RESEARCH PAPER

Cost of Neonatal Intensive Care Delivered through District Level Public Hospitals in India

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Objective*:* To assess the unit cost of level II neonatal intensive care treatment delivered through public hospitals and its fiscal implications in India.

Design: Cost analysis study.

Setting: Four Special Care Newborn Units (SCNUs) in public sector district hospitals in three Indian states, i.e. Bihar, Madhya Pradesh and Orissa, for the period 2010.

Methods: Bottom-up economic costing methodology was adopted. Health system resources, i.e. capital, equipment, drugs and consumables, non-consumables, referral and overheads, utilized to treat all neonates during 2010 were elicited. Additionally, 360 randomly selected treatment files of neonates were screened to estimate direct out-of-pocket (OOP) expenditure borne by the patients. In order to account for variability in prices and other parameters, we undertook a univariate sensitivity analysis.

Main Outcome Measures*:* Unit cost was computed as INR (Indian national rupees) per neonate treated and INR per bed-day treatment in SCNU. Standardized costs per neonate treatment and per bed day were estimated to incorporate the variation in bed occupancy rates across the sites.

Results: Overall, SCNU neonatal treatment costs the Government INR 4581 (USD 101.8) and INR 818 (USD 18.2) per neonate treatment and per bed-day treatment, respectively. Standardized treatment costs were estimated to be INR 5090 (USD 113.1) per neonate and INR 909 (USD 20.2) per bed-day treatment. In the event of entire direct medical expenditure being borne by the health system, we found cost of SCNU treatment as INR 4976 (USD 110.6) per neonate and INR 889 (USD 19.8) per bed-day.

Conclusions*:* Level II neonatal intensive care at SCNUs is cost intensive. Rational use of SCNU services by targeting its utilization for the very low birth weight neonates and maintenance of community based home-based newborn care is required. Further research is required on cost-effectiveness of level II neonatal intensive care against routine pediatric ward care.

Keywords: C*hild health, Costing, Economic evaluation, SCNU, Neonatal intensive care.*

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Several attempts to strengthen newborn care in India have been made, but a review of these interventions found that their overall impact on neonatal mortality was limited [1]. Under the National Rural Health Mission, newborn care has become central to the child survival strategy both in community and facility level interventions. Hospital-based neonatal units are being strengthened in India to provide specialized treatment services, which are classified into different levels. Level II care includes Special Care Newborn Units (SCNUs) at the district hospital level. These units are equipped to handle sick newborns other than those who need ventilatory support and surgical care. The level III units are the neonatal intensive care units [2]. In order to strengthen provision and utilization of neonatal services, Government of India recently launched a Maternal and Newborn Safety Program (*Janani Shishu Suraksha Karyakram,* JSSK), a scheme for provision of free delivery services and treatment for sick newborn till 30 days of birth in public hospitals [3].

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Neonatal intensive care is regarded as one of the most expensive components of pediatric health care [4,5]. This makes it important to gain insights into the cost of facility-based newborn care. Previous studies have limited their focus on the paediatric treatment costs for particular diseases and in focal geographic areas [6, 7]. Neonatal costs have been assessed in tertiary-care setting

only, and the methodology of these studies does not allow estimation of true economic cost [8,9]. The present study estimated the health system 'per neonate treatment cost' and 'per-bed-day treatment cost' in district-hospital based SCNUs in India.

METHODS

We collected data from four district hospitals in three states of India, namely Shivpuri and Guna (Madhya Pradesh), Bhubaneshwar (Orissa) and Vaishali (Bihar) during a period from February to September 2011. These 4 SCNUs were selected randomly from among a frame of 10 SCNUs which were established in the earliest phase of implementation and hence had been in operation for at least 3-5 years [2]. We estimated the economic cost to health system for treatment of neonates admitted in SCNUs. This perspective is broader than the financial cost framework, because it includes all resources consumed in production of a service, regardless of who pays for them [10].

Cost data were collected for SCNUs in four district hospitals for a one year period from January to December 2010. The first step taken in the assessment was to identify the various service centres so as to allocate the costs associated with the treatment. Each service centre which produced a product or output towards the treatment and care of neonates was identified. Once the outputs were defined, the quantity of output produced in the year 2010 was assessed from the routine medical records at the health facility. Next, the input resources used to produce the output were defined and measured.

