Environ Resource Econ (2009) 43:31–43
DOI 10.1007/s10640-008-9229-5

Family Behavior: Implications for Health Benefits Transfer from Adults to Children

Mark Dickie · Shelby Gerking

Received: 15 November 2007 / Accepted: 3 August 2008 / Published online: 28 August 2008

Abstract An approach to transfer adult health benefit estimates to children is developed from a consensus model of family behavior in which parents employ protective goods to reduce a health risk that they and their children face. The model is estimated using national survey data on parents' perceptions of skin cancer risks and their actual use of sun protection products in order to test the equilibrium condition that the parent's marginal rate of substitution between equal percentage reductions in her child's and her own risk equates to unity. Empirical results are consistent with this prediction. This finding suggests that the consensus model provides a useful basis to transfer adult health benefit estimates to children.

Keywords Benefit transfer · Children's health · Altruism · Family behavior

1 Introduction

Government policies in the United States and in many other countries seek to provide children with special protection from environmental hazards (Federal Register 1997; Scapecchi 2006). These policies have been adopted because exposure of children to certain pollutants exceeds that for adults and because health effects of a given amount of exposure can be more deleterious for children than for adults (USEPA 2003, pp. 2–1). Implementation of these initiatives, however, has been hampered by a lack of information about willingness-to-pay

The US Environmental Protection Agency (USEPA) partially funded the research described here under R-82871701-0. The research has not been subjected to USEPA review and therefore does not necessarily reflect the views of the Agency, and no official endorsement should be inferred. We thank participants in the Triangle Resource and Environmental Economics seminar in North Carolina for helpful comments on an earlier draft.

M. Dickie · S. Gerking (✉)
Department of Economics, University of Central Florida, Orlando, FL 32816, USA
e-mail: sgerking@bus.ucf.edu

M. Dickie
e-mail: mdickie@bus.ucf.edu

to improve children's health. Although a few prior health valuation studies (e.g., Jenkins et al. 2001; Liu et al. 2000; Nastis and Crocker 2003; Dickie and Messman 2004) consider children, most studies of this type focus exclusively on morbidity and mortality in adults.

This paper develops a straightforward approach to transfer adult health benefit estimates to children. Benefit transfer is emphasized as a means of obtaining children's health values because the cost of conducting health valuation studies makes it infeasible to complete separate studies for each of the large number of children's health risks that have been associated with exposure to environmental hazards. The conceptual framework for executing the benefit transfer is based on the well-known consensus model of family behavior described below.[1] In this model, a parent's marginal rate of substitution between an X% reduction in a health risk to one of her children and an X% reduction in that same health risk to herself equates to unity. Thus, the model suggests that estimated benefits of percentage reductions in adult health risks may be applied to children, provided that benefits of improved children's health largely accrue to their parents, rather than to the public at large.

This paper tests the model using data on perceived risk and sun lotion use from a 2005 national survey of parents of pre-teenage children. Dickie and Gerking (2007) previously found empirical support for this model using stated preferences for a hypothetical sun lotion obtained from a 2001 survey conducted in Hattiesburg, Mississippi. The main contribution of the present paper is to analyze revealed preferences for reducing skin cancer risk using national data on actual sun lotion use. Results obtained using the revealed preference data are consistent with the earlier study based on stated preferences and provide additional support for using consensus models of family behavior to transfer health benefit estimates for adults to children.

2 Model

This section presents a simple consensus model of family behavior (see Becker 1981) that incorporates household production of environmental health risk. The model is a one-period version of the model used by Dickie and Gerking (2007) and is presented to guide empirical work reported later on. In light of its close relation to the earlier paper, discussion in this section is kept to a minimum.

The model envisions a "family" composed of one parent and one child. Because the focus of the empirical work is on young children between the ages of 3 and 12 years, the parent is assumed to behave as a paternalistic altruist, simply choosing the quantities of goods and services for the child to consume.[2] Because the model includes only one parent, possible divergent interests between parents in a family are not explicitly considered.[3] Because only

[1] Agee and Crocker (2004) observe that economic models of family behavior can play a central role in transferring adult health benefit estimates to children, whereas theoretical economic models are less readily available to assist in transferring, say recreation benefits between locations.

[2] If the model focused on the behavior of parents toward teenage or adult children, it might be more appropriate to model the altruism of parents as benevolence (see Bergstrom 2006), but this alteration would not change the main predictions outlined below (for details on this point see Dickie and Gerking 2007).

[3] We are grateful to Alistair Munro for pointing out that parental consensus is not essential to obtaining the main results of this section. For instance, an alternative approach would be to posit a model of the household in which two parents purchase three goods: (1) composite private goods for themselves, (2) private risk reduction goods for themselves, and (3) contribute to a local public good that reduces risk for the child. Even if parents make decisions non-cooperatively, then it still would be the case that at the Nash equilibrium the marginal rate of substitution between reductions in risk for each parent and the child are equal to unity (compare to results presented below).

one child is included in the model, the analysis focuses on how parents allocate resources between themselves and their children, rather than on how parents make tradeoffs among different children.

