# STUDYING ENVIRONMENTAL RISK FACTORS AND LEVELS OF SOME HEAVY METALS AMONG A SAMPLE OF AUTISTIC CHILDREN IN EGYPT

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## ABSTRACT

**Background:** Autism is a developmental disability characterized by severe deficits in social interaction and communication. Although the exact cause of autism spectrum disorder (ASD) is still not known, it is believed that both genetic and environmental factors influence the onset and development of this disorder. **Aim of the study**: To assess the possible environmental risk factors and the levels of aluminum, mercury and lead in the hair of children with ASD. **Patients and methods:** A case control study was carried out. Thirty ASD children were studied in comparison to 30 age- and sex-matched controls. All participants were subjected to a questionnaire for data collection, clinical evaluation and hair sample for measurement of level of aluminum, mercury and lead which reflects past exposure.
**Results:** The mean age of the studied autistic children was 6.5±2.4year compared to 5.4±1.8 year in the controls with no significant difference (P>0.05), 76.7% of the cases were boys. Living near to traffic was found to be higher among cases than among controls with p <0.05 indicating high statistically significant difference. A short distance (> 500m) between the house and nearby traffic was another risk factor. Autistic children were found to play with wall paint more than the controls with high statistical difference between them. The use of aluminum cooking utensils and spoons was significantly higher among families of cases than controls. The mean level of aluminum was significantly higher in cases compared to the control (20.79±10.2, 7.85±1 respectively with P<0.0001). Mean level of mercury among cases was significantly higher than among controls (1.24±1.12,

0.22±0.147 respectively). Cases also had significantly higher levels of lead compared to controls but they were within the normal levels. **Conclusion**: Aluminum and Mercury were significantly higher in cases compared to controls.
**Key words:** aluminum, lead, mercury, autism, environmental risk factors.

## INTRODUCTION

Autism spectrum disorder (ASD) is a group of lifelong neurodevelopmental disorder characterized by impairments in social and communication skills as well as by a restricted, repetitive, stereotyped patterns of behavior (Who.int, 1993). Although the exact cause of ASD is still not known, it is believed that both genetic and environmental factors influence the onset and development of this disorder (Lai, Lombardo and Baron-Cohen, 2014; Tordjman *et al.*, 2014).

It is estimated that worldwide one in 160 children has an ASD. This estimate represents an average figure, and reported prevalence varies substantially across studies. The prevalence of ASD in many low- and middle-income countries is so far unknown (Who.int, 2019). The ASD prevalence in children has been reported to be as high as 2.6% (Kim *et al.*, 2011). The reported increase in prevalence appears partly attributable to greater public awareness, broadening ASD diagnostic criteria, lower age at diagnosis, and diagnostic substitution (Fombonne, 2008). The unexplained increase in ASD prevalence has raised considerable public concern, with a possible effect on some parents' health care decisions for their children.

Interaction between multiple genetic variants and epigenetic factors also increase the risk of having ASD (Tordjman *et al*., 2014).

The increase of ASDs prevalence cannot be fully explained by advances in diagnostics or sudden genetic shies. There is a growing consensus among scientists and clinicians that ASDs ensue from an interaction between biological vulnerability factors and environmental or iatrogenic insults (Aicardi *et al*, 2009). This points to the importance of environmental factors and raises the possibility of an etiological role for toxic exposures: either prenatal, postnatal, or in some cumulative pattern that combines the effect of maternal, gestational, and infant exposures (Adams *et al.*, 2007).

Exogenous exposures known or suspected to interfere with neurodevelopment may play a role in ASD etiology. Heavy metals such as lead and mercury have been relatively well studied in relation to impaired neurodevelopment (Grandjean *et al.*, 1997; Mendola *et al*., 2002). Aluminum causes oxidative stress within brain tissue, exacerbating the clinical presentation of autism by worsening of excitotoxicity and by microglial priming (Blaylock and Strunecka, 2009).

