

# Alterations in neurodevelopment in children under 5 years of age in two states of the Mexican Republic

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## Abstract

There are more than 1 billion people with disabilities worldwide, with 16% of children having some type of neurodevelopmental disorder (ND). In Mexico, 6% of the population presented some disability; however, there is a lack of data on ND in children under 5 years of age. **Objective:** The objective of this study was to determine the prevalence of neurodevelopmental alterations in children under 5 years of age in urban, suburban, and rural populations from two states of Mexico. **Methods:** This was an observational and cross-sectional design study. We included 501 clinically healthy children from 0 to 60 months of age, from urban, suburban, and rural populations from the state of Querétaro (201) and from the State of Mexico (300). Neurodevelopmental alterations were detected through the electronic N-PED system, exploring areas of neurological development of language, psychomotor, and sensory (auditory and visual). The positive subjects were clinically assessed to confirm the diagnosis. **Results:** A 14.7% prevalence of ND was found, with a significant difference between Querétaro (8.9%) and the State of Mexico (18.7%). Language alterations were significantly different for both states (4.9% and 16% for Querétaro and the State of Mexico, respectively). **Conclusions:** The prevalence of ND and language alterations presented significant differences between the two evaluated states.

**Keywords:** Neurodevelopmental deviations. Language. Psychomotor. Sensory.

## Alteraciones del neurodesarrollo en niños menores de 5 años en dos estados de la República Mexicana

### Resumen

Hay más de mil millones de personas con discapacidad en todo el mundo, el 16% de los niños tiene algún tipo de trastorno del desarrollo neurológico (DN). En México, 6% de la población presenta alguna discapacidad; sin embargo, faltan datos en niños menores de 5 años. **Objetivo:** Determinar la prevalencia de alteraciones del neurodesarrollo en menores de 5 años, en poblaciones urbanas, suburbanas y rurales, de 2 estados de México. **Métodos:** Estudio observacional, de diseño

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*transversal. Se incluyeron 501 niños, clínicamente sanos, de 0 a 60 meses de edad, de poblaciones urbanas, suburbanas y rurales de Querétaro (201) y del Estado de México (300). Se detectaron alteraciones del neurodesarrollo a través del sistema electrónico N-PED, explorando áreas del lenguaje, psicomotor y sensorial (auditivo y visual). Los sujetos positivos fueron evaluados clínicamente para confirmar el diagnóstico. Resultados: Se encontró una prevalencia de trastornos del DN de 14.7%, con una diferencia significativa entre Querétaro (8.9%) y el Estado de México (18.7%). Las alteraciones del lenguaje fueron significativamente diferentes para ambos estados (4.9% y 16% para Querétaro y el Estado de México, respectivamente). Conclusiones: La prevalencia de trastornos del DN y del lenguaje, presentaron diferencias significativas entre los dos estados evaluados.*

**Palabras clave:** Desviaciones del neurodesarrollo. Lenguaje. Psicomotor. Sensorial.

## Introduction

According to the WHO and the World Bank, it is estimated that more than one billion people live with a disability in the world<sup>1</sup>. Of these, alterations in psychomotor neurodevelopment could constitute up to 16%<sup>2</sup>; these appear as alterations in gross and fine motor coordination, language, speech, consciousness, social interaction, and activities of daily life. Its etiology is linked to psychomotor retardation and age and is manifested by specific alterations in adaptation and learning skills<sup>3,4</sup>. The early identification of these alterations allows the application of rehabilitation therapies that improve the limitations<sup>5</sup>.

This present study made a comparison of the prevalence of neurodevelopmental disorders (ND) found in urban, suburban, and rural populations of the States of Querétaro and Mexico, using the N-PED system. This electronic screening device allows the detection of alterations in the psychomotor development of children under 5 years of age<sup>6</sup>. The equipment is portable, automated, and validated for the early detection of neurodevelopmental alterations. It evaluates areas of language, psychomotor, and sensory (visual and auditory). The lack of accreditation in any of the items, selected automatically by the software according to the age group, in any of the variables, results in the overall non-accreditation of the test. Each unapproved subject required a specialized clinical evaluation for their definitive diagnosis<sup>7,8</sup>. The NPED degrees of confidence and reproducibility were previously validated.