The parent's utility function (U) is

$$U = U(X_p, X_c, R_p, R_c) \tag{1}$$

In Eq. 1, X denotes consumption of a composite market commodity, and the subscripts p and c denote parent and child. Also, R_p and R_c denote the parent's perception of skin cancer risk to herself and to the child. The response of utility to changes in consumption of the composite good and in risk is given by $\partial U/\partial X_j > 0$, $j = p, c$ and $\partial U/\partial R_j < 0$, $j = p, c$. The parent's perception of this risk is determined by an index of observable genetic factors (e.g., skin type and complexion), solar radiation exposure history, and information about or experience with skin cancer (Ω_j, $j = p, c$), and by consumption of a market good (G_j, $j = p, c$) (e.g., sun lotion) that otherwise has no utility to the parent, as shown in Eq. 2.

$$R_j = R_j(G_j, \Omega_j), \quad j = p, c. \tag{2}$$

Perceived risk is assumed to decline with increases in G.[4]

The parent faces the budget constraint in Eq. 3

$$Y = X_p + X_c + q(G_p + G_c), \tag{3}$$

where Y denotes income of the parent, the price of X is normalized to unity, and use is made of the simplification that the parent and child use the same good to reduce risk so that the same price (q) is paid for G_p and G_c.

First order necessary conditions for maximizing utility subject to the budget constraint imply that the parent's marginal rate of substitution between her child's consumption of $X(G)$ and her own consumption of $X(G)$ equals unity.

$$\frac{\partial U/\partial X_c}{\partial U/\partial X_p} = 1 = \frac{(\partial U/\partial R_c)(\partial R_c/\partial G_c)}{(\partial U/\partial R_p)(\partial R_p/\partial G_p)}. \tag{4}$$

These equalities result from the assumption that both parent and child consume X and G at the same prices. Also, the parent's marginal rate of substitution between her child's risk and her own risk equals the ratio of marginal costs of reducing risk. Because the parent and child face the same price of G, this ratio of marginal costs reduces to the ratio of marginal products of the protective good

$$\frac{\partial U/\partial R_c}{\partial U/\partial R_p} = \frac{q/(\partial R_c/\partial G_c)}{q/(\partial R_p/\partial G_p)} = \frac{\pi_c}{\pi_p} = \frac{\partial R_p/\partial G_p}{\partial R_c/\partial G_c}, \tag{5}$$

where $\pi_j = -q/(\partial R_j/\partial G_j) > 0$ denotes the marginal cost of risk reduction. Thus, parents' willingness to pay to reduce risk to their children relative to their willingness to pay to reduce risk to themselves equates to the ratio of marginal products of G in reducing risk.

Implications of the model for transferring health benefits from adults to children are as follows.[5] If an estimate of willingness to pay to reduce a particular morbidity or mortality

[4] The model is formulated to rule out situations in which use of G either may be a direct source of utility or may reduce two or more different risks. Dickie and Gerking (1996) find that joint production is unimportant in a related study of sun lotion use and skin cancer risk.

[5] The equilibrium conditions of the model also suggest that if parents are altruistic, informed about risks, and sufficiently well-off financially, then government policy to reduce risks to children may to some extent be undermined as parents reallocate family resources (see Dickie and Gerking 2007 for details).

risk is available for adults, Eq. 5 suggests that parents' willingness to pay to reduce the corresponding risk to children can be computed by multiplying the adult value by the marginal rate of substitution. The marginal rate of substitution, in turn, can be estimated using information about either the relative marginal costs of risk reduction or the relative marginal products of G in reducing risk. In fact, this outcome raises the possibility of estimating desired marginal rates of substitution from field studies that simply elicit parents' perceptions of a good's "effectiveness" in reducing risk to their children relative to reducing risk to themselves.

Additionally, Eq. 5 can be manipulated to show that when both the parent and child experience equal percentage risk reductions, the ratio of marginal products of G in reducing risk is equal to the ratio of initial risk levels. Thus, the marginal rate of substitution between equal percentage risk reductions to the child and parent is equal to unity, as shown in Eq. 6.

$$\frac{(\partial U/\partial R_c)/R_c}{(\partial U/\partial R_p)/R_p} = \frac{(\partial R_p/\partial G_p)/R_p}{(\partial R_c/\partial G_c)/R_c} = 1. \tag{6}$$

This means that benefits of reducing a risk by X% for adults are the same as the benefits of reducing that same risk by X% for children.

In specific applications, however, the simple approaches to health benefit transfer from adults to children implied by Eqs. 5 and 6 would have to be qualified by at least two considerations. (1) Parent's perceptions of risk and willingness to pay to avoid it must be representative of the entire adult population. This condition would not hold, for instance, if parents of young children are themselves young adults and if willingness to pay to avoid risk declines with age. (2) Benefits of improved health of children would have to accrue mainly to their parents. Nonetheless, Eqs. 5 and 6 still provide a simple and potentially useful starting point to make health benefit transfers from adults to children.

3 Data

Field data collected from parents of pre-teenage children are used to estimate the empirical specification of Eq. 2 (shown in Eq. 7 below) and to test whether Eq. 6 holds. Data were collected using a self-paced, interactive, computerized instrument that focused on risks of solar radiation exposure leading to skin cancer together with precautionary actions that people take to avoid this disease.[6] Earlier versions of the survey instrument were used in a pilot study of parents' willingness to pay to reduce skin cancer risks (Dickie and Gerking 2003) and in the previously mentioned test of the model based on stated preferences (Dickie and Gerking 2007). Subsequent versions were pre-tested and de-briefing sessions with pre-test participants guided development of the final version. Discussion in this section focuses mainly on measures of perceived skin cancer risk and protective actions taken to reduce this risk that are essential to estimating Eq. 2.

