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SYMPOSIUM: LEGG-CALVÉ-PERTHES DISEASE: WHERE DO WE STAND AFTER 100 YEARS?

Environmental Tobacco and Wood Smoke Increase the Risk of Legg-Calvé-Perthes Disease

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Abstract

Background The etiology of Legg-Calvé-Perthes disease (LCPD) remains unknown. A few studies have suggested passive smoke inhalation may be a risk factor, although the association is not confirmed and a causal relationship has not been established.

Questions/purposes We therefore undertook this study to confirm an association between environmental tobacco smoke, firewood smoke, and socioeconomic status and the risk of LCPD.

Methods We prospectively recruited 128 children with LCPD and 384 children attending the hospital for other orthopaedic complaints. The control subjects were frequency-matched with the cases by age and gender. Conditional logistic regression was used to assess the association between the exposures and risk of LCPD.

Results The main risk factors for LCPD were indoor use of a wood stove (adjusted odds ratio [OR], 2.56) and having a family member who smoked indoors (adjusted OR, 2.07). Children from the middle socioeconomic group appeared to be at a greater risk of developing LCPD (adjusted OR, 3.60).

Conclusions This study provides further evidence that environmental tobacco smoke is associated with an increased risk of LCPD. Exposure to wood smoke also appears to be a risk factor. However, it remains unclear why there are profound differences in the incidence of the disease between regions when the prevalence of smoking is comparable and why bilateral involvement and familial disease are infrequent.

Level of Evidence Level III, case-control study. See the Guidelines for Authors for a complete description of levels of evidence.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Introduction

Despite the fact that Legg-Calvé-Perthes disease (LCPD) was recognized 100 years ago [6, 21, 27], the etiology of the disease remains unclear. Although various theories on the etiology of the disease have been tested, no causal relationship has yet been established. One current theory on the etiology of LCPD suggests passive smoke inhalation is a risk factor [11, 12, 22] and a recent study demonstrated an association between maternal smoking during pregnancy and development of LCPD [1]. However, because most mothers who smoke during pregnancy may continue smoking after the child is born, it would be difficult to

determine to what extent passive smoke inhalation adds to the risk of LCPD in these children. Smoking is more common among the lower social classes in many societies [3, 7–10, 28, 33]. If passive smoke inhalation is indeed a predisposing factor for LCPD, the disease is likely to be more prevalent among the lower social classes. Although some studies do suggest LCPD is more common in the underprivileged inner-city areas [13, 14], other studies showed no greater predilection for the disease among the socially deprived [12, 31].

In India, LCPD is common in the southwest coastal plain among a predominantly rural community and is much less frequently encountered in the rest of south India [17]. The prevalence of smoking in the southwest coastal plain, however, is no higher than the rest of south India [8, 28]. Furthermore, smoking among women is uncommon in this region [8]. The use of firewood stoves for cooking, however, is common in rural India [2, 5] and therefore could be an added environmental factor for exposure to smoke although this potential association has not been studied.

To confirm previous studies and to explore a new association, we examined cases and control subjects for associations of LCPD and (1) two forms of passive smoke inhalation, namely tobacco smoke and smoke from wood fires; and (2) socioeconomic factors.

Patients and Methods

We prospectively recruited 128 children with LCPD as cases and 384 children attending the hospital for other orthopaedic complaints as control subjects. Cases were children younger than 12 years of age at the onset of symptoms with hip pain and/or a limp with plain radiographic features of LCPD and with no underlying hemoglobinopathy (confirmed by hemoglobin electrophoresis). We excluded children older than 12 years of age at onset of symptoms because there is uncertainty as to whether adolescent LCPD is a different clinical entity. All newly diagnosed patients attending the hospital for treatment and all patients attending the monthly Legg-Calvé-Perthes followup clinics during a period of 8 months were included in the study until the required sample size was attained. Some children included from the followup clinics were in the active stages of the disease, whereas in some, the disease had healed. Because all children with LCPD treated in this center are followed until skeletal maturity, some children with healed disease were older than 12 years of age at the time of the study. For control subjects, we identified children attending the hospital for other orthopaedic complaints with no previous or current symptoms related to the hip and a normal hip radiograph (if available) or no limitation of hip abduction and internal rotation (in children without hip radiographs). These hip movements are characteristically reduced in children with LCPD [29]. Absence of limitation of these specific hip movements was used as a criterion to ensure that the control subjects did not have LCPD. Limitation of hip abduction and internal rotation was excluded by highly sensitive screening tests described earlier [17]. Conditions that the control subjects had included fractures of the upper limb or their sequelae, osteomyelitis involving an upper limb bone or its sequelae, congenital anomalies of the upper limbs, congenital anomalies of the lower limbs (involving the leg or foot and ankle), and cerebral palsy. No patients were recalled specifically for this study; all data apart from the responses to the questionnaire (outlined subsequently) were obtained from medical records and radiographs. Written informed consent was obtained from all study participants or their parents as appropriate.

