Thimerosal-containing vaccines and neurodevelopmental outcomes
Review of the evidence

Thimerosal is an ethylmercury-containing compound that was used for decades in the United States as a preservative in multi-dose vials of vaccines and other products to prevent growth of harmful microbes such as bacteria and fungi. Under the FDA Modernization Act of 1997, the FDA conducted a comprehensive review of the use of thimerosal in childhood vaccines. This review found no evidence of harm from the use of thimerosal as a vaccine preservative, other than local hypersensitivity reactions (Thimerosal and Vaccines | FDA).

In 1999, with input from the Public Health Service and other partners, FDA requested all vaccine manufacturers for plans to remove thimerosal from vaccines. This was taken as a precautionary step, not due to evidence of harm, to reduce an infant's overall exposure to mercury, given that other environmental sources of mercury were challenging to eliminate.

Since 2001, all childhood vaccines licensed and recommended in the United States have been thimerosal-free, with the exception of some multi-dose formulations of influenza vaccines. Several vaccines used in the United States (e.g., MMR, varicella, inactivated polio, pneumococcal conjugate) have never contained thimerosal.

During the 2024-2025 season, 96% of all influenza vaccines in the United States were thimerosal-free, and 98% of federal vaccines procured through the Vaccines for Children or 317 program were thimerosal-free (source: CDC's Immunization Services Division). A recent analysis from CDC's Vaccine Safety Datalink showed that the proportion of pregnant women receiving a thimerosal-containing flu vaccine has decreased over time, with only 0.3% of doses administered in 2024 containing thimerosal (see *Figure*).

Over the past 25 years, multiple well-designed studies using various epidemiological study designs have been conducted in several countries evaluating a potential association between thimerosal exposure and autism spectrum disorder (ASD), other neurodevelopmental disorders, and cognitive functioning. Data from CDC's Vaccine Safety Datalink (VSD) showed that there was no increased risk of ASD from prenatal or early-life exposure to thimerosal (Price et al., 2010), or from increasing number of antigens from vaccines up to 7, 12, and 24 months (Iqbal et al., 2013). Similarly, in a nationwide cohort study of all children born in Denmark from 1990-1996 (n=467,450), risk of autism and other autistic-spectrum disorders did not differ between children vaccinated with thimerosal-containing vaccines and those with thimerosal-free vaccines (RR: 0.85, 95% CI 0.60,1.20). Some studies that evaluated performance on over 24 different tests of neurodevelopment did show a few significant associations between cumulative thimerosal exposure and on some tests of specific neurodevelopmental functions; however, these were few and not seen consistently across similar tests or across studies (Thompson et al., 2007; Tozzi et al, 2009; Verstraeten et al., 2003; Heron et al., 2004; Andrews et al., 2004). Meta-analyses suggest no relationship between thimerosal and autism or mercury and autism (Taylor et al., 2014; Yoshimasu et al., 2014). Furthermore, the Institute of Medicine (now known as the National Academies of Sciences, Engineering, and Medicine) examined

evidence evaluating the possible association between thimerosal-containing vaccines and autism in 2004, concluding that studies "consistently provided evidence of no association between thimerosal-containing vaccines and autism" (Immunization Safety Review: Vaccines and Autism | The National Academies Press).

Several non-CDC studies evaluating data from the VSD and the Vaccine Adverse Event Reporting System (VAERS) identified an increased risk of autism and neurodevelopmental disorders with thimerosal-containing vaccines. These studies have significant methodological limitations including unmeasured confounding, inaccurate assessment of exposures, differences in control and case groups, unverified diagnoses, and other potential biases that threaten the validity and reliability of the findings.

Considering the breadth of evidence and consistency in results from multiple population-based studies conducted in several countries with various study designs, the evidence does not support an association between thimerosal-containing vaccines and autism spectrum disorder or other neurodevelopmental disorders.

