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RESEARCH ARTICLE

Environmental, Maternal, Paternal, and Demographic Factors Associated with Urogenital Anomalies in Newborn Male Neonates

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ABSTRACT

Objective: This investigation aimed to determine whether urogenital anomalies (UGAs) correlate with maternal- and paternal-related factors in newborn males.

Methods: Out of 2410 males, 75 were found to have UGAs, thus representing 3.1% of the recruited male neonates. 54 neonates had undescended testis (UT), accounting for 2.24% of all neonates with UGAs, and 21 neonates had Hypospadias (HS), which represented 0.87% of all neonates with UGAs. A questionnaire was arranged to gather data from mothers of all recruited neonates.

Results: Among the examined variables, living condition was significantly associated with UGAs ($p < 0.001$; OR = 0.08, 95% CI: 0.03–0.23). Paternal occupation was significantly associated with the distribution of HS and UT ($p = 0.03$) and was the only significant predictor in regression analysis ($p = 0.008$; Exp(B) = 0.19, 95% CI: 0.056–0.65). Unilateral inguinal UT was the most frequent subtype (40.7%), while distal HS accounted for 95.2% of HS cases.

Conclusion: Living conditions and paternal occupation were the main factors associated with UGAs in the studied population. Unilateral inguinal UT and distal HS were the predominant subtypes within their respective anomaly groups. These findings support further investigation of socioeconomic, environmental, and familial factors underlying urogenital anomaly patterns.

Keywords: Hypospadias, undescended testis, urogenital anomalies, neonates, environment.

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Introduction

Undescended testis UT and hypospadias HS are among the most common congenital abnormalities in male births. UT refers to the failure of one or both testes to descend into the scrotum and can be either congenital or acquired [1,2]. UT occurs in approximately 1–4.5% of newborns, with a higher incidence in preterm infants, ranging from 30% to 45% [3,4]. While roughly 50–70% of congenital UT will spontaneously descend within the first year of life—most within the first three months—at least 1% of children continue to experience persistent UT [5]. Nevertheless, most acquired UTs spontaneously descend during puberty. [6, 7] HS the second most common congenital anomaly of the male external genitalia, after UT. The urethral orifice is displaced along the ventral side of the penis as a result of incomplete closure of the penile structures during embryogenesis[8]. approximately 70% of cases are distal, representing milder forms while the remaining cases are more severe and complex [9].

Several hypotheses have been proposed to explain HS, including endocrine disruptors, genetic abnormalities, and developmental arrest. Almost 30% of patients with more severe HS may have androgen disruption as their underlying cause [10,11].

Substances such as phenol, phthalates, and organochlorine compounds are endocrine-disrupting chemicals (EDCs) known to affect the endocrine system in all mammals. A wide variety of agricultural, industrial, canned food, and fire-retardant items contain these EDCs. Exposure to these substances via ingestion, inhalation, and dermal absorption has the potential to affect the endocrine glands [12,13]. If pregnant women are continuously exposed to these EDCs, these compounds can cross the placenta and have been detected in amniotic fluid. [14,15]. A higher risk of HS and/or UT may result from exposure to these EDCs during pregnancy. [16,17] male offspring exposed to these EDCs were more likely to develop UGAs, according to previous research [18,19].

Inhibiting androgens by these disruptors can raise the risk of testicular cancer, micropenis, and poor semen quality in later life. [20,21] The mechanism by which these disruptors act likely involves xenobiotic interactions with hormone receptors or exhibiting anti-androgenic properties. [22]

Some studies did not support the notion that these

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EDCs potentially increase the likelihood of UGAs in experimental animals. [23,24].

Despite growing evidence on factors associated with UGAs, local data on potential environmental, maternal, paternal, and demographic determinants remain limited. Therefore, this hospital-based study aimed to investigate these factors among male neonates in our population and compare affected cases with unaffected controls, providing locally relevant evidence to guide future research on preventive strategies.

The null hypothesis was that there was no significant association between urogenital anomalies and the study variables among male neonates.

The purpose of this research was to identify associations between UGA and the following variables in newborn males:

- Maturity of the neonates
- Paternal occupation
- Smoking status
- Maternal use of progesterone or iron supplements during pregnancy
- Any history of threatened abortion
- Any family history of UGA
- Is the infant a product of in vitro fertilization (IVF)
- Maternal age
- Rural or urban residence

Additionally, UGA cases were compared with unaffected male neonates.