Control subjects were frequency-matched to cases on age and gender with three control subjects for every case; control subjects were recruited successively until the required number was obtained. The cases and control subjects were comparable with respect to birth order and maternal age at delivery (Table 1).

Sample size power analysis was based on the formula for case-control study design with 1:3 matching. The primary exposure variable was considered as exposure to indoor wood smoke; we did not consider indoor exposure to tobacco smoke as the primary exposure variable because

Table 1. Characteristics of cases and control subjects

Variable	Cases (n = 128)	Control subjects (n = 384)	p value
Gender*			
Female	25 (19.5%)	75 (19.5%)	NA
Male	103 (80.5%)	309 (80.5%)	
Age (years)*			
< 5 years	2 (1.6%)	6 (1.6%)	NA
5–9.9 years	52 (40.6%)	156 (40.6%)	
10–14.9 years	55 (43.0%)	165 (43.0%)	
≥ 15 years	19 (14.8%)	57 (14.8%)	
Birth order			
1	57 (44.5%)	207 (54%)	0.066
2	57 (44.5%)	123 (32.0%)	
≥ 3	14 (11%)	53 (14%)	
Maternal age at delivery†	24.66 (4.09)	24.59 (4.75)	0.732
Number of family members smoking in the same household			
0	75 (58.6%)	296 (77.1%)	0.002
1	44 (34.4%)	81 (21.1%)	
2	6 (4.7%)	5 (1.3%)	
3	3 (2.3%)	2 (0.5%)	

* Matched on age and gender; †mean (SD); NA = not applicable.

there are no published data from this country on indoor tobacco smoke. It was assumed that the proportion of control subjects exposed to wood smoke would be 29.4% on the basis of national family health survey reports [15]. With an anticipated odds ratio of 2 or more as significant and an allocation ratio of three control subjects per case, a minimum sample size of 126 cases was required for a power of 90% and a level of significance of 5%.

Sociodemographic information as well as details on exposure to passive smoke inhalation and indoor wood smoke of both cases and control subjects was collected by the same investigator (ABD) who personally interviewed the parents with the help of a structured questionnaire when they reported to the clinic. Socioeconomic status was assessed with the help of the modified Pareek scale [26] that is applicable in rural India. The scale has 10 items to be scored taking into account the type of house, land holding, livestock and belongings, occupation, and educational status. Data concerning disease onset and family history were obtained from the patients' case records.

We used univariate conditional logistic regression analysis and calculated unadjusted odds ratios (ORs) to identify potential risk factors for LCPD from among the following variables: passive smoke inhalation (number of family members smoking in the household, maternal tobacco use during pregnancy, indoor use of a wood stove) and socioeconomic factors (the economic status of the family, birth order, maternal age at delivery, overcrowding at home, and religion). The variables identified as significant in the univariate analysis were included in the multivariate analysis. Conditional logistic regression for multiple variables with 1:3 case-control matching was used to compute adjusted ORs and their 95% CIs. Statistical analysis was carried out using Stata Version 9.2 (StataCorp, College Station, TX, USA).

Results

The presence of a family member smoking indoors and indoor use of a wood stove were variables that showed an association with a risk for LCPD in the univariate analysis (Table 2). Both of these variables were confirmed as risk factors for LCPD on the multivariate regression analysis with adjusted OR of 2.07 and 2.56, respectively (Table 3).