For costing purposes, inputs were segregated into capital and recurrent resources. The recurrent resources included staff salaries, drugs and consumables, payments for electricity, telephone, laundry, referral costs and other overheads etc. Capital resources constituted buildings which include the space costs for the neonatal unit, medical equipment including both diagnostic and therapeutic items, and non-medical items such as beds, chairs and other furniture items for patients or staff members. The floor size of the rooms includes not only the bed area, but also that of the entire step-down room, breast feeding corner etc. Both regular and part time medical staff and non-medical staff were considered in the analysis. All the staff members who were partly or completely involved in the delivery of neonatal intensive care services at district hospital through the SCNU were enlisted. This includes all doctors (pediatricians and general duty medical officers), nurses, ANMs or support staff such as attendants, cleaners, drivers etc. We also included the program management staff at the district hospital who contributed to overall management of the hospital.

Financial records for the year 2010 were assessed to gather the cost data for capital and recurring expenditures (***Web Table* I**). For human resources, full-time equivalents were calculated for each staff member. Staff members involved in activities other than neonatal care were interviewed to elicit information on the time spent by them on each activity on a normal day. Data on salaries was deduced from the pay slips of the staff. For space and infrastructure costs, estimates for the rental price of a similar space were used.

UNICEF rate list was used for prices of medical equipments [11]. We accessed information on the source of funding for equipments. Separate rates were used to estimate the cost, *i.e.* whether it was purchased by UNICEF or the state health services through NRHM etc. For non-medical equipments current market prices were utilized. Prices of drugs and consumables, laboratory tests were based on government rate contract prices [12]. For data pertaining to the number of neonatal admissions and their morbidity profile we analysed the routine MIS data. Standard assumptions regarding the life of the equipment and discount rates (3%) were made [13, 14]. In the case of certain equipments, where no standard was being followed, opinion of local health care providers and hospital managers was sought.

We also estimated the overall direct cost of treatment at SCNU in the scenario where health system provides for all the resources required for treatment. For estimation of overall cost of neonatal treatment, data on the medicines, consumables, diagnostic tests, and procedures performed was extracted from case records on 120 randomly selected patients at Shivpuri, Guna and Vaishali respectively. A total of 360 patient records were listed for the same. The quantity of resources provided by the hospital was deducted to estimate the average direct medical expenditure which was not provided by the hospital, and for which patients spent out-of-pocket. We collected data on the medicines, consumables, diagnostic tests etc which were prescribed to the patient, the extent to which it was provided by the hospital and the amount which had to be purchased by patient's family from outside. This was collected from the copy of slips (retained by the hospital) issued by the staff nurse on duty to patient's attendant and from patient case records.

Data Analysis

Unit Cost of Level II Neonatal Intensive care: All staff members whose information was elicited did not contribute exclusively to the activities of SCNU. A large number of these staff was contributing jointly to the

activities of SCNU and other hospital service centres. For *e.g.* a head staff nurse was involved in the supervision of SCNU as well as the general paediatric ward. Similarly the accountant of the hospital prepares accounts and salaries of staff for entire hospital staff. In such cases, we estimated the time contribution of the staff for SCNU related activities. This proportional time contribution towards SCNU services was then multiplied with the gross salary of the staff member, to elicit the cost of human resource for SCNU care. Proportional time contribution was elicited by interviewing the providers. In some cases such as hospital accountant, time allocation information was not available in a straightforward manner through interview or observation or diary method. In such case we used proxy measures, such as the proportion of total hospital patients constituted by the SCNU neonates admitted during a year.

Capital expenditure was annualized (which involves spreading out the costs of capital goods over time periods) over the useful life of the asset to arrive at the equivalent annual cost. Annualization took into consideration the discount rate (time preference for money and inflation) and the lifespan of capital equipments. We calculated space costs by multiplying the estimates of floor size of rooms devoted to neonatal care with local commercial rental prices of similar space. Cost of space which was jointly used for neonatal care and non-neonatal care was apportioned for neonatal care by the proportion of neonates who were provided treatment or diagnostic services in that room.