Methods

Ethical approval was obtained from the "Research Ethics Committee of the Iraqi Ministry of Health (2026230/Baghdad/Al-Karkh). The study adhered to the Declaration of Helsinki". This study used a cross-sectional design with a nested case-control approach at Alyarmouk Teaching Hospital and enrolled 2,410 newborn male neonates. The total number of neonates born was 5,701, with 2,869 males and 2,832 females. The number of male neonates missed because they were not examined for any UGAs was 459. Consequently, they recruited 2410 male neonates. They searched for UGAs, including UT and HS. 75/2,410 = 3.1%- "3.1% of screened male neonates, were found to have UGAs, 54/2,410 = 2.24%- "2.24% of screened male neonates with UGAs, 21/2,410 = 0.87%- "0.87% of screened male neonates with UGAs (Figure 1). The control group was selected based on a pilot study and in consultation with the study statistician. Controls were randomly selected from the same source population as the anomaly group, according to the predefined inclusion and exclusion criteria. A pediatrician and urologist performed clinical examinations, and a specialist radiologist performed an ultrasound examination after referral to determine testicular position. A questionnaire was arranged to gather data from mothers of all recruited neonates; these data include: Newborn male neonates' maturity, maternal occupation, urban or rural residence, paternal occupation, maternal progesterone use during pregnancy, history of threatened abortion, family history of HS, paternal or maternal smoking, gestational diabetes, and maternal use of iron supplements during the last pregnancy. The same questionnaire also documented the control group, which consisted of 89 healthy newborn male neonates. Disorders of sex development (DSD), chromosomal syndromes, and births that were more than one month old were excluded from the study. Utilizing SPSS version 25 (IBM Corp., Armonk, NY, USA), the statistical analyses were conducted. Statistical significance between study groups was indicated by a P value of less than 0.05 in the Chi-square test and Logistic Regression model.

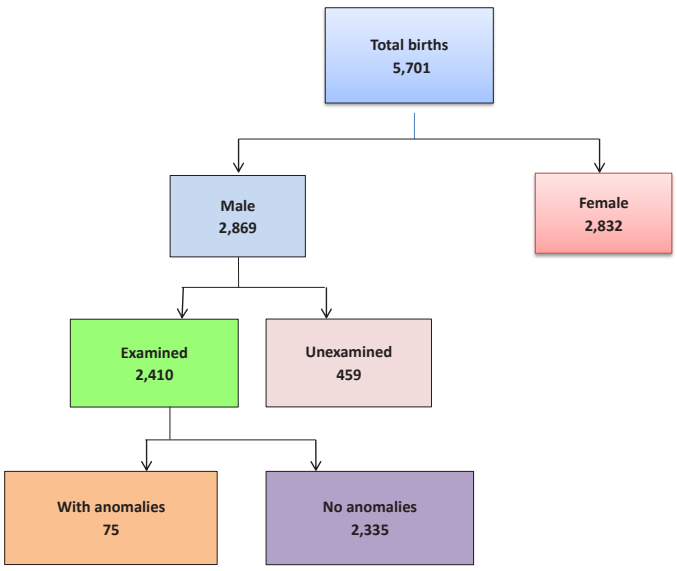


Figure 1. Flowchart of participant selection and study sample

Statistical analysis

An independent-samples t-test was used for comparisons between age groups. Categorical variables were compared using the chi-square test with Yates' continuity correction; Fisher's exact test was used instead wherever any expected cell count was <5 (noted per table). Odds ratios (OR) with 95% confidence intervals (CI) are reported alongside every p-value. The multivariable logistic regression was conducted using Firth's penalized

Results

There were no statistically significant differences in mean gestational age, maternal age, or paternal age between the two groups (p = 0.67, 0.92, and 0.59, respectively), indicating comparable distributions of these demographic characteristics (Table 1).

Most of the studied parameters showed no statistically significant differences between the anomaly and control groups. Significant differences were observed for residence (p < 0.001; OR = 0.08, 95% CI: 0.03–0.23) and maternal iron supplementation (p = 0.002; OR = 0.31, 95% CI: 0.12–0.80) (Table 2 and Figure 2).

Most studied parameters showed no statistically significant differences between the HS and UT groups. Significant differences were observed for paternal occupation (p = 0.031; OR = 3.47, 95% CI: 1.21–9.90) and family history of HS (p = 0.005). The odds ratio for family history was not estimable because no cases were positive in the UTs group, as shown in Table 3.