Summary of studies

No association between prenatal exposure to thimerosal-containing vaccinations and autism spectrum disorder in children

- Ludvigsson, J. F., Winell, H., Sandin, S., Cnattingius, S., Stephansson, O., & Pasternak, B. (2020). Maternal Influenza A(H1N1) Immunization During Pregnancy and Risk for Autism Spectrum Disorder in Offspring : A Cohort Study. *Ann Intern Med*, *173*(8), 597-604. https://doi.org/10.7326/m20-0167
    - Prenatal exposure to the Pandemrix H1N1 vaccine, a thimerosal-containing vaccine, was not associated with diagnosis of ASD among a prospective cohort of live births between October 2009-September 2010 at seven healthcare regions in Sweden (n=39,726 exposed, n=29,293 unexposed). Results were similar when restricting to only those with vaccination in the first trimester (aOR: 0.92, 95%CI: 0.74-1.16).
- Hviid A, Svanström H, Mølgaard-Nielsen D, Lambach P. Association Between Pandemic Influenza A(H1N1) Vaccination in Pregnancy and Early Childhood Morbidity in Offspring. *JAMA Pediatr.* 2017;171(3):239–248. doi:10.1001/jamapediatrics.2016.4023
    - In a large matched cohort study with all children born in Demark from singleton pregnancies during November 2009—March, 2010, children who had been exposed prenatally to a thimerosal-containing monovalent inactivated AS03-adjuvanted split viron influenza A (H1N1)pdm09 vaccine (Pandemrix) were not more likely to experience early childhood morbidity, including diagnoses of autistic disorders, compared to children not exposed to the prenatal vaccination.

- Price, C. S., Thompson, W. W., Goodson, B., Weintraub, E. S., Croen, L. A., Hinrichsen, V. L., Marcy, M., Robertson, A., Eriksen, E., Lewis, E., Bernal, P., Shay, D., Davis, R. L., & DeStefano, F. (2010). Prenatal and infant exposure to thimerosal from vaccines and immunoglobulins and risk of autism. Pediatrics, 126(4), 656-664. https://doi.org/10.1542/peds.2010-0309

    - This is a case-control study from VSD in which children ages 6-13 from 3 managed care organizations with a diagnosis of autism were evaluated for mercurcy exposure from vaccinations since birth. The adjusted odds ratios (95% confidence intervals) for ASD associated with a 2-SD increase in ethylmercury exposure were 1.12 (0.83–1.51) for prenatal exposure, 0.88 (0.62–1.26) for exposure from birth to 1 month, 0.60 (0.36–0.99) for exposure from birth to 7 months, and 0.60 (0.32–0.97) for exposure from birth to 20 months. No increased risk of ASD was observed from prenatal and early-life exposure to ethylmercury.

- Thompson, W. W., Price, C., Goodson, B., Shay, D. K., Benson, P., Hinrichsen, V. L., Lewis, E., Eriksen, E., Ray, P., Marcy, S. M., Dunn, J., Jackson, L. A., Lieu, T. A., Black, S., Stewart, G., Weintraub, E. S., Davis, R. L., & DeStefano, F. (2007). Early thimerosal exposure and neuropsychological outcomes at 7 to 10 years. *N Engl J Med*, *357*(13), 1281-1292. https://doi.org/10.1056/NEJMoa071434

    - Cohort study from VSD network of 1,047 children aged 7-10 years that assessed the association between neuropsychological performance and exposure to mercury during the prenatal and neonatal periods and the first 7 months of life. Results did not support a causal association between early exposure to mercury from thimerosal-containing vaccines and immune globulins and deficits in neuropsychological functioning at age 7 to 10 years.

- Van der Maas, N., Dijs-Elsinga J., Kemmeren J., van Lier A., Knol M., de Melker, H. Safety of vaccination against influenza A (H1N1) during pregnancy in the Netherlands: results on pregnancy outcomes and infant's health: cross-sectional linkage study. *BJOG* 2016; 123:709-717.

    - Among 1,920 pregnant women who completed questionnaires linked with the Netherlands Perinatal Registry, growth, developmental scores, and infection-related healthcare visits did not differ between infants of pregnant women vaccinated in the 2nd or 3rd trimester with thimerosal-containing H1N1 vaccines and infants of unvaccinated women.