Knowledge Networks (KN) conducted the survey during August–September 2005. Respondents were parents with at least one biological child between the ages of 3–12 living at home. The survey focused on biological children because skin cancer risk is partly determined by genetic characteristics inherited from parents (e.g., fairness of skin and sensitivity of skin to sunlight). KN's core resource is a nationally representative panel of web-enabled US households. Panel members are given inducements such as free Internet access in return

[6] The international benefit transfer study conducted by Brouwer and Bateman (2005) also looked at valuation of reduced solar radiation exposure.

for agreeing to regularly complete short surveys on subjects of academic or commercial interest. Surveys are administered by computer access to the Internet (if the respondent has access to a computer) or via WebTV©, a technology that involves attaching a device resembling a cable box to a television so that panel members can use remote-control devices or keyboards to complete surveys using the television as a monitor.

The survey was transmitted to 1,199 panelists and 755 (63%) panelists agreed to complete the survey. Of those who agreed to complete the survey, 644 panelists were eligible to participate (i.e., had at least one biological child between the ages of 3–12 living with them at home). Complete data on variables needed to estimate Eq. 2 were obtained from 624 eligible panelists. Of these parents, 64% were white, 8% were black, and 28% were members of other races. Also, 39% were male, 79% were married, average age was 37 years and mean household income was $57,000 (2,005 dollars) per year.

Parents generally were aware of skin cancer: 52% of respondents knew someone personally who had been diagnosed with this disease, 10% knew of someone (public figures, friends, or relatives) who had died from skin cancer, and 56% had considered the possibility that one of their children might get skin cancer. At an early stage in the interviews, one biological child aged 3–12 of each parent was randomly selected (if there was more than one child in this age range) and designated as the sample child. Questions asked mainly focused on the parent and the sample child. Half (49%) of the sample children were female and the average age of sample children was 7 years.

Parents assessed lifetime skin cancer risk using an interactive scale depicting 400 squares in 20 rows and 20 columns. All 400 squares were initially colored green and parents changed green squares to red ones to represent amounts of risk. In estimating lifetime skin cancer risk, parents were told to consider only the chances of getting skin cancer (or of getting it again if they had already had it), rather than how serious the case might be. Parents used the scale to estimate lifetime chances of getting skin cancer, first for themselves and then for their sample child. Frequency distributions of these responses presented in Table 1 indicate considerable variation in risk estimates with some parents believing that they will not get skin cancer and a smaller number of parents believing that they will get this disease for certain.

White parents on average perceived lifetime skin cancer risks for themselves and for their children that were two to three times higher than the risk levels perceived by black parents, differences that are statistically significant at the one percent level in two-tail tests. Mean risk beliefs held by parents of other racial backgrounds fell between those for whites and blacks. The differences in mean perceived risks between other races and both whites and blacks are significant at the 1% level for parents' risks and at less than the 5% level for children's risks. White parents believed that their own lifetime risk of getting skin cancer exceeded that of their sample child (21.2% vs. 18.5%), a difference that is significant at the 1% level in a two-tail matched-samples test. This outcome may reflect a number of factors. Possibly, parents might believe that they take greater precautions to protect their children from skin cancer risk than their parents did in an earlier period when less was known about the hazards of solar radiation exposure. Also, it may be the case that parents believed that skin cancer will take longer to develop in children than in parents together with the idea that delayed risks are perceived as smaller. In contrast, black parents and parents of other races saw their children's risks as higher than their own, although these differences are not statistically significant ($p > .45$ for blacks, $p > .75$ for other races).

Lifetime risk levels perceived by white parents are remarkably close to epidemiological estimates. Ries et al. (2003) found that whites have a lifetime chance of 21% of getting either melanoma or non-melanoma skin cancer. The risk faced by blacks, as well as by members of other races, is much lower. The fact that the survey introduced the possibility of getting skin

Table 1 Relative frequency distribution of parents' perceived lifetime risks of getting skin cancer

Risk range (%)	Whites ($n = 401$)		Blacks ($n = 50$)		Other races ($n = 73$)	
	Parents	Children	Parents	Children	Parents	Children
0–4.75	0.097	0.137	0.400	0.400	0.237	0.231
5–9.75	0.187	0.202	0.260	0.280	0.231	0.249
10–14.75	0.160	0.155	0.240	0.120	0.197	0.162
15–19.75	0.122	0.080	0.020	0.060	0.093	0.064
20–24.75	0.072	0.082	0.020	0.060	0.046	0.081
25–29.75	0.112	0.137	0.020	0.040	0.069	0.069
30–34.75	0.042	0.040	0.000	0.000	0.029	0.029
35–39.75	0.020	0.027	0.000	0.000	0.006	0.029
40–44.75	0.027	0.030	0.000	0.000	0.012	0.023
45–49.75	0.015	0.022	0.000	0.000	0.006	0.000
50–54.75	0.092	0.050	0.020	0.020	0.035	0.017
55–59.75	0.005	0.018	0.020	0.000	0.006	0.000
60–64.75	0.010	0.005	0.000	0.020	0.006	0.012
65–69.75	0.008	0.000	0.000	0.000	0.000	0.006
70–74.75	0.000	0.000	0.000	0.000	0.006	0.006
75–79.75	0.008	0.008	0.000	0.000	0.012	0.017
80–84.75	0.005	0.000	0.000	0.000	0.000	0.000
85–89.75	0.003	0.003	0.000	0.000	0.000	0.000
90–94.75	0.008	0.000	0.000	0.000	0.000	0.000
95–100	0.007	0.005	0.000	0.000	0.012	0.006
Mean	21.2	18.5	7.5	8.4	14.3	14.8

cancer again if the parent had already had it does not appear to be an important complicating factor in this regard. Sample parents are relatively young and 2.2% reported having been previously diagnosed with this disease.