Among the 54 infants with UTs, unilateral inguinal UTs were the most frequent presentation (22 cases, 40.7%), followed by bilateral abdominal UTs (17 cases, 31.5%). Uni-

Table 1. Maternal and paternal age of neonates, father age with and without urogenital anomalies (UGA).

Variable	Health Status			
	Anomalies N =75		Control N= 89	
	Mean	SD	Mean	SD
Gestational age (weeks)	37	2	37	1
Maternal age (years)	28	7	28	6
Paternal age (years)	33	9	33	8

[a] Includes hypertriglyceridemia, [b] Includes active and former smokers

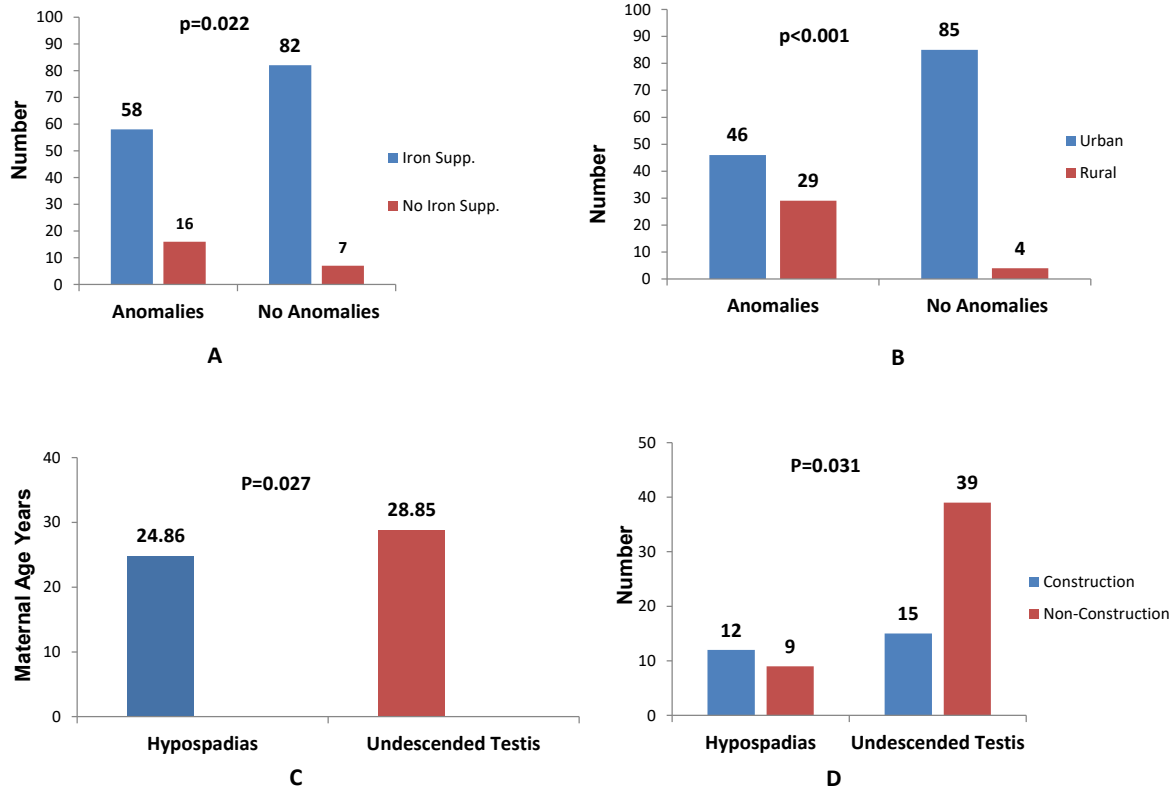


Figure 2. Urogenital anomalies according to different variables: A: Iron supplement for the mother, B: urban and rural areas; undescended testis and hypospadias according to maternal age (C) and paternal occupation (D)

Table 2. The distribution of the anomalies in relation to various parameters included in the study