What is known about environmental agents does not account for many cases, but it is a source of information on the nature of autism. (Elsawy *et al.*, 2011)

The present study aimed at exploring possible associations between some known neurotoxic heavy metals and severity of autism among a sample of

Egyptian autistic children to uncover environmental causes of autism, especially in Egypt.

## SUBJECTS AND METHODS

This study is a case control study. The cases were 30 autistic children, who were selected from El Fayoum governorate. They were diagnosed by DSM-V and classified according Childhood Autism Rating Scale (CARS) with a mean age (6.5±2.4) years. Also 30 children were randomly selected from the same area as a control group. Both groups were comparable with regards to age and gender and socioeconomic status.

Duration of the study 6/2017 to 12/2018

**Questionnaire:** The questionnaire was directed for the mothers of all confirmed 30 cases with ASD and corresponding number of children free from ASD.

Interview questions covered:

- Personal history, area of residency
- Socio demographic data including parent's education
- Age of the parent
- Family income
- Mother's medical history
- Family History including: Family history for any similar conditions, any genetic diseases, psychological or mental disorders in the family etc.

**Methods for hair analysis:** Sample Preparation:

- Hair samples should be cut from the nape of the neck and cut with a stainless-steel implement into pieces about 2 Cm in length. Mix the sample to insure homogeneity. Wash the sample in a 500-ml polyethylene bottle containing 150 ml of 1% solution of (non-ionic detergent) by agitating on a mechanical mixer for 30 minutes at room temperature.
- Transfer the sample to polyethylene filter crucible and rinse with a total of one liter of deionized water. Dry overnight at 110C, weigh and transfer to a 50-ml Erlenmeyer flask. Dry weight should be about 0.5g. Add 6-ml of conc. HNO3 and allow to react at room temp. Warm the digest and add 1ml of HCLO4 and heat at 200c until dense white fumes are evolved. The solution should be water clear. Transfer to a s-ml volumetric flask and dilute to volume with deionized water.
- Another digestion by using top wave to instead of by wet digestion. Sample preparation: lead (pb) and other heavy metals.
- Cut segments of hair about 5 to 10 mm in length and weighing at least 10 mg. treat each segment separately. Weigh each segment and wash in deionized water (DI) on a mechanical shaker and then boil. Transfer the sample to a 100-ml Teflon beaker and digest with a 1:5 mixture of Hclo4: HNO3 until only a few drops of clear liquid remains. Dilute the sample 1:50 with (DI).

**Equipment:** Agilent 8800 ICP-QQQ (ICP-MS/MS analysis system will be used in Egypt for measuring: Lead, Mercury and Aluminum. It is similar to

and coping with international standards exactly the same as Micro Trace Metal Lab in Germany (Amin *et al.,* 2011; Giangrosso *et al.*, 2016).

**Statistical Analysis:** SPSS package program was used for statistical analysis. Cases and control subjects were compared by using the Student's T-test for numeric variables.

Descriptive statistics (mean and standard deviation) is used for summary of quantitative data. Nonparametric tests (Mann Whitney) test is used in non-normally distributed data.

## RESULTS

**Table (1):** Socio-demographic characteristic of the studied children

| Socio-demographic characteristics | Cases Mean± SD | Controls Mean± SD | Test of significance | P value |
|---|---|---|---|---|
| Age (years) Mean± SD | 6.5±24 | 5.4±1.8 | t=1.87 | 0.07 |
| Gender<br>Boys (No (%)<br>Girls (No (%) | <br>23 (76.7%)<br>7 (23.3%) | <br>23 (76.7%)<br>7 (23.3%) | $X^2=1$ | >0.05 |
| Age of mother at birth | 25.9±5.5 | 24.8±6.2 | t=0.78 | 0.43 |
| Age of father at birth | 33.6±5.4 | 32.5±8.8 | t=0.54 | 0.58 |
| Family income (Egyptian pounds) | ~2500 | ~2250 | t=0.599 | 0.552 |
| CARS (Mean± SD)<br>Boys<br>Girls | 38.68 ± 5.23<br>38.65±4.8<br>38.78±6.8 | ---------- | | |

Table (1) demonstrates the socio-demographic characteristics of the studied subjects. No significant differences were found between cases and controls in all studied aspects e.g. age, gender, CARS (Childhood Autism Rating Scale), parents' age or family income.

