not be summed. See eTable 7 for a sensitivity analysis that incorporates variation in states' substantiated CAN rates

implementation were significantly greater, ranging from −\$227,956 (North Dakota) to −\$148,262 (Louisiana) per CAN victim averted. Implementing NFP in all states combined could save an estimated \$16.0 billion over the lifetime of each annual participating cohort of children from the societal cost perspective (eTable 6).

Sensitivity Analysis

Sensitivity analysis that adjusted each state's rates of substantiated CAN relative to the state where the effectiveness study was conducted led to modest differences from the base case analysis for the CPC programs (i.e., a reduction of 6% across all states compared to base case methods, to 102,496 averted cases with CPC PO, and 158,868 with CPC P + S), reflecting the fact that the state where the CPC effectiveness study was conducted—Illinois—currently has a CAN rate close to the average among all US states (eTable 7). The difference between the base case and sensitivity analysis estimates for NFP was more pronounced (i.e., a reduction of 67% across all states, to 51,016 averted cases), reflecting the fact that the reference study state site for the NFP effectiveness study—New York—currently has a high substantiated CAN rate relative to other states. Kentucky, a state with high substantiated CAN incidence, had the lowest estimated net lifetime payer perspective impact from the two versions of CPC in the sensitivity analysis, at a net cost of −\$2,910 and −\$4,859 per averted CAN case for CPC PO and CPC P + S, respectively (eTable 7). In Pennsylvania, a state with very low substantiated CAN incidence, the corresponding costs were much higher; hundreds of thousands of dollars per averted CAN case for both versions of CPC.

Threshold Analysis

With all other inputs at base case assumptions, eTable 6 reports the maximum program cost per child, minimum program completion rate, minimum program effectiveness, and minimum actual CAN rate required to return a neutral net present value in each of these programs from the payer and societal perspective by state. For example, in North Dakota, the program cost per child for CPC PO could more than double, from \$9,511 to \$19,615 and the program would still have a neutral cost impact from the societal perspective, owing to the high cost of CAN. In North Dakota, the minimum program completion rate required for CPC PO to be cost-neutral from the societal perspective was just 37%; and the program would still be cost-neutral even if CPC PO reduced CAN incidence by just 21% (compared to the 43% reduction predicted by the effectiveness study).

Discussion

This study translated cost and effectiveness data for current circumstances in each US state on two programs that previous studies have demonstrated are associated with reduced CAN. This study's results estimate that the programs would generate benefits greater than program costs from a societal perspective. In addition, the results suggest that many states could see the cost of implementing these programs substantially offset by future reductions in direct spending on health care, child welfare, criminal justice, and special education associated with CAN.

It important to stress that this analysis assessed the net present value of reduced CAN incidence, and did not include

the monetary value that might accompany other desirable health and developmental outcomes also associated with these programs. We also have not included non-monetary costs of CAN, including the pain and suffering of children, missed school among victims, conduct or emotional problems stemming from CAN, and decreased quality of life among CAN victims. This study has also assumed that programs would have similar effectiveness to the original program trials.

The overall benefit-cost ratio we have estimated for NFP (\$6.37) is close to one previous estimate of NFP (\$5.70) (Karoly et al. 2005) but higher than another (\$1.61) (Washington State Institute for Public Policy 2012). The similarity of our estimate to one of the previous estimates is a coincidence; a large part of that previous study's estimated NFP value was due to mothers' changed circumstances (i.e., reduced welfare benefits) during the first 15 years of the child's life—a program benefit we have not included here—and that study also included much lower estimated costs related to CAN. For example, in our analysis the value of averted CAN across all participants in all states combined was estimated at \$51,244 (eTable 8), compared to the previous study's estimate of the value of all program benefits—of which CAN was just one—of \$41,419 per child (2003 USD) (Karoly et al. 1998) (eTable 8). Another previous estimate of NFP similarly assumed a much lower value of averted CAN per program participant (\$9174) (2015 USD) (Washington State Institute for Public Policy 2012). Our benefit-cost ratio for CPC PO (\$1.73) is less than a previous study's estimate (\$10.83) (Reynolds et al. 2011). The previous study included intangible costs of crime, and used projected benefits value for a number of measured outcomes, in particular, program participants' lifetime earnings and criminal justice involvement. In comparison, these two elements were directly measured in the lifetime cost of CAN that we used in this analysis (Fang et al. 2012).

Limitations

We evaluated selected effective programs that had published cost data. Our analysis relied on reference studies' methods, which included cost estimates that are at least a few years old. Program cost estimates for economic evaluation ideally employ incremental, rather than average, costs of program implementation in a target population; for our assessment of both CPC and NFP, we had only average program costs per child, and to the extent these programs replace existing alternative services, we may have overestimated the cost of the programs. Program cost estimates for CPC were based on relatively small populations; it is possible that larger scale implementation could yield lower costs per participating child or family. We have accounted for differences in time and location between study sites and the present time in each US state in a limited way through inflation indices. It is not clear, for

example, what other aspects of local conditions might have affected cost estimates in reference studies to the point that it might be inappropriate to generalize the estimates to other US states. Moreover, estimating costs at the state level is challenging. First, program costs will vary within states, primarily based on urban and rural locations, which we were not able to account for. Second, our analysis assumed all states will recoup the benefits of reduced CAN (i.e., reduced crime and medical costs due to lower incident CAN, as well as state tax revenues from averted lost productivity) relative to program investment; available data did not allow us to account for interstate movement of children and families that might cause program benefits to shift out of states that provided an investment in CAN prevention through these programs.