Variable		Health Status				
		Anomalies N=75		Control N=89		
	Count	Column N %	Count	Column N %	P Value	
Gestational Maturity>=37	Yes	51	68.0%	63	70.8%	p = 0.83 (χ^2, Yates) OR 0.88 (0.45–1.71)
	No	24	32.0%	26	29.2%	
Maternal occupation	House Wife	72	96.0%	85	95.5%	p = 1.00 (Fisher's exact) OR 1.13 (0.25–5.21)
	Employed	3	4.0%	4	4.5%	
Residence	Urban	46	61.3%	85	95.5%	p < 0.001 (χ^2, Yates) OR 0.08 (0.03–0.23)
	Rural	29	38.7%	4	4.5%	
Paternal occupation	Construction	27	36.0%	25	28.1%	p = 0.36 (χ^2, Yates) corrected from p=0.027 OR 1.44 (0.74–2.79)
	Non-construction	48	64.0%	64	71.9%	
Maternal use of progesterone	Yes	32	42.7%	40	44.9%	p = 0.89 (χ^2, Yates) OR 0.91 (0.49–1.69)
	No	43	57.3%	49	55.1%	
Threatened abortion	Yes	12	16.0%	14	15.7%	p = 1.00 (χ^2, Yates) OR 1.02 (0.44–2.37)
	No	63	84.0%	75	84.3%	
Family history of hypospadias	Yes	4	5.3%	2	2.2%	p = 0.41 (Fisher's exact) corrected from p<0.001 OR 2.45 (0.44–13.8)
	No	71	94.7%	87	97.8%	
Patrnal smoking	Yes	46	61.3%	50	56.2%	p = 0.61 (χ^2, Yates) OR 1.24 (0.66–2.31)
	No	29	38.7%	39	43.8%	
Maternal smoking	Yes	4	5.3%	2	2.2%	p = 0.41 (Fisher's exact) OR 2.45 (0.44–13.8)
	No	71	94.7%	87	97.8%	
Maternal type 2 diabetes	Yes	5	6.7%	9	10.1%	p = 0.61 (χ^2, Yates) OR 0.64 (0.20–1.98)
	No	70	93.3%	80	89.9%	
Iron supplementation of mother	Yes	59	78.7%	82	92.1%	p = 0.025 (χ^2, Yates) OR 0.315 (0.122–0.813)
	No	16	21.3%	7	7.9%	

Table 3. Comparison between Hypospadias and Undescended Testis according to parameters included in the study

Variable	**Count**	**Hypospadias N= 21**		**Undescended Testis N=54**		
		Column N %	**Count**	**Column N %**	**P Value / OR (95% CI)**	
Gestational Maturity>= 37	Yes	16	76.2%	35	64.8%	p = 0.42 OR 1.74 (0.55–5.48)
	No	5	23.8%	19	35.2%	
Maternal occupation	H. Wife	20	95.2%	52	96.3%	p = 1.00 OR 0.77 (0.07–8.96)
	Employed	1	4.8%	2	3.7%	
Residence	Urban	15	71.4%	31	57.4%	p = 0.30 OR 1.86 (0.62–5.52)
	Rural	6	28.6%	23	42.6%	
Paternal occupation	Construction	12	57.1%	15	27.8%	p = 0.031 OR 3.47 (1.21–9.90)
	Non-construction	9	42.9%	39	72.2%	
Maternal use of progesterone	Yes	11	52.4%	21	38.9%	p = 0.31 OR 1.73 (0.63–4.78)
	No	10	47.6%	33	61.1%	
Threatened abortion	Yes	3	14.3%	9	16.7%	p = 1.00 OR 0.83 (0.20–3.44)
	No	18	85.7%	45	83.3%	
Family History of Hypospadias	Yes	4	19.0%	0	0.0%	p = 0.005
	No	17	81.0%	54	100.0%	
Paternal smoking	Yes	14	66.7%	32	59.3%	p = 0.61 OR 1.38 (0.48–3.96)
	No	7	33.3%	22	40.7%	
Maternal Smoking	Yes	0	0.0%	4	7.4%	p = 0.57 OR ~0 (0.02–5.88)
	No	21	100.0%	50	92.6%	
Maternal Type 2 diabetes	Yes	1	4.8%	4	7.4%	p = 1.00 OR 0.63 (0.07–5.94)
	No	20	95.2%	50	92.6%	
Iron supplementat-ion of mother	Yes	18	85.7%	40	75.5%	p = 0.53 OR 1.95 (0.49–7.70)
	No	3	14.3%	13	24.5%	

lateral supracrotal and unilateral abdominal UTs accounted for 7 (13.0%) and 5 (9.3%) cases, respectively, while bilateral inguinal UTs were observed in 3 cases (5.6%).

Among the 21 neonates with HS, distal HS was the predominant subtype, accounting for 20 cases (95.2%), including 13 glandular (61.9%) and 7 subcoronal (33.3%) cases. Penoscrotal HS was observed in 1 case (4.8%) (Table 4).