Parents then were provided information about skin cancer and were questioned about their and their children's observable genetic characteristics (sensitivity of skin to sunlight and fairness of skin), sun exposure history (experience with bad sunburns), and sun lotion use. Parents were asked, "Do you ever use sun protection products such as sunscreen lotion?" Those answering in the affirmative were asked, "During the summer, about how much of the time that you are outdoors do you use sunscreen lotion or other sun protection products?", and "Each sun protection product is rated by its 'sun protection factor,' or SPF. What is the SPF of the sun protection products you normally use for yourself?" Parallel questions were asked about the sample child. Table 2 summarizes data on sun lotion use. Fewer than half of black parents and children ever use sun lotion. For whites and members of other races, over 85% of parents and over 95% of children use sun protection at least some of the time when outdoors, and children use sun lotion with greater frequency and higher SPF than do their parents.

4 Empirical Results

This section uses data described in Sect. 4 to test whether equilibrium conditions of the model hold (see Eqs. 5 and 6). The test is implemented by solving the first order equations of the model (second-order conditions are assumed to hold) for the parent's demand for protective goods, G_j^*, $j = p, c$ in terms of parent's income, the relative price of G, genetic characteristics of both parent and child, and parents' information about and experience with skin cancer, and then inserting the result into Eq. 2 as shown in 7.

Table 2 Relative frequency distribution of sun protection use

	Whites ($n = 401$)		Blacks ($n = 50$)		Other races ($n = 73$)	
	Parents	Children	Parents	Children	Parents	Children
Frequency of time outdoors that sun protection products used						
Never	0.165	0.025	0.640	0.560	0.116	0.035
Less than half	0.252	0.165	0.140	0.160	0.353	0.202
About half	0.224	0.274	0.080	0.120	0.162	0.243
More than half	0.155	0.220	0.080	0.080	0.145	0.197
Always/almost always	0.205	0.317	0.060	0.080	0.225	0.324
Sun protection factor normally used						
Not used	0.165	0.025	0.640	0.560	0.116	0.035
Less than 15	0.075	0.035	0.040	0.060	0.081	0.046
15 to less than 30	0.304	0.200	0.160	0.180	0.312	0.202
30 or higher	0.456	0.741	0.160	0.200	0.491	0.717

$$G_j^* = G_j^*(q, Y, \Omega_p, \Omega_c)$$
$$R_j^* = R_j(G_j^*, \Omega_j) = r_j(q, Y, \Omega_p, \Omega_c). \quad (7)$$

By estimating the reduced form equation for G_j^* and the structural risk production function $R_j(G_j^*, \Omega_j)$ for both parents and children, it is possible to test whether an additional unit of protective action taken by the parent results in equal percentage risk reductions for herself and her child.

Estimates employ two alternative ordinal indicators of protection from solar radiation exposure as the measure of G_j: (1) frequency of sun lotion use while outdoors in direct sunlight, and (2) choice of sun protection factor (SPF). Frequency of sun lotion use is measured using five categories (never, less than half the time, about half the time, more than half the time, always/almost always), while the choice of SPF has four categories, (do not use sun protection products, and use sun protection products with a sun protection factor of less than 15, 15 to less than 30, and 30 or higher) (see Table 2).[7] Risk is measured as parents' initial perception of lifetime skin cancer risk in percentage points (i.e., four grid squares colored red equates to one percentage point) for themselves and for their children.

Because G_j^* is an endogenous variable in the model, estimates of the equations in (7) were obtained in a simultaneous equations framework by adapting Amemiya's (1978) simultaneous equation generalized probit estimator to the case of ordered probit. Amemiya showed that this estimator is more efficient than the two-stage estimator that would be obtained by estimating the risk production function after replacing observed values of G_j with predicted values from the reduced form.

Table 3 presents estimates of reduced form equations for parents' and children's use of sun protection. Column (2) shows sample means while columns (3) and (4) present results frequency of sun lotion use while outdoors and columns (5) and (6) present results for choice of SPF. Specification of these equations makes use of the expression for the optimal choice of the risk reducing good shown in Eq. 7. Thus, covariates used in the Table 3

[7] Alternative modeling approaches considered were (1) including frequency and SPF jointly in the risk production function, (2) treating the decision to use any sun protection separately from decisions about frequency or SPF, and including measures of all three outcomes in the risk production function, and (3) accounting for an ordinal indicator of time spent outdoors in direct sunlight near midday (less than others of the same age, about the same as others of the same age, more than others of the same age) along with sun protection use. However, the complexity of the Amemiya estimator increases substantially as additional endogenous variables are included in the model.