We approached the issue of uncertainty around program costs, program participants' completion, and program effectiveness through a threshold analysis of key inputs required for each program to be cost-neutral in the long term. More information on the timing of CAN incidence in these cohorts, as well as more information on the timing of associated costs (i.e., medical care, child welfare, etc.), could improve forecasts about the impact these programs could have. The reference study estimate for the lifetime cost of CAN is an underestimate, based on limited data to estimate the full range of effects for victims and associates, as well as documented undercounting of CAN through official reporting of substantiated cases (Fang et al. 2012). When interpreting the results of this analysis, decision makers should weigh the non-monetary benefits of reduced CAN and consider the range of benefits documented from these programs.

Program effectiveness measures as published were generally based on per-protocol (i.e., all children completing treatments and with follow-up data) study populations, and our estimates did not account for program attrition. Program attrition could have a substantial impact on our results; for example, if a large number of children incurred costs through program participation but dropped out of the program before completion, this could decrease the number of CAN cases averted and increase the average program cost per averted CAN case. Also, to the extent that these programs are implemented differently in new communities, deviating from the methods as measured in the programs' effectiveness studies, it may be that our assumption of equal effectiveness in a new location is inappropriate.

Substantiated CAN was the outcome measure for this economic evaluation because it was the effectiveness measure reported in available reference studies. Substantiated CAN is a conservative measure of incidence, and is influenced by states' different procedures for investigating and classifying reported CAN (Fang et al. 2012; US Department of Health and Human Services 2015). In 2013, US Child Protective Services received nearly 3.9 million referrals of children being abused or neglected (US Department of Health and Human

Services 2015). Approximately 17.5% of CAN investigations nationwide were substantiated, ranging from 2% in Missouri to 34% in Iowa. Previous research has shown that there is no significant difference in developmental outcomes for children with substantiated CAN versus those subject to an investigation but not substantiated (Hussey et al. 2005). In a threshold analysis, we reported a minimum CAN rate required to return a neutral net present value, and in a sensitivity analysis, we adjusted effectiveness studies' observed substantiated CAN by state to estimate extant CAN rates in the programs' target groups for each state. The base case methods revealed differences among states primarily based on expected program costs and CAN lifetime costs, while the sensitivity analysis incorporated differences among states based on CAN substantiation. Inclusion of a state-level substantiated CAN adjustment in the sensitivity analysis had a notable effect on states that are outliers in terms of substantiated CAN. For example, with a state-level adjustment for substantiated CAN, Pennsylvania—a state with a very low substantiated CAN rate relative to other states—was estimated to avert just 180 incident CAN cases, whereas in the base case analysis, Pennsylvania's expected number of averted cases was 2283 (eTable 7). Local CAN professionals may be in the best position to judge the validity of the substantiated CAN estimate reported in NCANDS as a true reflection of CAN among the state's population.

Research suggests that CAN incidence varies by demographic characteristics, which we were not able to account for based on available data in reference studies. For example, mothers with greater experience of domestic violence in the NFP study were more likely to perpetrate CAN (Eckenrode et al. 2000). The available estimated monetary value of averted lifetime CAN required that we measure program impact in terms of the number of children who had or did not have CAN report, instead of a more nuanced measure such as the number of reports per child (Eckenrode et al. 2000). An NFP evaluation reported significantly fewer substantiated CAN reports per child from age 0–15 years among NFP mothers compared to control mothers (0.44 versus 0.73 reports per child) (Eckenrode et al. 2000; Olds et al. 1997). A related but broader issue is that because our CAN measure was incidence per child, we were not able to include programs with demonstrated effectiveness to reduce CAN recidivism, such as Parent-Child Interaction Therapy (Chaffin et al. 2011; Goldfine et al. 2008).

Notably, this analysis did not account for states that may already have these programs. NFP, for example, presently operates in 43 states, serving over 31,000 families (Nurse-Family Partnership 2015) and CPC was recently expanded in select Midwestern states (Chicago Public Schools 2016). Our analysis has estimated the total potential impact of these programs, a portion of which might already be achieved if these programs are in place in some areas.

Conclusion

In this study, we have translated existing peer-reviewed evidence of CAN prevention programs' cost and effectiveness to current conditions in each US state to assist decision-making around such programs. Our results indicate that these programs might help thousands of children per cohort to avoid CAN and that program costs could be substantially offset in the long term through the monetary value of benefits associated with averted CAN.

Compliance with Ethical Standards Study information is reported in accordance with Consolidated Health Economic Evaluation Reporting Standards (CHEERS).

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Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval and Informed Consent All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

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