Among the 75 affected neonates, binary logistic regression was used to examine factors associated with the type of urogenital anomaly, with UT coded as 1 and HS as 0. Most variables were not associated with anomaly type. Paternal occupation was the only variable associated with the outcome (B = −1.657, Wald = 7.01, p = 0.008), with an estimated odds ratio of approximately 0.19 (95% CI: 0.056–0.65). The negative regression coefficient indicates

lower odds of UT relative to HS among neonates whose fathers were construction workers (Table 5).

Discussion

This study found that newborns from rural areas had a higher odds of UGA. K. Wagner-Mahler et al. [25] and Pierre Bougnères et al. [26] both agree with my outcome. Li et al. [27] also report a more frequency of UGA in urban regions. Differences in ethnicity and sample size may explain this discrepancy. However, rural residence was significantly associated with the occurrence of UGAs in the case–control comparison, but not with anomaly type among affected neonates (OR = 0.445, 95% CI: 0.123–1.611, p = 0.217). This distinction reflects the different outcomes examined in the two analyses rather than a contradiction between the findings.

Agricultural chemicals used in rural areas may contain EDCs and may contribute to HS and UT. However, this study did not assess direct exposure to these chemicals. The observed occupational pattern may therefore reflect multiple interacting factors, including socioeconomic conditions, nutritional status, healthcare access, and other environmental or lifestyle exposures. This is consistent with the multifactorial etiology of UGAs and the complexity of linking individual environmental exposures to cryptorchidism [28]. In our study, the occupational differences observed may thus have several possible explanations rather than being attributed directly to EDCs. This interpretation is also consistent with previous occupational evidence linking non-construction occupations with UT by Das et al. [29] and Pierik et al. [30]. Although Nassar et al.[31] reported a more frequency of HS among construction workers, differences between studies may reflect variation in population characteristics and study design.

A positive family history of HS was observed in four neonates with HS and none with UT (p = 0.005), consistent with previous observations by Schnack et al. [32] and van der Zanden et al. [33]. However, the small number of positive cases warrants cautious interpretation, and this finding should be considered preliminary and hypothesis-generating.

Lower maternal iron supplementation was associated with higher odds of anomalies in the unadjusted comparison, although this association was not statistically significant in the adjusted regression analysis. Iron is essential for fetal development and for numerous enzymatic processes, and inadequate maternal iron status may affect fetal development. Mohammad ZZadeh et al. [34] also discussed this possible relationship. However, Carmichael et al. [35] found no correlation between maternal iron supplementation and UGAs. The difference between these observations may reflect variations in maternal nutritional status, study populations, or study design

In contrast to this study and Ye et al. [36], who found no association between UGA and smoker fathers, Shekar et al. [37] found an association. This investigation, consistent with the findings of Akay et al. [38] and Carmichael et al. [35], found no significant correlation between UGA and mothers' use of progesterone during the first trimester (OR = 0.91, 95% CI: 0.49–1.69, p = 0.89).

Previous studies have suggested different patterns regarding maternal age and UT. Younger maternal age may protect against UT in sons [39,40], whereas another study indicated a positive association among mothers who were

Table 4. Subtypes of both HS and UT and their percentages

Anomalies		Count		Column N %
unilateral undescended testis inguinal		22		40.7% (of 54)
bilateral undescended testes inguinal		3		5.6% (of 54)
unilateral undescended testis abdominal		5		9.3% (of 54)
bilateral undescended testes abdominal		17		31.5% (of 54)
unilateral undescended testis suprascrotal		7		13.0% (of 54)
Distal hypospadias	Glandular	13	20	95.2% (of 21)
	Subcoronal	7		
penoscrotal hypospadias		1		4.8% (of 21)

Note: percentages are calculated within each condition's own group (undescended testis, n=54; hypospadias, n=21).

Table 5. Regression analysis demonstrating the effect of various factors on urogenital anomalies.