Children from the middle and low socioeconomic groups appeared to be at a greater risk of developing LCPD in the univariate analysis. However, only the middle socioeconomic group showed an association (adjusted OR, 3.60) in the multivariate analysis (Table 3).

Among the 128 children with LCPD recruited for this study, only one had another sibling affected by the disease.

Discussion

The etiology of LCPD is still not known and until now no causal associations with any risk factor have been identified. A few recent studies suggest that passive tobacco smoke inhalation may be a risk factor for it to develop [11, 12, 22]. There has also been a suggestion that LCPD is more prevalent among children of underprivileged families [13, 14] although this has not been confirmed in other studies [12, 31]. We set out to test the associations between passive inhalation of tobacco and firewood smoke and socioeconomic status and the risk of developing LCPD in a region that has one of the highest incidence rates of the disease in the country [17].

Our study has some important limitations. First, some of the control subjects included in the study did not have radiographs of the pelvis to conclusively demonstrate that they had no stigmata of LCPD. Although this raises the

Table 2. Results of univariate analysis for identifying variables associated with a risk of Legg-Calvé-Perthes disease

Variable	Cases (n = 128)	Control subjects (n = 384)	Unadjusted odds ratio (95% CI)
Family member smokes indoors	53 (41.4%)	88 (22.9%)	2.53 (1.53–3.61)
Socioeconomic status			
Low	27 (21.1%)	58 (15.1%)	6.14 (1.75–21)
Middle	98 (76.6%)	285 (74.2%)	4.56 (1.38–14)
High	03 (2.3%)	41 (10.7%)	1
Indoor use of wood stove	106 (82.8%)	233 (60.7%)	3.03 (1.84–5)
Maternal tobacco use in pregnancy	3 (2.3%)	10 (2.6%)	1 (0.28–3.45)
Overcrowding at home (> 2 people per room)	31 (24.2%)	68 (17.7%)	1.48 (0.91–2.42)
Religion			
Hindu	70 (54.7%)	264 (68.9%)	1
Muslim	50 (39.1%)	91 (23.8%)	1.96 (1.29–2.98)
Christian	8 (6.3%)	28 (7.3%)	1.06 (0.46–2.45)

Table 3. Risk factors for Legg-Calvé-Perthes disease identified in the multivariable conditional logistic regression analysis model

Exposure variable	Adjusted odds ratio	95% CI	p value
Family member smokes indoors	2.07	1.3–3.27	0.002
Socioeconomic status			
Low	3.47	0.88–12.7	0.08
Middle	3.60	1.03–12.59	0.045
High	1		
Indoor use of wood stove	2.56	1.5–4.38	0.001
Religion			
Hindu	1		
Muslim	1.83	1.14–2.92	0.011
Christian	1.32	0.52–3.32	0.55

possibility that some of the control subjects may have had asymptomatic disease, this is unlikely because none of the control subjects had limitation of hip motion, which is characteristically seen in LCPD. Second, the responses of mothers to questions about tobacco use in pregnancy may have been influenced by recall bias. However, because tobacco use among mothers of both cases and control subjects was low, the results of the study are unlikely to have been affected appreciably. Third, we did not attempt to determine if the risk of LCPD increases with increased exposure to passive smoke because it was impossible to accurately estimate the quantity of passive smoke to which the child was exposed. We suspect family members who smoked might underreport the number of cigarettes smoked indoors each day and it would also be difficult to ascertain the nature of ventilation of the house; both of these factors would certainly influence the actual exposure to tobacco smoke. On the other hand, the population we studied was unique in that none of the mothers of the cases or control subjects smoked, although a very small proportion (2.3% and 2.6% of mothers of cases and control subjects, respectively) chewed tobacco during pregnancy. This enabled us to study the association of exposure to passive tobacco smoke and the risk of LCPD without the confounding effect of prenatal maternal smoking.