**Table (2):** Hair Level of Aluminum, Mercury and Lead among the studied children

| Hair level of some heavy metals | Cases | | Controls | | Test of significance | P value | Odds ratio |
|---|---|---|---|---|---|---|---|
| Mean Level of Aluminum(ppm) | 20.79±10.2 | | 7.85±1.6 | | 59.25 | 0.000 | ---------- |
| ≥8.0 ppm<br><8.0ppm | 28<br>2 | 93.3%<br>6.7% | 16<br>14 | 53.3%<br>46.7% | 12.27 | 0.001 | 12.25(2.46-60.91) |
| Mean Mercury level(ppm) | 1.24±1.12 | | 0.22±0.147 | | 4.940 | 0.00 | ---------- |
| Level of Mercury ≥0.30ppm<br><0.30 ppm | 24<br>6 | 80.0%<br>20.0% | 3<br>27 | 10.0%<br>90.0% | 29.69 | 0.000 | 36.0 (8.105-159.8) |
| Mean Lead Level (ppm)* | 1.88±1.35 | | 1.09±0.69 | | 2.26 | 0.012 | ---------- |
| Level of Lead ≥3.00ppm<br><3.00 ppm | 6<br>24 | 20.0%<br>80.0% | 1<br>29 | 3.3%<br>96.7% | 4.043 | 0.103 | 7.250 (0.815-64.45) |

*Normal level: Aluminium :<8.0ppm, Lead (Pb):<3.00ppm and Mercury (Hg):<0.30ppm,

Table (2) shows that levels of aluminum, mercury and lead were much higher among cases than among controls with high statistical significance difference between them ($p< 0.05$). Cases also had significantly higher levels of lead compared to controls although they are within the normal levels.

**Table (3):** Environmental Risk factors among the studied children

| Environmental Risk Factors | Cases N=30 | | Controls N=30 | | Test of significance | P value | Odds ratio |
|---|---|---|---|---|---|---|---|
| Home near by traffic | 20 | 66.7% | 7 | 23.3% | 11.38 | 0.002 | 6.57 (2.10-20.47) |
| Distance to the traffic<500 meter | 19 | 86.4% | 3 | 42.9 | 5.48 | 0.038 | 8.00 (1.15-55.26) |
| Near by factory | 1 | 3.4% | 1 | 3.4% | 0 | 1.000 | 1 (0.60-16.79) |
| Living near cultivated land using pesticide | 11 | 36.7% | 8 | 26.7% | .69 | 0.580 | 1.592 (0.531-4.77) |
| Living near garbage | 3 | 10.0% | 4 | 13.3% | 0.162 | 1.000 | 0.722 (0.147-3.545) |
| Storing pesticides inside safe place in house | 11 | 37.9% | 13 | 43.3% | 0.178 | 0.792 | 0.799 (.282-2.264) |
| Use of pesticides | 3 | 10.3% | 4 | 13.3% | 0.126 | 1.000 | 0.750 (0.153-3.687) |
| Wall paint:<br>Oil<br>Lime | 28<br>2 | 93.3%<br>6.7% | 24<br>6 | 80.0%<br>20.0% | 2.31 | .254 | 3.50 (0.645-18.98) |
| Wall paint is not good | 9 | 30.0% | 4 | 13.3% | 2.455 | 0.209 | 2.78 (0.751-10.331) |
| Child messing with wall paint | 9 | 30.0% | 2 | 6.7% | 5.455 | 0.04 | 6.00 (1.17-30.72) |
| Mother uses nail polish (yes/sometimes) | 5 | 16.7% | 1 | 3.3% | 2.96 | 0195 | 5.80 (0.63-5301) |
| Mother uses hair dye (yes/sometimes) | 8 | 27.6% | 5 | 16.7% | 1.023 | 0.360 | 1.91 (054-6.708) |
| Cooking utensils<br>Aluminum<br>Other | 26<br>4 | 86.7%<br>13.3% | 17<br>13 | 56.7%<br>43.3% | 6.65 | 0.020 | 7.971 (1.38-17.82) |
| Spoons made of<br>Aluminum<br>Other | 23<br>7 | 76.7%<br>23.3% | 12<br>18 | 40.0%<br>60.0% | 8.29 | 0.008 | 4.92(1.61-15.07) |
| Child uses same utensils as parents | 29 | 96.7% | 28 | 93.3% | 0.351 | 1.000 | 2.071(0.178-24.148) |