Variables		B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
								Lower	Upper
Step 1[a]	mother age	0.094	0.049	3.732	1	0.053	1.099	0.999	1.209
	Living (1)	-0.810	0.657	1.522	1	0.217	0.445	0.123	1.611
	paternal occupation (1)	-1.657	0.626	7.012	1	0.008	0.191	0.056	0.650
	family history of hypospadias (1)	-3.435	1.774	3.750	1	0.053	0.032	0.0002*	0.393*
	iron_ supplement (1)	-0.512	0.801	0.408	1	0.523	0.599	0.125	2.882
	Constant	0.214	1.350	0.025	1	0.874	1.238		

a. Variables entered in Step 1 were maternal age, paternal occupation, family history of hypospadias, and iron supplementation during pregnancy. The outcome was undescended testis (1) versus hypospadias (0). Because the unpenalized model showed complete separation for family history of hypospadias, Firth penalized logistic regression was used. The profile-likelihood 95% CI was used for this variable because the standard Wald CI was unreliable.

either younger or older [41]. In our study, maternal age did not differ significantly between the anomaly and control groups (p = 0.92). However, in the regression analysis comparing UT and HS within the case group, maternal age showed a borderline association, with mothers of children with UT being marginally older (OR = 1.099, p = 0.053). These varying observations suggest that the relationship between maternal age and UT may vary across populations. The findings of by McGlynn et al. [39] and Jones et al. [40] suggested that younger maternal age may offer some protection against UT in sons, whereas the study by Toliczenko-Bernatowicz et al. [41] noted a positive association with maternal ages above 30 years or below 20 years.

Limitations

The study design allowed the identification of associations but could not establish causation. Paternal occupational categories were broad, and more specific occupational classification may provide greater insight. In addition, direct biomonitoring data for EDCs, such as blood or urine levels, were not available to establish a clearer link between suspected exposure and the observed outcomes. No follow-up was conducted; therefore, some cases may have resolved spontaneously. Although prematurity is an established correlate of UT, its independent contribution could not be adequately assessed in the present study. Gestational age was summarized using group means and standard deviations, while prematurity was classified categorically as gestational age below 37 weeks. These limitations restricted the assessment of the relationship between prematurity and the study outcomes. Maternal parity and pregnancy-related conditions were not assessed, limiting the evaluation of their potential confounding effects. Birth weight and laterality were not assessed in the present study and should be considered additional limitations. Furthermore, the limited number of HS cases relative to the number of predictors may reduce the stability of the multivariable estimates; therefore, these findings should be interpreted as exploratory. Detailed descriptions of the clinical examination procedures and specific diagnostic protocols were beyond the scope of the study. In addition, some exposure variables lacked detailed measurements, including the timing, duration, and quantity of smoking exposure, iron supplementation, and further details regarding paternal occupation and gestational maturity. These limitations should be considered when interpreting the findings.

Conclusion

Residence was significantly associated with the presence of UGAs, while paternal occupation was the only significant factor identified in the regression model. Unilateral inguinal UT and distal HS predominated within their respective groups. The findings suggest that socioeconomic and potentially environmental factors may contribute to the observed pattern, although larger studies with direct assessment of environmental and familial exposures are needed to clarify these associations.

Authors' contributions

B. A. M, O. A. A., D. E. K. and B. A. M. conceived and designed the study, developed the methodology, and collected the data. All authors revised, and approved the final manuscript.

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Conflict of interest

The authors declare no conflicts of interest.