Our data suggest there is an association between passive smoke inhalation in childhood and the risk of development of LCPD. Because only 2.3% of the mothers of affected children exposed the unborn fetus to the effects of tobacco chewing, the association points predominantly to the effects of passive smoke inhalation. This observation challenges the contention of Bahmanyar et al. [1] that environmental tobacco smoke is not associated with a risk of LCPD. Rather, our observations reinforce the earlier reports of an association between passive smoke inhalation and the risk of LCPD [12, 22] (Table 4). Although we found an association between smoking and LCPD, several questions remain unanswered. If smoking is a causative factor in LCPD, why are there profound differences in the incidence of the disease between regions when the prevalence of smoking is comparable? The prevalence of tobacco smoking in the southwest coastal plain is lower than elsewhere in south India [7, 8, 28], yet the incidence of LCPD in this region is 10 times higher than the eastern region of south India [17]. If smoking is a causative factor in LCPD, why is there such a profound predilection for boys and why is bilateral and familial disease uncommon? If smoking is a causative factor in LCPD, what is the duration of exposure to passive tobacco smoke (the dose) needed for the disease to develop? Further studies are clearly needed to try to clarify how passive smoke inhalation predisposes to LCPD and to attempt to answer these important questions.

One would have expected to see a stronger association between social class and the risk of LCPD, because several studies show smoking is more prevalent among the poor [3, 7–10, 28]. We could not demonstrate that predilection for LCPD was greatest among the most socially deprived as noted in previous studies [13, 14]. Compared with the cases, a higher proportion of the control subjects belonged to the high socioeconomic group, which may have resulted in an overestimation of the risk for development of LCPD among the cases. We cannot explain why the risk of LCPD in this region was greater among Muslim children who are not ethnically different; it is possible that more Muslims in this region are from the lower socioeconomic strata but this was not evident in this study. We considered religion as a variable because lifestyles and food habits of the different religious groups are likely to be different.

Because numerous households in rural India rely on firewood stoves for cooking, smoke from these stoves too would be inhaled by the occupants of the house. We were interested to study whether smoke from firewood stoves could also be associated with LCPD because biomass smoke exposure is reportedly associated with a risk of stillbirths [24] and respiratory diseases [19]. Our study also shows exposure to wood smoke is associated with a higher risk of developing LCPD. This association has not been demonstrated earlier and this raises the possibility that toxins in wood smoke other than nicotine may be responsible for the predisposition to LCPD. It is unclear how exposure to environmental tobacco and wood smoke leads to LCPD. Several adverse effects of maternal smoking during pregnancy on fetal development have been suggested and they include impaired placental function and reduced placental blood flow [30, 32]. These effects can lead to intrauterine growth retardation and low birth weight, which are known to have an association with LCPD [1, 20, 25]. Interestingly, exposure to wood smoke is

Table 4. Evidence in the literature showing associations between passive smoke inhalation and Legg-Calvé-Perthes disease

Author	Details of the study	Factors associated with Legg-Calvé-Perthes disease			
		Passive tobacco smoking	Maternal smoking in pregnancy	Socioeconomic status	Exposure to wood smoke
Gordon et al. [12]	Observational study with descriptive statistics 60 patients 96 control subjects (control subjects were not matched)	Associations noted: Smoker living in the house ($p < 0.01$) Number of smokers living in the house ($p < 0.001$) Passive smoker years per year of life ($p < 0.001$)	Not tested	No association noted	Not tested
Mata et al. [22]	Case-control study with logistic regression analysis 90 patients 183 control subjects (control subjects were not matched)	Association noted: Adjusted OR, 5.32; 95% CI, 2.29–9.69	Not tested	Not tested	Not tested
Bahmanyar et al. [1]	Case-control study with conditional logistic regression analysis 852 patients 4432 control subjects (control subjects were matched for age, sex, and region of residence)	Not directly tested	Association noted: Adjusted OR, 2.02; 95% CI, 1.59–2.58 ($\geq$ 10 cigarettes per day)	Not tested	Not tested
Current study	Case-control study with conditional logistic regression analysis 128 patients 384 control subjects (matched for age and sex)	Association noted: Adjusted OR, 2.07; 95% CI, 1.3–3.27 ($p = 0.002$)	Not tested	Association noted: Adjusted OR, 3.60; 95% CI, 1.03–12.59 for middle socioeconomic status ($p = 0.045$)	Association noted: Adjusted OR, 2.56; 95% CI, 1.5–4.38 ($p = 0.001$)

also associated with low birth weight [4, 23]. The effects of environmental smoke may produce changes that predispose to LCPD either in utero by affecting placental and fetal development [16] or may act postnatally through direct effects on the child's vascular system [18]. It is unclear whether the toxins in smoke are directly responsible for the vascular changes in LCPD or whether they are simply modifiers of an underlying genetic predisposition for the disease that might not express itself in the absence of exposure to these toxins.