Table (3) shows that several environmental living conditions were found to exist among autistic cases. Living near traffic was found to be higher among cases than among controls with p <0.05 indicating high statistical significant difference. Also a short distance (> 500m) between the house and nearby traffic was another risk factor. Autistic children were found to play with house paint more than the controls with high statistical difference between them. Also the use of aluminum cooking utensils and spoons was significantly higher among families of cases than controls.

**Table (4):** Association between Risk factors and level of Aluminum in hair of Autistic children

| **Risk Factors** | **Aluminum Level in the hair of Autistic children** | | | | **P value** | **Odds ratio** |
|---|---|---|---|---|---|---|
| | ≥8.0ppm (n= 28) | | <8.0 ppm (n=2) | | | |
| Age<br>>=6<br><6 | 14 | 50% | 1 | 50.0% | 1.00 | 1.00(0.057-17.62) |
| Age of mother at birth >=30<br><30 | 9<br>19 | 32.1%<br>67.9% | 1<br>1 | 50.0%<br>50.0% | 1.00 | 0.47(0.027-8.46) |
| Age of father at birth >=35<br><35 | 18<br>10 | 64.3%<br>35.7% | 0<br>2 | .0%<br>100.0% | 0.152 | ---------- |
| Cooking utensils Aluminum | 27 | 96.4% | 1 | 50.0% | 0.131 | 27.0(0.89-821.79) |
| Spoon made of Aluminum | 23 | 82.1%% | 0 | 0.0% | 0.048 | ---------- |
| Child uses aluminum utensils as parents | 27 | 96.4% | 2 | 100% | 1.000 | ---------- |

Table (4) shows that using spoons made of aluminum was significantly higher among families of autistic children with increased levels of aluminum in their hair ($p<0.05$) than among autistic children but with normal aluminum levels.

**Table (5):** Risk factors among the studied children with level of Aluminum in their hair above normal ( ≥8.0ppm)

| **Risk Factors** | **Aluminum above the normal level≥8.0ppm** | | | | **P value** | **Odds ratio** |
|---|---|---|---|---|---|---|
| | Autistic children (n= 28) | | Control (n=16) | | | |
| Cooking utensils Aluminum | 27 | 96.4% | 9 | 56.3% | 0.002 | 21.0(2.26-194.7) |
| Spoon made of Aluminum | 23 | 82.1%% | 6 | 37.5% | 0.007 | 7.66(1.89-31.08) |
| Child uses aluminum utensils as parents | 27 | 96.4% | 15 | 93.8% | 1.000 | 1.8(0.10-30.89) |

Table (5) shows that the most important risk factors for increased level of aluminum in the hair in studied children were the use of cooking utensils and spoons made of aluminum with high statistically significant difference between cases and controls. The percentage of autistic children using aluminum spoons as their parents was also higher than the normal children using aluminum spoons. However, the difference was not significant.