## Materials and Methods

The study design was observational and cross-sectional. This research project was carried out in two states of the Republic, Querétaro and the State of Mexico. In the first, a total of 201 children were studied, 67 children from an Urban community (Q1), 67 from a Suburban community (Q2), and 67 more from a Rural community

(Q3). In the second state, a total of 300 children were studied: 100 children from one Urban community (T1) and 200 children from two suburban communities (T2 and T3, 100 children each). All the children studied were between 0 and 60 months of age and in all cases, the studies were carried out in the presence of at least one parent. The N-PED system was applied before individual training and qualification by the specialists who developed the computerized instrument. The consistency of the evaluators' results was verified through an inter-trial evaluation that is not included in this work. For the application of the instrument, an informative talk was previously held with the parents of each of the children and in all cases, only those children where the parents agreed were accepted for their participation, after signing a letter of confirmation informed consent. The project was also approved by a Bioethics committee in each case, and scientific research should be conducted in accordance with the World Medical Association Code of Ethics (Helsinki Declaration) for experimentation involving human beings. The evaluations were carried out in children with no known pathological history, who attended the agreed appointments for the examination with the N-PED system and who did not manifest acute diseases that prevented or altered the results of the evaluation. The children included in the study were evaluated on their usual schedule for preschool activities. The N-PED system allowed the detection of neurodevelopmental alterations in the areas of language, psychomotor, and sensory (auditory and visual). This system considers the test as "not accredited" when the performance of the evaluated child is not performed according to what is established as the normal expected for any of the items<sup>6</sup>. Once the evaluation was completed, the individuals who did not accredit the test were submitted to a clinical and electrophysiological assessment of the abnormalities detected, where the diagnosis was confirmed. Subsequently, a medical report was delivered and it was referred to the health services of each state for treatment. It is worth

mentioning that all the children were evaluated with the tests considered as the gold standard for the detection of language, psychomotor, and sensory disorders. Subsequently, the data obtained through the N-PED system was emptied, with the purpose of its subsequent analysis. Descriptive statistics were performed, establishing the prevalence of ND in the urban population. Subsequently, the Chi-square test and Fischer's exact test were used to determine the existence of significant statistical differences ( $p < 0.05$ ).

## Results

The analysis of the results corresponds to a global population of 501 children under 5 years of age, 201 for the State of Querétaro and 300 for the State of Mexico. In the state of Querétaro, three communities with 67 children each group were analyzed: urban (Q1), Suburban (Q2), and Rural (Q3). For the State of Mexico, three communities with 100 children each group were also included: urban (T1) and two Suburban communities (T2 and T3). The study included 105 children 0-12 months of age; 89 children from 13 to 24 months; 79 children from 25 to 36 months; 73 children from 37 to 48 months; and, finally, 155 children from 49 to 60 months of age (Table 1). Of the total sample evaluated, 85.23% of the children were classified as having normal neurodevelopmental by the neurodiagnostic test. A total of 74 children, corresponding to 14.77% of the cases, showed problems in their neurodevelopment, language alteration was the most frequent globally with 11.57%, psychomotor alterations were presented in 4.79% and sensory alterations were 3.98%, with auditory alterations in 2.59% and visual alterations in 1.39% (Table 2).

Next, an analysis of the neurodevelopmental alterations was carried out, comparing the results of the two states. For the State of Querétaro, a global failure of 8.95% was found, showing a significant difference to that found in the State of Mexico, which was 18.7%. The analysis of the prevalence of language disorders also showed a significant difference between the two states, with a prevalence of 4.97% for Querétaro and 16% for the State of Mexico. The alterations in the psychomotor area did not show significant differences, with 3.48% for Querétaro and 5.7% for the State of Mexico.

Finally, in the analysis of sensory alterations, there were no significant differences between Querétaro and Estado de México, with auditory alterations 1.49% and

3.3% and visual alterations of 1.99% and 1%, respectively (Table 3).

Subsequently, a comparison was made between the communities of both states, finding statistically significant differences in the presence of global failure between the community T3 (23%) with the communities (10.45%), Q2 (5.97%), and Q3 (10.45%). When the language failures results were analyzed, significant differences were found between the Q2 community, that did not present any cases, and the Q3 (8.95%), T1 (13%), T2 (13%), and T3 (22%) communities. A significant difference was also found in language alterations between the Q3 community (8.95%) and the T3 community (22%). The results of the evaluations in the psychomotor and visual sensory area did not show significant differences between the studied communities. Finally, the auditory sensory evaluation registered significant differences between the T1 community (8%) and the T2 (1%) and T3 (1%) communities, all from the state of Mexico (Table 4).