We emphasize the patient population studied here is very different from other societies where LCPD is common; the lifestyles are different and the disease pattern is different. The patients are predominantly from rural or semiurban communities and not from inner-city areas as seen in the United Kingdom [13, 14, 31]. The mean age at onset of LCPD is approximately 8 to 9 years; this is approximately 2 years higher than the age at onset in white children [17]. The pattern of tobacco use also differs quite profoundly from some Western societies. For example, 52% of women in greater Glasgow smoked [31], whereas none of the mothers included in this study smoked. One study from this region [8] suggested women very seldom smoke and the overall prevalence of smoking is low [7, 8, 28]. These differences make the results of this study all the more important because the association between passive smoke inhalation and LCPD does not seem to be unique to the urban societies of the United Kingdom or the United States.

We found associations between exposure to environmental tobacco smoke and wood smoke and LCPD. Like with other similar studies, we cannot identify a causal relationship between environmental smoke and LCPD, but our observations add to the evidence linking passive smoke inhalation and LCPD and suggest a further association with exposure to wood smoke from cooking fires.

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References

1. Bahmanyar S, Montgomery SM, Weiss RJ, Ekbom A. Maternal smoking during pregnancy, other prenatal and perinatal factors, and the risk of Legg-Calve-Perthes disease. *Pediatrics.* 2008;122: e459–464.
2. Balakrishnan K, Parikh J, Sankar S, Padmavathi R, Srividya K, Venugopal V, Prasad S, Pandey VL. Daily average exposures to respirable particulate matter from combustion of biomass fuels in rural households in southern India. *Environ Health Perspect.* 2002;110:1069–1075.
3. Barbeau EM, Krieger N, Soobader MJ. Working class matters: socioeconomic disadvantage, race/ethnicity, gender, and smoking in NHIS 2000. *Am J Public Health.* 2004;94:269–278.
4. Boy E, Bruce N, Delgado H. Birth weight and exposure to kitchen wood smoke during pregnancy in Guatemala. *Environ Health Perspect.* 2002;110:109–114.
5. Bruce N, Perez-Padilla R, Albalak R. Indoor pollution in developing countries: a major environmental and public health challenge. *Bull World Health Organ.* 2000;78:1078–1092.
6. Calvé J. [On a particular form of pseudo-coxalgia associated with characteristic deformities of the proximal femur] [in French]. *Revue de Chirurgie Paris.* 1910;42:54–84.
7. Chaudhry K, Prabhakar AK, Prabhakaran PS, Prasad A, Singh K, Singh A. Prevalence of tobacco use in Karnataka and Uttar Pradesh in India. Final report of the study by the Indian Council of Medical Research and the WHO South East Asian Regional Office, New Delhi; 2001. Available at: http://searo.who.int/EN/Section1174/section1462/pdfs/surv/SentinelIndia2001.pdf. Accessed January 22, 2008.
8. Daniel AB, Nagaraj K, Kamath R. Prevalence and determinants of tobacco use in a highly literate rural community in southern India. *Natl Med J India.* 2008;21:163–165.
9. Global Adult Tobacco Survey. Bangladesh Report 2009. Summary. Available at: www.searo.who.int/LinkFiles/Regional_Tobacco_Surveillance_System_GATSBAN_Report2009.pdf. Accessed March 31, 2010.
10. Glover JD, Hetzel DMS, Tennant SK. The socioeconomic gradient and chronic illness and associated risk factors in Australia. Australia and New Zealand Health Policy. 2004;1:8. Available at: www.anzhealthpolicy.com/content/1/1/8. Accessed March 31, 2010.
11. Glueck CJ, Freiberg RA, Crawford A, Gruppo R, Roy D, Tracy T, Sieve-Smith L, Wang P. Secondhand smoke, hypofibrinolysis, and Legg-Perthes disease. *Clin Orthop Relat Res.* 1998;352:159–167.
12. Gordon EJ, Schoenecker PL, Osland JD, Dobbs MB, Szymanski DA, Luhmann SJ. Smoking and socio-economic status in the etiology and severity of Legg-Calve-Perthes' disease. *J Pediatr Orthop B.* 2004;13:367–370.
13. Hall AJ, Barker DJ, Dangerfield PH, Taylor JF. Perthes' disease of the hip in Liverpool. *Br Med J (Clin Res Ed).* 1983;287:1757–1759.
14. Hall AJ, Barker DJ, Lawton D. The social origins of Perthes' disease of the hip. *Paediatr Perinat Epidemiol.* 1990;4:64–70.
15. International Institute for Population Sciences (IIPS) and ORC Macro. *National Family Health Survey (NFHS-2), 1998-99: India.* Mumbai: IIPs; 2000.
16. Jaddoe VW, Verburg BO, de Ridder MA, Hofman A, Mackenbach JP, Moll HA, Steegers EA, Witteman JC. Maternal smoking and fetal growth characteristics in different periods of pregnancy: the generation R study. *Am J Epidemiol.* 2007;165:1207–1215.
17. Joseph B, Chacko V, Rao BS, Hall AJ. The epidemiology of Perthes' disease in south India. *Int J Epidemiol.* 1988;17:603–607.
18. Kallio K, Jokinen E, Raitakari OT, Hämäläinen M, Siltala M, Volanen I, Kaitosaari T, Viikari J, Rönnemaa T, Simell O. Tobacco smoke exposure is associated with attenuated endothelial function in 11-year-old healthy children. *Circulation.* 2007; 115:3205–3212.
19. Kurmi OP, Semple S, Simkhada P, Smith WCS, Ayres JG. COPD and chronic bronchitis risk of indoor air pollution from solid fuel: a systematic review and meta-analysis. *Thorax.* 2010;65:221–228.
20. Lappin K, Kealey D, Cosgrove A, Graham K. Does low birthweight predispose to Perthes' disease? Perthes' disease in twins. *J Pediatr Orthop B.* 2003;12:307–310.