**Table (6):** Association between Risk factors and level of mercury in hair of Autistic children

| Risk Factors | Mercury Level in Autistic children | | | | P value | Odds ratio |
|---|---|---|---|---|---|---|
| | ≥0.30ppm (n= 24) | | <0.30 ppm (n=6) | | | |
| Age:<br>>=6<br><6 | 13<br>11 | 54.2%<br>45.8% | 2<br>4 | 33.3%<br>66.7% | 0.651 | 2.36(0.36-15.45) |
| Age of mother at birth: >=30<br><30 | 9<br>15 | 37.5%<br>62.5% | 1<br>5 | 16.7%<br>83.3% | 0.633 | 3.0(0.30-29.9) |
| Age of father at birth: >=35<br><35 | 14<br>10 | 58.3%<br>41.7% | 4<br>2 | 66.7%<br>33.3% | 1.000 | 0.70(0.107-4.59) |
| Wall paint<br>Oil<br>Lime | 22<br>2 | 91.7%<br>8.3% | 6<br>0 | 100%<br>0% | 1.000 | ---------- |
| Wall paint is not good | 9 | 37.5% | 1 | 16.7% | 0.633 | 3.0 (0.30-29.9) |
| Child messing with wall paint | 8 | 33.3% | 1 | 16.7% | 0.637 | 2.5(0.248-25.15) |
| Child exposed to broken thermometer | 8 | 33.3% | 1 | 16.7% | 0.637 | 2.5(0.24-25.15) |
| Mother dental amalgum | 3 | 12.5% | 1 | 16.7% | 1.00 | 0.71(0.06-8.39) |

Table (6) shows that autistic children with high levels of mercury in hair were more exposed to broken thermometers than those with normal mercury levels. However, the difference between them was not statistically significant.

**Table (7):** Risk factors among the studied Autistic children regarding the level of Lead in their Hair

| Risk Factors | Lead Level in Autistic children | | | | P value | Odds ratio |
|---|---|---|---|---|---|---|
| | ≥3.0ppm (n= 6) | | <3.0ppm (n=24) | | | |
| Age: >=6<br><6 | 3<br>3 | 50.0%<br>50.0% | 12<br>12 | 50.0%<br>50.0% | 1.000 | 1.0(0.16-5.98) |
| Age of mother at birth >=30<br><30 | 2<br>4 | 33.3%<br>66.7% | 8<br>16 | 33.3%<br>66.7% | 1.000 | 1.0(0.15-6.67) |
| Age of father at birth >=35<br><35 | 3<br>3 | 50.0%<br>50.0% | 15<br>9 | 62.5%<br>37.5% | 0.66 | 0.60(0.09-3.63) |
| Home near traffic | 5 | 83.3% | 15 | 62.5% | 0.633 | 3.0 (0.30-29.9) |
| Distance to the traffic <500 meter (out of 20 child home near by traffic) | 5 | 100% | 12 | 80.0% | 0.539 | ---------- |
| House paint: Oil<br>Geer | 5<br>1 | 83.3%<br>16.7% | 23<br>1 | 95.8%<br>4.2% | 0.366 | 0.21(0.012-4.09) |
| Wall paint is not good | 4 | 66.7% | 6 | 25.0% | 0.14 | 6.0(0.86-41.4) |
| Child messing with wall paint | 3 | 50.0% | 6 | 25.0% | 0.329 | 3.0(0.47-19.0) |
| House floor made of dust | 3 | 50.0% | 1 | 4.2% | 0.018 | 23.0(1.77-298.4) |
| Tap water inside the house | 6 | 100% | 24 | 100% | --- | -------- |
| Mother uses nail polish (yes/sometimes) | 1 | 16.7% | 4 | 16.7% | 1.000 | 1.00(0.09-11.02) |
| Mother uses hair dye | 2 | 33.3% | 6 | 26.1% | 1.000 | 1.41(0.20-9.81) |
| Mother uses makeup | 2 | 33.3% | 6 | 26.1% | 1.000 | 1.41(0.20-9.81) |
| Mother puts kohl in child's eyes | 4 | 66.7% | 6 | 25.0% | 0.141 | 6.00(0.86-41.44) |

Table (7) shows that 50%autistic children with high hair lead levels were living in houses whose floors were made of dust. Only 4.2% of autistic

children with normal hair lead levels lived in such houses. Difference between both groups was highly statistically significant. High hair lead levels were also found in the majority of autistic children whose homes were near to traffic (83.3%) and the distance between their homes and traffic was less than 500 meters (100%). However the difference between them and those with normal lead levels was not statistically significant.