References

1. Bonney T, Hutson J, Southwell B, Newgreen D. Update on congenital versus acquired undescended testes: Incidence, diagnosis and management. ANZ J. Surg. 2008; 78: 1010–1013.
2. Kolon TF, Herndon CD, Baker LA, Baskin LS, Baxter CG, Cheng EY, et al. American Urological Assocation. Evaluation and treatment of cryptorchidism: AUA guideline. J Urol. 2014;192(2):337-345. doi: 10.1016/j.juro.2014.05.005. Epub 2014 May 20. PMID: 24857650.
3. Ashley RA, Barthold JS, Kolon TF. Cryptorchidism: Pathogenesis, diagnosis, treatment and prognosis. Urol. Clin. North Am. 2010; 37: 183–193.
4. Hutson JM, Balic A, Nation T, Southwell B. Cryptorchidism. Semin. Pediatr. Surg. 2010; 19: 215–224.
5. Barthold JS, Gonzalez R. The epidemiology of congenital cryptorchidism, testicular ascent and orchiopexy. J. Urol. 2003; 170: 2396–2401.
6. Eijsbouts SW, de Muinck Keizer-Schrama SM, Hazebroek FW. Further evidence for spontaneous descent of acquired undescended testes. J. Urol. 2007; 178: 1726–1729.
7. Sijstermans K, Hack WW, van der Voort-Doedens LM, Meijer RW, Haasnoot K. Puberty stage and spontaneous descent of acquired undescended testis: Implications for therapy? Int. J. Androl. 2006; 29:597–602.
8. Bouty A, Ayers KL, Pask A, Heloury Y, Sinclair AH. The genetic and environmental factors underlying hypospadias. Sex Dev 2015;9:239–259
9. Duckett JW Jr . Hypospadias. Pediatr Rev 1989;11:37–42
10. Baskin LS. Hypospadias anatomy and embryology and reconstructive techniques. Braz J Urol. 2000;26:621–629.
11. Stein R. Hypospadias. J Euro Urol Suppl. 2012;11:33–45.
12. Erythropel HC, Maric M, Nicell JA, Leask RL, Yargeau V. Leaching of the plasticizer di(2-ethylhexyl)phthalate (DEHP) from plastic containers and the question of human exposure. Appl. Microbiol. Biotechnol. 2014;98 (24): 9967–9981. https://doi.org/10.1007/s00253-014-6183-8.
13. Zarean M, Keikha M, Feizi A, Kazemitabaee M, Kelishadi R. The role of exposure to phthalates in variations of anogenital distance: a systematic review and meta-analysis. Environ. Pollut. 2019;247: 172–179. https://doi.org/10.1016/j. envpol.2019.01.026.
14. Zhang J, Liu L, Wang X, Huang Q, Tian M, Shen H. Low-level environmental phthalate exposure associates with urine metabolome alteration in a Chinese Male Cohort. Environ. Sci. Technol. 2016; 50: 5953–5960.
15. Ribeiro C, Mendes V, Peleteiro B, Delgado I, Araújo J, Aggerbeck M, et al. Association between the exposure to phthalates and adiposity: a meta-analysis in children and adults. Environ. Res. 2019;179 (Pt A): 108780. https://doi.org/10.1016/j. envres.2019.108780.
16. Poon S, Koren G, Carnevale A, Aleksa K, Ling J, Ozsarfati J, et al. Association of in utero exposure to polybrominated diphenyl ethers with the risk of hypospadias. JAMA Pediatr 2018;172 (9): 851–856. https://doi.org/10.1001/ jamapediatrics.2018.1492, 1.
17. Koren G, Carnevale A, Ling J, Ozsarfati J, Kapur B, Bagli D. Fetal exposure to polybrominated diphenyl ethers and the risk of hypospadias: focus on the congeners involved. J Pediatr Urol 2019;15 (4): 405.e1–405.e6. https://doi.org/10.1016/j.jpurol.2019.05.023.
18. Sharpe RM, Irvine DS. How strong is the evidence of a link between environmental chemicals and adverse effects on human reproductive health? BMJ 2004;328 (7437):447–451. https://doi.org/10.1136/

bmj.328.7437.447, 21.