Thimerosal exposure in pediatric vaccines and neurodevelopmental disorders, including autism spectrum disorder

- Andrews, N., Miller, E., Grant, A., Stowe, J., Osborne, V., & Taylor, B. (2004). Thimerosal exposure in infants and developmental disorders: a retrospective cohort study in the United kingdom does not support a causal association. Pediatrics, 114(3), 584-591. https://doi.org/10.1542/peds.2003-1177-L

- This retrospective cohort study conducted in the UK included 109,863 children born during 1988-1997 and evaluated number of DTP (diptheria-tetanus-pertussis) and DT (diptheria-tetanus) vaccinations received by 3 and 4 months of age, cumulative thimerosal exposure by 6 months and any associations between general developmental disorders, language or speech delays, tics, attention deficit disorder, autism, or behavior problems. No evidence of an association was found between autism and thimerosal exposure. There was some evidence of increasing risk of tics with increasing doses of thimerosal (Cox's HR: 1.50 per dose at 4 months, 95% CI: 1.02-2.2). There was an inability to adjust for confounding factors.

- DeStefano, F., Price, C. S., & Weintraub, E. S. (2013). Increasing Exposure to Antibody-Stimulating Proteins and Polysaccharides in Vaccines Is Not Associated with Risk of Autism. *The Journal of Pediatrics*, *163*(2), 561-567. https://doi.org/https://doi.org/10.1016/j.jpeds.2013.02.001

  - A case-control study of 256 children with ASD and 752 control children conducted in the United States found that increasing exposure to antibody-stimulating proteins and polysaccharides in vaccines, including thimerosal-containing vaccines, during the first 2 years of life was not related to the risk of developing ASD. There was no association between exposure to antigens from vaccines and developing ASD with regression.

- Heron, J., Golding, J., & and the, A. S. T. (2004). Thimerosal Exposure in Infants and Developmental Disorders: A Prospective Cohort Study in the United Kingdom Does Not Support a Causal Association. Pediatrics, 114(3), 577-583. https://doi.org/10.1542/peds.2003-1176-L

  - In this prospective cohort study of 12,810 children born during 1990-1991 in the UK, neurodevelopmental outcomes at 7.5 years were examined. No association between thimerosal exposure and conduct behavior, fine motor development, and tics were identified. Only poor prosocial behavior at 47 months was associated with thimerosal exposure at 3 months (OR: 1.21,95%CI: 1.01-1.23). Reports of neurodevelopment were parent-reported and not validated against medical records.

- Hviid, A., Stellfeld, M., Wohlfahrt, J., & Melbye, M. (2003). Association between thimerosal-containing vaccine and autism. JAMA, 290(13), 1763-1766. https://doi.org/10.1001/jama.290.13.1763

  - In this Danish nationwide cohort study of all children born in Denmark during 1990-1996 (n=467,450), risk of autism and other autistic-spectrum disorders did not differ between children vaccinated with thimerosal-containing vaccines and those with thimerosal-free vaccines (RR: 0.85, 95% CI: 0.60-1.20).

- Iqbal, S., Barile, J. P., Thompson, W. W., & DeStefano, F. (2013). Number of antigens in early childhood vaccines and neuropsychological outcomes at age 7–10 years. Pharmacoepidemiology and Drug Safety, 22(12), 1263-1270. https://doi.org/https://doi.org/10.1002/pds.3482

- This study used the same population as Thompson et al, 2007 from the VSD (n=1107). There was no association between any neuropsychological-domain specific outcomes and increase in number of antigens (per 1000) from vaccines, including thimerosal-containing vaccines, up to 7, 12, and 24 months. Neuropsychological domains included general intellectual function, speech and language, verbal memory, fine motor coordination, attention, executive function, and behavior regulation.

- Mrozek-Budzyn, D., Majewska, R., & Kiełtyka, A. (2015). Early exposure to thimerosal-containing vaccines and children's cognitive development. A 9-year prospective birth cohort study in Poland. Eur J Pediatr, 174(3), 383-391. https://doi.org/10.1007/s00431-014-2412-5

    - This prospective cohort study was conducted in Poland. A total of 318 children were enrolled during 2000-2003 at birth and followed to the 9th year of life. Similar outcomes on all cognitive developmental tests was observed for children exposed and not exposed to thimerosal-containing vaccines (hepatitis B and DTP). Tests included Fagan test at 6 months, Baley Scales of Infant Development-II (BSID-II) at 12 and 36 months, Raven test at 5 years and 8 years, and Wechsler Inteilligence Scale for Children (WISC-R) at 6, 7, and 9 years. Results of BSID II at 36 months and WISC-R at the 9th year were higher among those exposed to thimerosal-containing vaccines, suggesting beneficial effects of thimerosal-containing vaccines on children's development.