## DISCUSSION

Autism is a multifactorial neurodevelopmental disorder which is caused by genetic and environmental factors. Due to the increasing prevalence of autism over the last decades, many studies were done in order to identify etiologic and risk factors of autism. Although research examining the etiology of autism across the last 25 years has been dominated by a focus on genetic factors; however, there is an increasing awareness of the potential significance of environmental influences in the etiology of autism.

In this study, some environmental factors were studied as potential risk factors involved in the occurrence of autism. Investigated environmental risk factors included toxic exposures to some heavy metals namely aluminum, lead and mercury.

The current study included 30 autistic children; their ages ranged from 3 to 11 years with a mean of 6.5 years. Nearly 77% were males and 23% were females. Thirty normal children with matched socio-demographic

characteristics were taken as controls. Hair levels of aluminum, mercury and lead were measured for all studied children.

The comparison between the levels of these heavy metals in the hair of autistic children and the controls showed statistically significantly higher levels among cases than controls ($p<0.05$). While previous Egyptian studies agreed with these results (El Baz et al., 2015; El-Sheshtawy *et al*., 2011), other studies reported that there was no correlation between a higher levels of toxic metals and autism (Abdullah *et al*., 2012; Lenti *et al*., 2012). A recent meta-analysis examining the link between toxic metals and autism found that autism cases presented with higher levels of lead and mercury (Lam *et al.*, 2016).

The increased hair levels of toxic heavy metals in autistic cases may not be due to excessive exposure only, but may be caused by the inability to eliminate these metals from the body. Several studies have suggested that hair toxic metal concentrations may be related to poor excretion rate (Adams *et al*., 2009; Geier *et al*., 2008).

In the current study, the mean aluminum (Al) hair level in the autistic children was significantly higher than that in the controls. Al is a neurotoxic metal that is blamed to be a significant contributing factor to the rising prevalence of autism in the Western world (Tomljenovic and Shaw, 2011).

Exposure to Al through the use of cooking utensils made of aluminum was found in the great majority of autistic children (96.4%) and with high

significant difference than their controls. Also eating with aluminum spoons was another significant risk factor.

As for mercury, the mean mercury hair level in the autistic patients was significantly higher than that of the controls which was consistent with other studies assessing the increased mercury body toxicity in subjects diagnosed with autism (Geier *et al*., 2012; Al-Farsi *et al*., 2012).

Several risk factors associated with mercury toxicity were studied. It was found that autistic children with high mercury hair levels were more exposed to broken thermometers. However there was no evidence that maternal use of dental amalgam was associated with increased mercury levels. Contrary to our results, some studies showed that mercury levels increased in autistic patients as the maternal use of dental amalgam increased. (El-Sheshtawy *et al.*, 2011; Palkovicova *et al*., 2008).

Regarding Lead (Pb), the results of the current study indicated that although the mean lead hair levels of autistic children were within the normal levels, yet they were significantly higher than in the controls. El Baz *et al.*(2015) studied heavy metal concentrations in hair of preschool autistic children and found that hair lead concentration was significantly elevated. (EL-Baz *et al*., 2015). The most common lead exposure pathway for children are ingestion or inhalation of lead-bearing road dust, whether in the household or outdoor environment and its most common sources are fossil fuels, asphalt and paints (Arora *et al*., 2017; Curtin *et al*., 2018).

The current study showed a statistical increase in lead levels with a presence of nearby heavy traffic. This is in agreement with a study Naeher *et al.* (2004), that demonstrated that the lead levels of children living nearby gas stations were marginally higher than for children living away from gas stations (Naeher *et al*, 2004).