Overhead costs (laundry, electricity, water etc) and number of diagnostic tests were apportioned for neonatal care by a proportion of total floor area and proportion of SCNU inpatients to total admissions in the health facilities respectively. Data on overhead costs was available for the entire hospital as a whole, rather than for SCNU. Similarly information on number of diagnostic tests and hence its cost, was also available for the entire hospital. This resource utilization (or cost) had to be apportioned for the SCNU. In order to do so we used standard methods of apportionment [15]. Since the consumption of overhead charges such as laundry or electricity is dependent on the floor size, hence the same was apportioned for SCNU by the floor area of SCNU as a proportion of the floor area of entire hospital. Similarly, the number of laboratory tests is dependent on the number of patients which are treated. Thus we apportioned the cost of laboratory tests for SCNU by the number of SCNU admissions as a proportion of the total hospital admissions.

Resource consumption on drugs and consumables were recorded separately for SCNU at each facility. Cost of drugs, consumables and laboratory test was ascertained by multiplying the unit prices with the resources consumed. We estimated the average costs as Indian Rupees (INR) per neonate treatment and INR per bed day for each SCNU. Since the capacity utilization varied across the sites, we standardized the costs pertaining to personnel, overheads, equipments and space using bed occupancy as the indicator for capacity utilization. Other recurrent costs were not standardized. Using these, we obtained estimates of standardized treatment costs of treatment for each SCNU. Average unit costs for SCNU treatment was computed as the weighted average across each hospital, with weighting done by the number of neonates treated at each SCNU. All costs were converted to 2010 prices and monthly average for conversion of INR to US Dollar (USD) was used to report the costs in USD [16].

Cost of Level II Neonatal Intensive Care in India: Direct medical out-of-pocket (OOP) cost of neonatal treatment was estimated from patient level data, by computing the average quantity of medicine, consumables, laboratory tests and procedures which were privately purchased by patients. The same was multiplied with locally prevalent market prices for each and summed with the actual health system costs to estimate the overall direct cost of delivering treatment at the SCNUs. Assuming that 15% of total live births require level II intensive neonatal care in India, we estimated the cost (INR) to the Indian health system to treat neonates at varying coverage levels of SCNU care.

Owing to region wise variations in the input parameters, we performed a multivariate probabilistic sensitivity analysis based on 1000 Monte Carlo simulations using the SensIt version 1.45 software to test the robustness of the actual unit health system cost estimates [17] A uniform distribution was assumed between the maximum and minimum range specified within which the true value is expected to lie. We did a scenario analysis to further test the variability of different input parameters such as prices of drugs, consumables, equipments etc, and staff salaries. In scenario 1, we varied all prices by 25% on either side of case value. However, large variations in drugs, consumables and equipment prices have been observed in India [18-21]. In view of these considerable reported differentials, we undertook another scenario 2, where salaries, consumables and equipment prices were varied by 25%; prices of laboratory tests and drugs by 50% on either side of base value. Under scenario 3, variations in all prices were kept similar to scenario 2, but drug prices were varied by 80% on the lower side and 100% on the higher

side of the base value. Under scenario 4, keeping everything else similar to scenario 3, drug prices were varied from 80% of base value on lower side to 200% on the higher side of base estimate.

Permission to collect data was obtained from concerned authorities including the Medical Superintendent of hospitals and in-charge of SCNUs, after duly explaining them the purpose of present study.

RESULTS

The details of admitted neonatal are shown in ***Table* I**. Almost half of all admissions in these SCNUs comprised of neonates delivered at respective hospitals. Lowest bed occupancy rate of 52.4% was observed at Vaishali, while it was as high as 139.6% in Guna. Majority of neonates admitted in SCNUs were normal weight. Perinatal asphyxia and neonatal sepsis were the most common