Table 3 Reduced form equations for use of sun protection: ordinal probit estimates

Covariate	Mean (SD) or proportion	Frequency of use[a]		SPF[b]	
		Parent	Child	Parent	Child
$d.v. = 1$ if parent's skin always burns after 2 h in direct sunlight	0.155	0.319* (0.151)	−0.053 (0.155)	0.549* (0.167)	−0.098 (0.195)
$d.v. = 1$ if parent's complexion is very fair	0.123	0.155 (0.163)	0.000 (0.167)	−0.014 (0.177)	−0.040 (0.211)
$d.v. = 1$ if parent has had at least one sunburn with peeling skin and blisters	0.742	0.067 (0.118)	0.152 (0.118)	0.299* (0.124)	0.379* (0.137)
$d.v. = 1$ if parent is female	0.607	0.523* (0.097)	0.279* (0.097)	0.128 (0.103)	0.131 (0.119)
Parent age (/100)	0.371 (0.075)	0.280 (0.719)	−0.242 (0.721)	0.306 (0.761)	−1.981* (0.860)
$d.v. = 1$ if parent has considered possibility that he/she might get skin cancer	0.622	−0.054 (0.120)	−0.109 (0.121)	0.089 (0.128)	0.137 (0.146)
$d.v. = 1$ if child's skin always burns after 2 h in direct sunlight	0.144	0.089 (0.157)	0.569* (0.165)	−0.149 (0.170)	−0.045 (0.201)
$d.v. = 1$ if child's complexion is very fair	0.146	−0.107 (0.147)	−0.032 (0.152)	−0.087 (0.160)	0.331 (0.202)
$d.v. = 1$ if child has had a sunburn with peeling skin and blisters	0.202	0.022 (0.115)	−0.144 (0.117)	0.037 (0.124)	−0.246 (0.142)
$d.v. = 1$ if child is female	0.486	−0.019 (0.087)	0.132 (0.088)	−0.049 (0.093)	0.089 (0.109)
Child age (/10)	0.763 (0.297)	0.031 (0.170)	−0.651* (0.172)	−0.036 (0.182)	−0.337 (0.208)
$d.v. = 1$ if parent has considered possibility that child might get skin cancer	0.558	0.250* (0.116)	0.322* (0.117)	0.162 (0.123)	0.491* (0.145)
$d.v. = 1$ if race is white	0.643	0.949* (0.205)	1.328* (0.201)	0.761* (0.212)	1.338* (0.218)
$d.v. = 1$ if race is "other" (not white, not black)	0.277	0.956* (0.205)	1.252* (0.200)	0.918* (0.212)	1.273* (0.218)
$d.v. = 1$ if parent has been diagnosed with skin cancer	0.022	0.199 (0.299)	−0.060 (0.301)	0.372 (0.350)	0.215 (0.423)
$d.v. = 1$ if parent knows of a public figure who has had skin cancer	0.260	−0.032 (0.104)	−0.101 (0.104)	0.048 (0.111)	−0.294* (0.131)
$d.v. = 1$ if parent knows someone personally who has had skin cancer	0.519	0.037 (0.094)	0.190* (0.095)	0.059 (0.101)	0.063 (0.119)
Annual household income (in 10,000 of 2,005 dollars)	0.570 (0.379)	0.376* (0.140)	0.169 (0.142)	0.246 (0.149)	0.685* (0.192)
$d.v. = 1$ if parent is married	0.795	0.127 (0.119)	0.303* (0.120)	0.087 (0.127)	0.152 (0.143)
Number of children in household (/10)	0.230 (0.105)	−0.037 (0.428)	−0.439 (0.429)	−0.092 (0.458)	−0.320 (0.508)
$d.v. = 1$ if parent is college graduate	0.290	0.227* (0.109)	0.157 (0.111)	0.230 (0.118)	0.175 (0.140)
$d.v. = 1$ if parent has residence in the south	0.361	0.047 (0.137)	−0.046 (0.140)	−0.088 (0.148)	−0.268 (0.185)
$d.v. = 1$ if parent has residence in the midwest	0.258	−0.254 (0.144)	−0.331* (0.146)	−0.289 (0.154)	−0.409* (0.191)
$d.v. = 1$ if parent has residence in the west	0.239	−0.076 (0.147)	−0.010 (0.150)	−0.081 (0.160)	−0.260 (0.200)
Constant	–	−0.864* (0.354)	0.444 (0.354)	−0.505 (0.374)	0.783 (0.426)
Mu(1)[c]	–	0.906* (0.049)	1.032* (0.058)	0.297* (0.037)	0.391* (0.060)

Table 3 continued

Covariate	Mean (SD) or proportion	Frequency of use[a]		SPF[b]	
		Parent	Child	Parent	Child
Mu(2)[c]	–	1.465* (0.052)	1.841* (0.053)	1.172* (0.059)	1.356* (0.082)
Mu(3)[c]	–	1.950* (0.062)	2.443* (0.060)	–	–
Chi-Square(24)[d]		136.683*	193.600*	120.249*	204.014*
N		624	624	624	624
R^{2}[e]		0.069	0.102	0.078	0.183

[a] Dependent variable is ordinal frequency of use of sun lotion, measured as fraction of time outdoors (never, less than half, about half, more than half, always/almost always) that sun protection products are used
[b] Dependent variable is ordinal sun protection factor (never use, use SPF < 15, use SPF 15 to <30, use SPF > 30)
[c] Estimated thresholds in ordered probit
[d] Wald test of null hypothesis that slope coefficients are jointly zero
[e] McFadden's pseudo R^2
* Denotes significance at 5%

regressions include measures of family income and other demographic variables, as well as observable genetic factors (e.g., skin type and complexion), solar radiation exposure history, and information about/experience with skin cancer for *both* parent and child. The price of sun protection products, q, is assumed to be the same for all respondents and is excluded. Indicators for Census region of residence are included. All racial groups are pooled due to the small numbers of nonwhite parents in the sample, but estimates allow intercept shifts by racial category. Chi-square tests indicate that the slope coefficients in all Table 3 regressions are jointly significantly different from zero at the 1% level.