21. Legg AT. An obscure affection of the hip joint. *Boston Med Surg J.* 1910;162:202.
22. Mata SG, Aicua EA, Ovejero AH, Grande MM. Legg-Calve-Perthes disease and passive smoking. *J Pediatr Orthop.* 2000;20:326–330.
23. Mishra V, Dai X, Smith KR, Mika L. Maternal exposure to biomass smoke and reduced birth weight in Zimbabwe. *Ann Epidemiol.* 2004;14:740–747.
24. Mishra V, Retherford RD, Smith KR. Cooking smoke and tobacco smoke as risk factors for stillbirth. *Int J Environ Health Res.* 2005;15:397–410.
25. Molloy MK, Macmahon B. Birth weight and Legg-Perthes disease. *J Bone Joint Surg Am.* 1967;49:498–506.
26. Pareek U, Trivedi G. *Manual of Socio-economic Status Scale (rural)*. Delhi: Manasayan; 1980.
27. Perthes G. [About arthritis deformans juvenalis] [in German]. *Deutsche Zeitschrift für Chirurgie.* 1910;107:111–159.
28. Rani M, Bonu S, Jha P, Nguyen SN, Jamjoum L. Tobacco use in India: prevalence and predictors of smoking and chewing in a national cross sectional household survey. *Tob Control.* 2003; 12:e4.
29. Rao KN, Joseph B. Value of measurement of hip movements in childhood hip disorders. *J Pediatr Orthop.* 2001;21:495–501.
30. Salafia C, Shiverick KT. Cigarette smoking and pregnancy II: vascular effects. *Placenta.* 1999;20:273–279.
31. Sharma S, Sibinski M, Sherlock DA. A profile of Perthes' disease in Greater Glasgow: is there an association with deprivation? *J Bone Joint Surg Br.* 2005;87:1536–1540.
32. Shiverick KT, Salafia C. Cigarette smoking and pregnancy I: ovarian, uterine and placental effects. *Placenta.* 1999;20:265–272.
33. Subramanian SV, Nandy S, Kelly M, Gordon D, Davey Smith G. Patterns and distribution of tobacco consumption in India: cross sectional multilevel evidence from the 1998-9 national family health survey. *Br Med J.* 2004;328:801–806.