TABLE I FACILITY AND PATIENT CHARACTERISTICS OF NEONATES TREATED AT SPECIAL CARE NEWBORN UNITS

Facility/ Infant Characteristics	*SCNU Centres*			
	Vaishali	*Guna*	*Shivpuri*	*Bhubaneshwar*
Facility characteristics				
Number of beds	15	24	22	15
Doctor-bed ratio	1:3	1:6	1:5.5	1:2.1
Nurse-bed ratio	1:1.25	1:2.7	1:1.8	1:0.9
Bed-occupancy rate (%)	52.4	139.6	129.4	89.6
Total Admissions	844	2223	1599	844
Inborn	401 (47.5)	1133 (51)	742 (46.4)	450 (53.3)
Outborn	443 (52.5)	1090 (49)	857 (53.6)	394 (46.7)
Average length of stay (d)	3.4	5.5	6.5	6.2
Birth weight				
> 2500 gm	581 (68.8)	975 (44)	636 (39.8)	327 (38.7)
1800 - 2499 gm	111 (13.1)	781 (35)	487 (30.5)	349 (41.4)
1200 - 1799 gm	84 (10)	390 (17.5)	378 (23.6)	146 (17.3)
< 1200 gm	68 (8.1)	77 (3.5)	98 (6.1)	22 (0.2)
Gestational age				
>37 weeks	675 (80)	1524 (68.5)	708 (44.3)	N.A.@
34 - 37 weeks	84 (10)	429 (19.3)	420 (26.3)	
30 - 34 weeks	51 (6)	188 (8.5)	367 (22.9)	
< 30 weeks	34 (4)	82 (3.7)	104 (6.5)	
Disease/ Illness				
Perinatal asphyxia	381 (45.1)	872 (39.3)	372 (23.2)	351 (41.6)
Neonatal sepsis	307 (36.4)	692 (31.2)	393 (24.6)	161 (19)
Hyperbilirubinemia	-	381 (17.1)	166 (10.4)	42 (5)
Pneumonia	122 (14.4)	198 (8.9)	102 (6.4)	92 (11)
Diarrhea	29 (3)	1 (0.04)	19 (1.2)	74 (8.8)
Others*	5 (0.1)	79 (3.5)	547 (34.2)	124 (14.6)
Outcome				
Discharge	557 (66)	1822 (82)	1284 (80.3)	602 (71.3)
Deaths	118 (14)	286 (12.9)	201 (12.6)	110 (13)
Referral	135 (16)	19 (0.8)	49 (3.1)	106 (12.6)
Left Against Medical Advice	34 (4)	96 (4.3)	63 (4)	26 (3.1)

**Includes congenital malformation, neonatal seizure, hyaline membrane disease, respiratory distress syndrome, aspiration pneumonitis, hypothermia, and anaemia; #Data pertaining to gestation age wise classification of neonates was unavailable.*

clinical conditions for which neonates were admitted in SCNUs (***Table* I**).

The average annual economic cost for functioning a level II SCNU was INR 6.3 (USD 1.4) million. It ranged from INR 59,73,851 (USD 132,752) in Guna to INR 70,63,400 (USD 156,964) in Vaishali (***Web Table* II**). Salaries for personnel constituted the single largest contributor of total costs (55.3% - 81.1%) followed by non-consumables (9.3% - 14.7%) which includes mainly expenditure on procurement of medical equipments.

We estimated an average health system cost per neonate treatment of INR 4581 (USD 102) (***Table* II**). Variations in unit cost were observed, with the lowest at Guna (INR 2687, USD 60) Per-bed day cost of SCNU treatment was found to be INR 818 (USD 18). Inclusive of all direct costs, we found the overall cost of providing treatment in SCNU was INR 4976 (USD 111) per neonate and INR 889 (USD 20) per bed-day.

The overall extent of variation in unit costs of neonatal treatment over the four scenarios is 5.5% (4766, 5029) (***Web Table* III**).

DISCUSSION

Overall we estimated the health system costs of operating SCNUs at the district level to be INR 6.3 (USD 1.4) million annually. The cost of providing intensive neonatal services through district hospital based SCNUs will cost the Government of India about INR 2042 million (USD 45.4), INR 10210 million (USD 227), INR 14294 million (USD 318) and INR 20420 million (USD 454), at a treatment coverage of 10%, 50%, 70% and 100% sick neonates, respectively. In this paper, we report that the overall cost of neonatal intensive care for all those who require level II care would be about INR 20.4 billion. Together, these findings have significant implications. In the event when India goes on the path of universal health care, level II neonatal care would comprise 0.8% of India's health care spending. Thus it does not impose too much fiscal pressure. However, the resources would need to be used judiciously for the babies who actually require neonatal intensive care.