## Discussion

The present work tries to emphasize the need for the early diagnosis of ND in children under 5 years of age, which are prevalent in populations from different socio-cultural strata. The performance of the normal healthy children examined for a second time was 88.6% compared to their first evaluation ( $p < 0.0001$ ; Kendalls tau  $b = 0.72$ ,  $c = 0.57$ ); (F. Guadarrama, E. Santos, D. Aguirre, unpublished data). In a previous work, NPED was tested in a neighborhood of the City of Habana, Cuba, against the results studies of specialized clinical and neurophysiological cases, it is considered to be the gold standard, and at the time, the sensitivity and specificity of the NPED instrument were determined to be, respectively, 95% and 86%<sup>9</sup>.

It is estimated that approximately 16-18% of children could present some type of normal neurodevelopmental deviations due to sensory deficits (auditory or visual), delays in psychomotor development, and language and/or communication disorders<sup>10-12</sup>. Early detection and intervention can lessen unfavorable consequences and may allow children to achieve optimal development of their abilities. For this reason, it is very important to identify children who may present deviations in normal neurological development, with the use of an easy-to-apply tool. National health systems in any country could benefit from early detection tools that can be applied quickly and easily, without requiring highly specialized personnel.

**Table 1.** Distribution of children by age and by community

Age (months)	Community Q-1	Community Q-2	Community Q-3	Community T-1	Community T-2	Community T-3	Total
0-12	12	8	9	41	19	16	105
13-24	14	19	10	15	21	10	89
25-36	14	1	7	20	25	12	79
37-48	8	3	9	8	25	20	73
49-60	19	36	32	16	10	42	155
Total	67	67	67	100	100	100	501

Q1: Queretaro urban community, Q2: Queretaro suburban community, Q3: Queretaro rural community, T1: urban community State of Mexico, T2: suburban community State of Mexico, T3: suburban community state of Mexico.

**Table 2.** Number of cases and percentage of failure by areas

Areas	N	%
Global failure	74	14.77
Language	58	11.57
Psychomotor	24	4.79
Vision	7	1.39
Auditory	13	2.59

The alteration in the language area was the most frequent neurodevelopmental alteration found in the study. N: number of cases, %: percentage.

**Table 3.** Percentage of failures by state

Areas	Q-% (201)	T% (300)	p (Chi-square)	p (Fisher)
Global failure	8.95	18.7	0.0026	0.0028
Language	4.97	16	0.0001	<0.0001
Psychomotor	3.48	5.7	0.1576	0.2046
Vision	1.99	1	0.4817	0.7045
Auditory	1.49	3.3	0.1365	0.1639

The analysis of the results showed significant differences in global failure and in the language area for both states. Q. Querétaro: 210 children. T. State of Mexico: 300 children.

State of Mexico, it was 18.7%, prevalences that are within the published ranges for these alterations<sup>2,13-15</sup>. A study carried out in Turkey reported a prevalence of ND of 18.9%, using the Denver II test<sup>16</sup>.

The experience of the health team, the age of the child, the population characteristics, as well as the socioeconomic level, rurality, participation in stimulation programs, and preschool education, are factors that frequently influence this variability<sup>17,18</sup>. Variability in prevalences can also be found in industrialized countries; however, similar to what occurs in developing countries, language impairments are the most prevalent impairment<sup>19</sup>. Thus, a prevalence of language disorders of around 5% has been reported in children 2-4 years of age<sup>20</sup>. In the present study, a higher prevalence of alterations in language was found, followed by alterations in psychomotor development and in the sensory sphere. The need for a standardized and validated screening tool for alterations in normal psychomotor development is clear worldwide and its characteristics and performance must pass the scrutiny of the medical community<sup>21,22</sup>.