In column (3) of Table 3, coefficient estimates indicate that sun protection use is more frequent among parents who: (1) have skin that is very sensitive to sunlight, (2) are female, (3) have thought about the possibility that their child might get skin cancer, (4) are not black, (5) have higher incomes, or (6) are college graduates. Corresponding results for children are presented in column (4). These estimates show that sun protection use is more frequent among children: (1) who have very sun-sensitive skin, (2) who have had at least one bad sunburn, (3) are female, (4) are younger, (5) whose parents have considered the possibility that their children might get skin cancer, (6) are not black, (7) whose parents know someone personally who has had skin cancer, (8) with married parents, and (9) who do not live in the Midwest. Also, mothers reported greater sun protection for their children than did fathers. These results are generally consistent with the idea that parents make use of greater sun protection as their incomes rise, when genetic factors or prior exposure to solar radiation place them or their children at higher risk of skin cancer, and when they are aware of others who have had this disease. They are also broadly consistent with identically specified regressions using choice of SPF as the dependent variable presented in columns (5) and (6).

Structural risk production function estimates obtained using simultaneous generalized ordered probit to account for the endogeneity of sun lotion use are presented in Table 4. In all, four equations are estimated, two each for parents and children, to determine effects of using the two alternative measures of G. As suggested by Eq. 7, covariates in the parent equations measure extent of parent sun protection (G_p), along with the parent's genetic determinants of skin cancer risk, the parent's solar radiation exposure history and the parent's knowledge and prior experience with skin cancer (Ω_p), and the parent's gender, race, and age. Covariates in the child equations include measures of child sun protection (G_c), the child's genetic determinants of skin cancer, the child's solar radiation exposure history (Ω_c), the child's gender, race (same as the parent's race), and age, together with the parent's knowledge and prior experience with skin cancer risk (included because the survey was completed by the parent). Household income and region of residence were excluded from both equations. Chi-square statistics indicate that the slope coefficient estimates in Table 4 are jointly significantly different from zero at the 1% level. Squared correlation coefficients

Table 4 Estimated production functions for perceived risks: simultaneous generalized ordinal probit estimates[a]

Covariate	Frequency of use[b]		SPF[c]	
	Parent risk	Child risk	Parent risk	Child risk
G_p = parent sun protection	−8.163* (2.951)	–	−7.718* (3.173)	–
$d.v.$ = 1 if parent's skin always burns after 2 h in direct sunlight	5.262* (2.319)	–	6.770* (2.610)	–
$d.v.$ = 1 if parent's complexion very fair	3.155 (2.371)	–	2.562 (2.360)	–
$d.v.$ = 1 if parent has had a sunburn with peeling skin or blisters	3.493 (1.869)	–	5.624* (2.052)	–
$d.v.$ = 1 if parent is female	1.926 (1.844)	–	−0.836 (1.469)	–
Parent age (/100)	−7.352 (9.841)	–	−7.859 (9.733)	–
$d.v.$ = 1 if parent has considered chance that he/she might get skin cancer	10.563* (1.684)	–	11.874* (1.722)	–
G_k = Child sun protection	–	−7.482* (2.718)	–	−1.534 (1.741)
$d.v.$ = 1 if child's skin always burns after 2 h in direct sunlight	–	1.265 (2.420)	–	−2.195 (2.134)
$d.v.$ = 1 if child's complexion very fair	–	0.415 (2.100)	–	1.822 (2.095)
$d.v.$ = 1 if child has had a sunburn with peeling skin or blisters	–	5.266* (1.753)	–	6.553* (1.753)
$d.v.$ = 1 if child is female	–	−0.382 (1.289)	–	−0.688 (1.280)
Child age (/10)	–	−11.848* (3.075)	–	−6.659* (2.425)
$d.v.$ = 1 if parent has considered chance that child might get skin cancer	–	7.739* (1.597)	–	7.710* (1.702)
$d.v.$ = 1 if race is white	10.929* (3.807)	14.366* (4.389)	9.612* (3.661)	7.088 (3.740)
$d.v.$ = 1 if race is "other" (not white, not black)	8.721* (4.053)	12.005* (4.481)	8.598* (4.283)	4.546 (3.758)
$d.v.$ = 1 if parent has been diagnosed with skin cancer	24.954* (4.446)	10.140* (4.184)	27.002* (4.525)	11.817* (4.193)
$d.v.$ = 1 if parent knows of public figure who has had skin cancer	1.694 (1.637)	−0.539 (1.602)	2.782 (1.629)	0.450 (1.622)
$d.v.$ = 1 if parent knows someone personally who has had skin cancer	5.328* (1.507)	2.527 (1.454)	5.756* (1.494)	1.906 (1.409)
Constant	0.265 (5.774)	9.318* (3.237)	3.814 (5.170)	8.347* (3.135)