We found one previous study which estimated the cost of neonatal intensive care in India [8]. However, this study was undertaken in the setting of a tertiary-care hospital and used a narrow financial perspective to estimate cost of level III neonatal intensive care. In light of recent policy developments in India, greater impetus is being laid on establishment of level II SCNUs at district-based public hospitals. This makes the findings of our study more relevant.

We noted that personnel salaries constituted the major cost of neonatal intensive care. Higher component of staff salaries (55%-81%) towards overall cost of SCNU care was also observed in other studies from outside India [22]. As per estimates from Narang, *et al*. (2005), personnel salaries constituted a quarter of the total costs of level III intensive care services [8]. This difference in contribution of personnel costs could be attributed to the difference in methods adopted for analyzing cost data. Narang, *et al*. (2005) did not annualize capital costs and used a rudimentary financial costing. Even in their analysis personnel salaries form a significant proportion (55%) of the running costs. In another study from Malaysia [23], even though staff salaries constitute a significant proportion of total costs (24-31%), consumables form the largest cost component (47% - 56%). This difference, as mentioned in their study,

TABLE II BASE COST PER NEONATE AND PER-BED-DAY HEALTH SYSTEM COSTS AT SPECIAL CARE NEWBORN UNITS AT DISTRICT LEVEL, INDIA, 2010

SCNU Centres	*Health System Costs*				*True Treatment Costs**			
	Actual costs		*Standardized costs*		*Actual costs*		*Standardized costs*	
	INR per neonate treated	*INR per bed day*	*INR per neonate treated*	*INR per bed day*	*INR per neonate treated*	*INR per bed day*	*INR per neonate treated*	*INR per bed day*
Vaishali	8369 (186)	2461 (54.7)	4561 (101.4)	1342 (29.8)	9355 (207.9)	2752 (61.2)	5548 (123.3)	1632 (36.3)
Bhubaneshwar	7321 (162.7)	1181 (26.2)	6705 (149)	1081 (24)	NA[#]	NA[#]	NA[#]	NA[#]
Guna	2687 (59.7)	489 (10.9)	3541 (78.7)	644 (14.3)	2909 (64.6)	529 (11.8)	3762 (83.6)	684 (15.2)
Shivpuri	4011 (89.1)	617 (13.7)	4977 (110.6)	766 (17)	4294 (95.4)	661 (14.7)	5260 (116.9)	809 (18)
Overall	4581 (101.8)	818 (18.2)	5090 (113.1)	909 (20.2)	4976 (110.6)	889 (19.8)	5279 (117.3)	943 (21)

** True treatment costs include the cost of direct medical expenditure which was not borne by the health system, [#]Data not available.*

was due to the fact that most consumables were being imported in Malaysian context and also remuneration of government health staff, including neonatal specialist doctors and nurses in their country was reportedly low.

There were significant variations in costs across SCNUs, some of which could be possibly explained from present analysis. Personnel costs were significantly higher in Vaishali. This was on account of higher number of doctors and nurses. Nurse and doctor bed-ratio in Vaishali were 1:1 and 1:2.6, respectively as compared to 1:2 and 1:6.7 respectively in Guna [2]. Moreover, greater proportion of doctors and nurses were deployed from regular health services who were paid higher salaries, other service allowances and benefits. On the contrary, majority of personnel in SCNUs elsewhere were employed on contractual basis with lesser fixed salary and without any service benefits or allowances. Shivpuri had the largest SCNU in terms of number of beds [2], and hence higher equipment costs. Review of Shivpuri and Guna drug supply chain showed better management with least stockouts and regular supply of medicines and consumables, hence higher costs on account of drugs. Vaishali had the significantly less overhead costs on account of smaller size of the district hospital than the rest SCNU hospitals.

We also found significant variations in the unit-cost estimates in different district hospitals, even after standardizing for capacity utilization. Comparatively lower unit costs in Guna was on account of higher number of neonates treated. High bed-day costs in Vaishali seem to be because of lower overall admissions, along with lower average length of stay in comparison to the other districts in the study. This is also explained by less severe profile of babies admitted in Vaishali, as reflected by higher proportion of normal birth weight children who were admitted. A review of SCNUs in India found birth weight to be a strong predictor of the length of stay, besides survival [2].