Researchers found that early-life exposure to air pollution may be a risk factor for autism. Children living 310 meters or less near a highway, and traffic-related pollution, were twice as likely to develop ASD (Volk *et al.*, 2011).

Similarly, our study found that families living in houses 500 meters or less near traffic or near factories had children with autism more than those living at a far distance from traffic-polluted areas. These findings emphasize the importance of limiting exposure to harmful airborne pollutants. Parents must care about where they choose to live to be far from environmental pollutions. Recreational and clinical facilities must be available wherever possible. Limitations of our study were the sample size. A larger sample size would be needed to improve the power of the study and validate the findings.

## CONCLUSION AND RECOMMENDATIONS

This study demonstrates several environmental risk factors which are significantly associated with autism. Detection of these factors can help parents avoid the danger of autism onset in their children.

Understanding of the causal role of environmental factors in the etiology of autism can potentially inform both primary prevention and evidence-based interventions.

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# دراسة عوامل الخطر البيئية ومستويات بعض المعادن الثقيلة في عينة من الأطفال المصابين بالتوحد في مصر

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## المستخلص

**الخلفية:** التوحد هو إعاقة فى النمو تتميز بعجز شديد فى التفاعل والتواصل الاجتماعى. على الرغم من أن السبب الحقيقى لمرض التوحد لا يزال غير معروف، إلا أنه يعتقد أن كلا من العوامل الوراثية والبيئية تؤثر على بداية هذا الاضطراب وتطوره. **هدف الدراسة:** تقييم عوامل الخطر البيئية المحتملة ومستويات الألومنيوم والزئبق والرصاص في شعر الأطفال الذين يعانون من التوحد.

**طريقة إجراء البحث:** تم إجراء الدراسة على ٣٠ طفل مصاب بالتوحد والمقارنة مع ٣٠ من العينة الضابطة من نفس العمر والنوع. تعرض جميع المشاركين إلى استبيان لجمع البيانات، وتقييم السريري وتحليل عينة الشعر لقياس مستوى الألومنيوم والزئبق والرصاص والذي يعكس التعرض السابق للتلوث.

**النتائج:** متوسط عمر الأطفال المصابين بالتوحد كان ٦,٥ ± ٢,٤ سنة مقارنة مع ٥,٤ ± ١,٨ سنة فى العينة الضابطة مع عدم وجود اختلاف إحصائى. وكان ٧٦,٧ ٪ من الأولاد المصابين من الذكور. كما وجد أن عدد كبير من المصابين بالتوحد كانوا يقيمون فى مناطق قريبة من الحركة المرورية الكثيفة مع وجود دلالة احصائية. كما أن المسافة بين السكن و حركة المرور كانت لا تزيد عن ٥٠٠ متر مما يشير إلى أن ذلك من عوامل الخطر. تم اكتشاف ان الأطفال المصابين بالتوحد كثيري اللعب بطلاء المنازل أكثر من أطفال العينة الضابطة مع وجود فرق إحصائى كبير بينهما. كما وجد أن استخدام أوانى الطهى والملاعق المصنوعة من الألومنيوم كانت أكثر بين الحالات المصابة عن الحالات الضابطة. أما عن مستوي الألومنيوم بالشعر فإنه كان أعلى بكثير فى الحالات مقارنة بالعينة الضابطة (٢٠,٧٩ ± ١٠,٢ ، ٧,٨٥ ± ١ على التوالى P<٠,٠٠٠١ ) أما عن متوسط مستوى الزئبق بين الحالات فكان أعلى بكثير عن مستواه فى العينة الضابطة (١,٢٤ ± ١,١٢ ، ٠,٢٢ ± ٠,١٤٧ على التوالى) كما كان مستوي الرصاص أعلى في الحالات مقارنةً بالعينة الضابطة ولكنه كان في حدود المستوى الطبيعي.

**الكلمات الدالة:** الومنيوم، رصاص، زئبق، التوحد، عوامل الخطر البيئية.