Table 4 continued

Covariate	Frequency of use[b]		SPF[c]	
	Parent risk	Child risk	Parent risk	Child risk
Chi-Square (12)[d]	114.479*	63.666*	116.600*	60.798*
N	624	624	624	624
r^{2e}	0.111	0.073	0.157	0.141
Percentage marginal product of sun protection	−0.450 (0.320)	−0.449 (0.307)	−0.425 (0.298)	−0.0921 (0.122)
Marginal rate of substitution for percentage risk reduction	1.001 (0.818)		4.614 (5.320)	

[a] Dependent variable is the initial perception of lifetime skin cancer risk measured in percentage points. Each pair of columns shows estimates of coefficients of health production functions for perceived risk (with standard errors in parentheses), using the variable named at the top of the column as the endogenous input G

[b] Measure of G is ordinal frequency of sun protection use as fraction of time outdoors in direct sunlight (never, less than half, about half, more than half, always/almost always)

[c] Measure of G is ordinal SPF (never use, use SPF $<$ 15, use SPF 15 to $<$30, use SPF $>$ 30)

[d] Wald test of null hypothesis that slope coefficients are jointly zero

[e] Squared first-order correlation coefficient between observed and predicted dependent variable

[−] Excluded variable

[*] Denotes significance at 5%

between observed and predicted values of perceived risk range from 0.111 to 0.157 in the parent equations and from 0.073 to 0.141 in the child equations.

Estimated coefficients of the sun protection variables show effects of latent variables measuring use of sun protection on perceived risk and indicate that sun lotion use reduces perceived risk. Columns (2) and (3) show that more frequent sun lotion use reduces perceived risk at the 1% level for both parents and children. Results in column (4) similarly show that perceived risk declines as SPF increases for parents at the 1% significance level. In column (5), however, the reduction in perceived risk associated with increasing SPF for children is not significant. Considering the overall results from all four equations, parents' perceptions of lifetime skin cancer risks appear to be predictably related to the use of sun lotion. The test for whether these estimates are consistent with Eqs. 5 and 6, the main implications from the model, will be discussed momentarily.

Coefficient estimates of remaining variables indicate that, holding parents' frequency of sun protection use constant in column (2), perceived risk is higher for mothers and for parents who have sun-sensitive skin, have considered the possibility that they might get skin cancer or have been diagnosed with the disease, know someone personally who has had skin cancer, and are not black. Corresponding estimates in column (3) indicate that for given frequency of children's sun protection use, parents perceive higher risk for children who have had at least one bad sunburn, are younger, or are not black. Parents who themselves have been diagnosed with skin cancer or who have considered the possibility that their child might get skin cancer also see higher risk for their children. These results are broadly consistent with estimated effects holding SPF constant, shown in columns (4) and (5) of Table 4.

Estimates presented in Table 4 are used to test the null hypothesis that the parent's marginal rate of substitution between equal percentage risk changes to herself and her child is equal to unity, as predicted by Eq. 6. The test statistic computed, shown in Eq. 8,

$$\hat{S} = \frac{(\partial \hat{R}_p / \partial G_p)/\hat{R}_p}{(\partial \hat{R}_c / \partial G_c)/\hat{R}_c} \tag{8}$$

is used to test the null hypothesis $H_0 : S = 1$. In Eq. 8, $\partial \hat{R}_j / \partial G_j$ denotes the coefficient of sun protection for the parent ($j = p$) or the child ($j = c$) in Table 4, and $\hat{R}_j$ represents the predicted value of perceived risk from estimates in Table 4, at sample means. The test statistic ($\hat{S}$) is obtained by computing the ratio of the coefficient of sun protection to the predicted value of perceived risk for the parent, and then dividing this ratio by the corresponding ratio for the child. The numerator and denominator of the test statistic are reported as "Percentage Marginal Product of Sun Protection" at the bottom of Table 4, while the test statistic is reported as "MRS for Percentage Risk Change." Standard errors are computed by the delta method.[8]

When sun protection is measured by frequency of use, the estimated marginal rate of substitution is $\hat{S} = 1.001$, and the null hypothesis $H_0 : S = 1$ is not rejected under a Wald test ($p = .99$). When SPF is used as the indicator of sun protection, the small and insignificant coefficient of SPF in the child perceived risk production function results in a markedly larger test statistic ($\hat{S} = 4.614$) that remains insignificantly different from unity ($p = .50$).[9]

The finding that S does not differ significantly from unity is consistent with results in the earlier stated preference experiment (Dickie and Gerking 2007) in which the parents' estimated marginal rate of substitution between a 1% reduction in skin cancer risk for their children and a 1% skin cancer risk reduction for themselves did not differ significantly from unity. Thus, evidence presented in both studies supports the use of the consensus model of family behavior as a framework to transfer health benefit estimates from adults to children.