19. Fernandez MF, Olmos B, Granada A, Lopez-Espinosa MJ, Molina-Molina JM, Fernandez JM, et al. Human exposure to endocrine-disrupting chemicals and prenatal risk factors for cryptorchidism and hypospadias: a nested case-control study. Environ. Health Perspect 2007; 115 (Suppl. 1): 8–14. https://doi.org/10.1289/ehp.9351. Suppl 1.
20. Stewart MK, Mattiske DM, Pask AJ. In utero exposure to both high- and low dose diethylstilbestrol disrupts mouse genital tubercle development. Biol. Reprod 2018; 99 (6):1184–1193. https://doi.org/10.1093/biolre/ioy142.
21. Schreiber E, Garcia T, González N, Esplugas R, Sharma RP, Torrente M, et al. Maternal exposure to mixtures of dienestrol, linuron and flutamide. Part I: Feminization effects on male rat off spring. Food Chem Toxicol. 2020;139:111256. doi: 10.1016/j.fct.2020.111256.
22. Palmer JR, Herbst AL, Noller KL, Boggs DA, Troisi R, Titus-Ernstoff L, et al. Urogenital abnormalities in men exposed to diethylstilbestrol in utero: a cohort study. Environ Health. 2009;8:37. doi: 10.1186/1476-069X-8-37. PMID: 19689815; PMCID: PMC2739506.
23. Skakkebaek NE, Rajpert-De Meyts E, Buck Louis GM, Toppari J, Andersson AM, Eisenberg ML, et al. Male reproductive disorders and fertility trends: Influences of environment and genetic susceptibility. Physiol Rev. 2016; 96:55–97.
24. Gaspari L, Tessier B, Paris F, Bergougnoux A, Hamamah S, Sultan C, et al. Endocrine-disrupting chemicals and disorders of penile development in humans. Sex Dev 2021;15(1-3):213-228.
25. Wagner-Mahler K, Kurzenne JY, Delattre I, Bérard E, Mas JC, Bornebush L, et al. Prospective study on the prevalence and associated risk factors of cryptorchidism in 6246 newborn boys from Nice area, France. Int J Androl. 2011;34(5 Pt 2):e499-510. doi: 10.1111/j.1365-2605.2011.01211.x.
26. Bougnères P, Porcher R, Esterle L, Baker D, de La Vaissière A, Meurisse S, et al. Exploring the risk of hypospadias in children born from mothers living close to a vineyard. PLoS One. 2021;16(4):e0249800.
27. Li W, Chen Z, Xu W, Gao Y, Liu Z, Li Q, et al. Prevalence of congenital cryptorchidism in China: A nationwide population-based surveillance study, 2007-2021. Andrology 2025;13(3):577-586. doi: 10.1111/andr.13686.
28. Holmboe SA, Beck AL, Andersson AM, Main KM, Jørgensen N, Skakkebæk NE, et al. The epidemiology of cryptorchidism and potential risk factors, including endocrine disrupting chemicals. Front Endocrinol (Lausanne). 2024;15:1343887. doi: 10.3389/fendo.2024.1343887. PMID: 38633762; PMCID: PMC11021654.
29. Das D, Dutta HK, Borbora D, Brahma RC, Das JM. Assessing the relationship between hypospadias risk and parental occupational exposure to potential endocrine-disrupting chemicals. Occup Environ Med. 2023;80(2):93-96. doi: 10.1136/oemed-2022-108594. Epub 2022 Dec 26. PMID: 36572527.
30. Pierik FH, Burdorf A, Deddens JA, Juttmann RE, Weber RF. Maternal and paternal risk factors for cryptorchidism and hypospadias: a case-control study in newborn boys. Environ Health Perspect. 2004;112(15):1570-1576. doi: 10.1289/ehp.7243.
31. Nassar N, Abeywardana P, Barker A, Bower C. Parental occupational exposure to potential endocrine disrupting chemicals and risk of hypospadias in infants. Occup Environ Med. 2010;67(9):585-589.
32. Schnack TH, Zdravkovic S, Myrup C, Westergaard T, Christensen K, Wohlfahrt J, Melbye M. Familial aggregation of hypospadias: a cohort study. Am J Epidemiol 2008;167(3):251-256.
33. Van der Zanden LF, Van Rooij IA, Feitz WF, Franke B, Knoers NV, Roeleveld N. Aetiology of hypospadias: a systematic review of genes and environment. Hum Reprod Update 2012;18(3):260-283.
34. Mohammad zadeh A, Farhat A, Esmaieli H, Shiranzaei S. Prevalence and risk factors of hypospadias in a private hospital in northeast Iran. Iran J Pediatr 2011;21(4):497.
35. Carmichael SL, Shaw GM, Laurent C, Croughan MS, Olney RS, Lammer EJ. Maternal progestin intake and risk of hypospadias. Arch Pediatr Adolesc Med 2005;159(10):957-962.
36. Ye ZH, Chen HS, Zhang ZC, Wang X, Liu X, Wei GH. Parental smoking and risk of hypospadias: An updated meta-analysis of observational studies. Front Pediatr 2023;11:1003037.
37. Shekar BS, Avadhani R. Parental risk factors associated with hypospadias. Arch Med Health Sci 2013;1(1):15-18.
38. Akay MA, Yıldız GE. Impact of gestational and parental factors and maternal intake of progesterone on the development of hypospadias: A retrospective case–control study. Taiwan J Obstet Gynecol 2021;60(5):894-898.
39. McGlynn KA, Graubard BI, Klebanoff MA, Longnecker MP. Risk factors for cryptorchism among populations at differing risks of testicular cancer. Int J Epidemiol 2006; 35: 787-795.
40. Jones ME, Swerdlow AJ, Griffith M, Goldacre MJ. Prenatal risk factors for cryptorchidism: A record linkage study. Paediatr Perinatal Epidemiol 1998; 12: 383-396.
41. Toliczenko-Bernatowicz D, Matuszczak E, Komarowska M, Hermanowicz A, Dębek W. Epidemiology, pathophysiology, and pathogenesis of cryptorchidism. Evaluation and treatment of undescended testicle. Pediatria Polska - Polish Journal of Paediatrics. 2020;95(1):37-43. doi:10.5114/polp.2020.94927.