Curative care in India is highly skewed towards private sector [24]. More than 80% out-patient care and nearly 60% in-patient care is sourced from private providers [24]. Given the fact that neonatal care is cost-intensive, it imposes significant economic burden on households pushing them into poverty. Our estimate for cost of SCNU care can be used for setting the payment rates to providers of neonatal care under *Rashtriya Swasthya Bima Yojna* (RSBY) of the Government.

The cost of SCNU care also holds important fiscal implications, especially in view of Government of India's recently launched *Janani Shishu Suraksha Karyakram* (JSSK), a scheme for provision of free delivery services and treatment for sick newborn till 30 days of birth in public hospitals [3]. In view of this, it is important to assess the cost effectiveness of SCNU care. High fiscal costs imply that the services need to be rationed carefully for the ones who need it most. We recommend careful implementation of selection criteria for admission to SCNUs. Currently, almost half of normal birth weight children were being admitted to SCNUs despite having clear cut admission guidelines. This is also corroborated by evidence from another study [2]. Experience worldwide has shown that level II units can contribute maximally towards bringing down the mortality among low-birth weight babies [25-27]. Similar findings were reported from India where babies in the range of 1500-2499 g had maximum reductions in mortality [28]. Secondly, establishment of SCNUs should not crowd out resources for community-based newborn care. Numerous research studies point to a greater role that home and community based interventions can play in tackling neonatal mortality, especially in low resource settings with weak health systems [29, 30]. Apart from being less costly they can serve as a foundation for improved care seeking and demand for clinical care, which are essential for the effect of clinical care services to be fully realised [31]. Thus both community and facility-based newborn care should be concurrently strengthened.

The third implication of our findings is an imperative need to conduct a full economic evaluation of level II SCNU care versus routine pediatric care in district hospitals. Estimates from cost effectiveness of neonatal intensive care from other countries imply high value for money [32-35]. However, neonatal intensive care delivered through SCNUs (Level II) is different from intensive care evaluated elsewhere (Level III care).

We would like to note a few limitations of our study. Firstly, although it is important to conduct a full economic evaluation, we did not analyze the incremental costs of SCNU per DALY averted, as compared to routine care setting. Secondly, we do not report condition or disease-specific unit cost of neonatal treatment at the SCNUs. However, we have estimated the per bed-day cost, which takes account of the average length of stay, and can be used to arrive at disease-wise cost, given their average length of stay. Also we did not undertake a complete economic burden from a societal perspective as we did not account for indirect costs such as productivity losses and transportation costs. This would include measurement of loss of care-givers' wages during treatment and as a result of premature mortality.

Further we used a record-based method to estimate OOP direct cost of treatment. It is important to estimate out-of-pocket costs through prospective interviews. We

concede that there is a possibility of missing information on certain consumables such as syringes, needles, gloves etc. However, we believe that our OOP estimates are valid. Firstly, the SCNUs which we selected had better record-keeping and so the extent of missing data is expected to be relatively less. Secondly, despite the possibility of missing information, it is likely that the same would be minimal for medicines and laboratory diagnostics which are recorded quite comprehensively in patient records. Literature shows that the predominant constituent of OOP expenditures in India is on account of medicines (50%-80% of total OOP), with laboratory tests coming next in order [36,37]. The contribution of other consumables such as gloves, syringes etc. is very minimal. Hence, whatever reduction in OOP estimates from our study were caused as a result of missing information in the requisition slips of nurses and case files, its effect on overall OOP expenditure was minimal.

Other studies from India show that OOP costs in India constitute a significant portion in curative treatment, which poses catastrophic burden on households [38-40]. However, we found that the direct medical expenditure borne by the households was about 7-10% of the total cost of SCNU treatment. This could be in view of significant greater provision of drugs and supplies from Government side.

To conclude, neonatal treatment through special care newborn units is cost-intensive in India and imposes significant fiscal challenge. This implies that rational implementation and utilization of SCNUs should be planned. There needs to be strict implementation of admission policies in SCNUs for very low birth weight babies. Emphasis on low cost and highly efficacious home-based newborn care should be maintained, alongside up-gradation of facilities for curative care. Lastly, cost-effectiveness of SCNU based level II neonatal intensive care should be assessed against a comparator of routine paediatric care delivered through district hospitals by rigorous economic evaluations in India to lend further support to the establishment of SCNUs.

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