5 Summary and Conclusion

This paper has presented empirical estimates of a consensus model of family behavior in which parents employ protective goods to reduce a latent health risk that they and their children face. The model predicts that the parent's marginal rate of substitution between her child's and her own health risk equals the corresponding ratio of marginal costs of reducing risk through use of protective goods. This prediction provides a basis for transfer of health benefit values from adults to children because an estimate of benefits of reducing risk to a child could be obtained as the product of an existing estimate of benefits of reducing risk for an adult and the ratio of marginal risk-reduction costs.

Empirical results are consistent with the model in that: (1) parents' choices of sun protection appear to reduce perceived risks to parents and children, (2) perceived risks and choices of protective actions are broadly consistent with determinants specified by the model, and (3) parents' marginal rates of substitution between equal percentage reductions in skin cancer

[8] Although the parent risk and child risk equations are estimated separately, estimation of the standard error of $\hat{S}$ allows for a nonzero covariance between the two equations, based on the sample covariance of the residuals.

[9] The null hypothesis $H_0 : S = 1$ also was tested after removing all blacks from the sample and again after further restricting the sample to whites only. The hypothesis was not rejected in either case. In the full sample, the model was re-estimated twice using an alternative ordinal indicator of endogenous sun protection: time spent outdoors in direct sunlight. This variable had three categories (less than others, about the same as others, and more than others of the same age). Decreased time outdoors represents increased sun protection. In the parent perceived risk regression, the coefficients of outdoor time was positive, and significant at less than 5%. For children, the coefficient of outdoor time was positive in the risk production function but was not significant. In any case, the null hypothesis was not rejected this alternative model specification. Finally, the hypothesis was tested after pooling the data used here with comparable data on perceived risk and sun protection obtained in the previously cited survey in Hattiesburg, Mississippi (Dickie and Gerking 2007). Again the null hypothesis was not rejected using estimates based on frequency of use, SPF, or time spent outdoors in the pooled sample.

risk to their children and to themselves test equal to unity. Results obtained for the marginal rate of substitution between parents' and children's risk corroborate related findings by Dickie and Gerking (2007) using a consensus family behavior model in conjunction with stated preference data on the value of skin cancer risk reduction. Together, these outcomes suggest that parents' marginal rates of substitution between equal absolute changes in risk to their children and to themselves is equal to the corresponding ratio of marginal risk reduction costs. If confirmed in future studies, this finding would provide a firm basis for cross-walking between known adult willingness to pay values for improved health and unknown values of willingness to pay to improve children's health.

References

Agee MD, Crocker TD (2004) Transferring measures of adult health benefits to children: a review of issues and results. Contemp Econ Policy 22:468–482. doi:10.1093/cep/byh035

Amemiya T (1978) The estimation of a simultaneous equation generalized probit model. Econometrica 44:1193–1205. doi:10.2307/1911443

Becker GS (1981) A treatise on the family. Harvard University Press, Cambridge, MA

Bergstrom TC (2006) Benefit-cost in a benevolent society. Am Econ Rev 96:339–351. doi:10.1257/000282806776157623

Brouwer R, Bateman IJ (2005) Benefit transfer and willingness to pay and functions for health-risk reductions: a cross-country study. J Health Econ 24:591–611. doi:10.1016/j.jhealeco.2004.09.004

Dickie M, Gerking S (1996) Formation of risk beliefs, joint production and willingness to pay to avoid skin cancer. Rev Econ Stat 78:451–464. doi:10.2307/2109792

Dickie M, Gerking S (2003) Parents' valuation of latent health risks to their children. In: Wesseler J, Weikard H-P, Weaver RD (eds) Risk and uncertainty in natural resource and environmental economics. Edward Elgar, Cheltenham, UK

Dickie M, Gerking S (2007) Parental altruism and environmental risks to health of parents and the children. J Environ Econ Manage 53:323–341

Dickie M, Messman VL (2004) Parental altruism and the value of avoiding acute illness: are kids worth more than parents. J Environ Econ Manage 48:1146–1174. doi:10.1016/j.jeem.2003.12.005

Federal Register (1997) Executive order 13045 of April 21, 1997—protection of children From environmental health risks and safety risks, 62, FR Doc. 97-10695 (April 23)

Jenkins RR, Owens N, Wiggins LB (2001) Valuing reduced risks to children: the case of bicycle safety helmets. Contemp Econ Policy 19:397–408. doi:10.1093/cep/19.4.397

Liu J-T, Hammitt JK, Wang J-D, Liu J-L (2000) Mother's willingness to pay for own and her child's health: a contingent valuation study in Taiwan. Health Econ 9:319–326. doi:10.1002/1099-1050(200006)9:4<319::AID-HEC521>3.0.CO;2-3

Nastis SA, Crocker TD (2003) Pregnant mother's valuation of own and of child health. Presented at USEP-A/University of Central Florida conference, "Valuing environmental health risk reductions to children," http://yosemite.epa.gov/EE/epa/eerm.nsf/vwRepNumLookup/EE-0475?OpenDocument

Ries LAG, Eisner MP, Kosary CL, Hankey BF, Miller BA, Clegg L et al (eds) (2003) SEER cancer statistics review, 1975–2000. National Cancer Institute, Bethesda, MD http://seer.cancer.gov/csr/1975_2000

Scapecchi P (2006) Valuation differences between adults and children. In: Scarpecci P (ed) Economic valuation of environmental health risks to children. OECD, Paris

U.S. Environmental Protection Agency (2003) Children's health valuation handbook. National Center for Environmental Economics