The first 5 years of life constitute a period of great neuronal plasticity, in which important changes in the central nervous system and the development of sensory systems take place. As a result of this maturation process, children at birth quickly acquire skills that turn out to be crucial for their development: body movements and locomotion are perfected, language appears and evolves, as a consequence of all this, the child not only learns but also who communicates and interacts with other people. At the same time, intelligence and thinking develop<sup>23,24</sup>. It has been shown that in the absence of a screening procedure, the detection of normal neurodevelopmental deviations only

The main objective of this work was to evaluate if the prevalence of ND differs between urban, suburban, and rural communities of two states of the Mexican Republic. The results obtained for the state of Querétaro confirmed a global prevalence of 8.95%, while for the

**Table 4.** Percentage failures by community

Areas	Community Q-1	Community Q-2	Community Q-3	Community T-1	Community T-2	Community T-3
Global failure	10.45 (7)	5.97 (4)	10.45 (7)	18 (18)	15 (15)	23 (23) (** vs. Q2; * vs. Q3)
Language	5.97 (4)	0	8.95 (6) (* vs. Q2)	13 (13)	13 (13) (** vs. Q2)	23 (23) (***) vs. Q2; * vs. Q3)
Psychomotor	4.47 (3)	2.98 (2)	2.98 (2)	8 (8)	2 (2)	7 (7)
Vision	2.98 (2)	2.98 (2)	0	1 (1)	1 (1)	1 (1)
Auditory	2.98 (2)	1.49 (1)	0	8 (8)	1 (1) (* vs. T1)	1 (1) (* vs. T1)

Data analysis showed significant differences in global failure, language and auditory sensory disturbances. The psychomotor and visual sensory area did not show significant differences. Fisher's exact test: \* $p < 0.05$ ; \*\* $p < 0.01$ , and \*\*\* $p < 0.001$ .

happens very late in life and is therefore considerably reduced the effectiveness of any form of intervention approach<sup>25</sup>.

In the present study, the results obtained after the application of the automated and computerized NPED instrument are presented in two states of the Mexican Republic, the global failure percentage of the entire sample was 14.77%. Coinciding with previous publications in similar populations<sup>26-28</sup>. Global failures found in the language were 11.57% of the cases. In a comprehensive review of the literature, Law et al. found a 12-16% prevalence of speech and language delays<sup>29</sup>. Another study, conducted in Meriden, New Haven, Connecticut by Horwitz et al., estimated the prevalence of language disorders of 13.5% in children 18-23 months of age, 15% in children 24-29 months of age, and 18% in 30-39 months of age<sup>30</sup>. The failures in psychomotor development reported here were 4.79%, while other authors, with a study carried out in the United Arab Emirates by applying the Denver Development Test, in a representative random sample of 694 3-year-old children, found that 8.4% had a delay in global development<sup>31</sup>. Furthermore, through clinical diagnostic interviews, the prevalence of clinically significant developmental disability was estimated at 2.44%. Another study, which carried out an examination of psychomotor development problems in the first level of care carried out in Argentina<sup>32</sup>, found that in 839 children, apparently healthy and under 6 years of age, who attended the healthy child clinic of three health centers, a prevalence of 15-23% of development problems for each health center. In this study, hearing failures represented 2.59% of the total sample, a level much higher than that reported by Prieve et al., from 0.1% to 0.3%; in addition, 1.39% of vision failures were found, in all cases due to refractive defects<sup>33</sup>. A recent study,

carried out in the Dominican Republic, reported a much lower prevalence of ND, of only 2.7%<sup>34</sup>.

The results obtained in this research allow us to reflect on the tools available for the detection of neurodevelopmental abnormalities at the primary level of care as well as to become aware of the important window of opportunity that we have to make an early presumptive diagnosis. The N-PED system used in our study is a valuable tool for screening and detecting ND in children under 5 years of age. This acquires greater relevance if one takes into account that in our country the lag in early detection of ND is notable; therefore, the task of analyzing our role, scope, and perspectives cannot be postponed, to contribute significantly to the reduction of preventable morbidity from this type of alterations through timely diagnosis and treatment.

## Conclusions

The global prevalence of ND in children from 0 to 60 months of age from two states of Mexico was similar to that reported in similar populations both nationally and internationally. Language disorders were the area of neurodevelopmental that was most frequently affected.

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## Conflicts of interest

The authors declare that they have no conflicts of interest.

## Ethical disclosures

**Protection of human and animal subjects.** The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

**Confidentiality of data.** The authors declare that they have followed the protocols of their work center on the publication of patient data.

**Right to privacy and informed consent.** The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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