- Parker, S., Todd, J., Schwartz, B., & Pickering, L. (2005). Thimerosal-containing vaccines and autistic spectrum disorder: a critical review of published original data. Pediatrics, 115(1), 200. https://doi.org/10.1542/peds.2004-2402

    - This was a review of 12 studies from articles published from 1996-2004. 10 epidemiological studies, 2 pharmacokinetic studies; design and quality of studies showed significant variation. The authors concluded that the epidemiological evidence does not support association between thimerosal-containing vaccines and ASD. The authors also conclude that epidemiological studies supporting an association are of poor quality. Pharmacokinetic studies suggest that an association is unlikely. There were 4 studies that suggested an association but had overlapping datasets and contained critical methodologic flaws that rendered the data and interpretation noncontribuatory.

- Smith, M. J., & Woods, C. R. (2010). On-time Vaccine Receipt in the First Year Does Not Adversely Affect Neuropsychological Outcomes. *Pediatrics*, *125*(6), 1134-1141. https://doi.org/10.1542/peds.2009-2489

    - A study using data from the Vaccine Safety Datalink compared neuropsychological outcomes at 7-10 years among children (n=1047) who completed vaccinations, including with thimerosal-containing vaccines, in the first year of life compared with those who did not receive all immunizations scheduled in the first year of life. There were no significant differences in neuropsychological outcomes among those who

received vaccinations on time and those that did not. Limitations of this study is that there were limited number of children who were fully unvaccinated in the first year of life.

- Taylor, L. E., Swerdfeger, A. L., & Eslick, G. D. (2014). Vaccines are not associated with autism: an evidence-based meta-analysis of case-control and cohort studies. Vaccine, 32(29), 3623-3629. https://doi.org/10.1016/j.vaccine.2014.04.085
    - In a meta-analysis of cohort-studies and case-control studies, no relationship between vaccination and ASD was observed (OR: 0.91, 95% CI: 0.68-1.20, 7 studies). There was no relationship between MMR vaccine and autism (OR: 0.84, 95% CI: 0.70-1.01, 3 studies), thimerosal and autism (OR: 1.00, 95% CI: 0.77-1.31, 2 studies), or mercurcy and autism (OR: 1.00, 95%CI: 0.93-1.07, 2 studies).
- Thompson, W. W., Price, C., Goodson, B., Shay, D. K., Benson, P., Hinrichsen, V. L., Lewis, E., Eriksen, E., Ray, P., Marcy, S. M., Dunn, J., Jackson, L. A., Lieu, T. A., Black, S., Stewart, G., Weintraub, E. S., Davis, R. L., & DeStefano, F. (2007). Early thimerosal exposure and neuropsychological outcomes at 7 to 10 years. *N Engl J Med*, *357*(13), 1281-1292. https://doi.org/10.1056/NEJMoa071434
    - This cohort study from the VSD assessed the association between exposure to mercury prenatally, during the neonatal period, and the first 7 months of life and neuropsychological performance at ages 7-10 years. Results did not support a causal association between early exposure to mercury from thimerosal-containing vaccines and immune globulins and deficits in neuropsychological functioning at age 7 to 10 years.
- Tozzi, A. E., Bisiacchi, P., Tarantino, V., De Mei, B., D'Elia, L., Chiarotti, F., & Salmaso, S. (2009). Neuropsychological Performance 10 Years After Immunization in Infancy With Thimerosal-Containing Vaccines. Pediatrics, 123(2), 475-482. https://doi.org/10.1542/peds.2008-0795.
    - This cohort study, conducted in Italy, evaluated neuropsychological outcomes among 10 year old children who received thimerosal-containing vaccines during 1992-1993. Among 24 neuropsychological outcomes evaluated, two were associated with thimerosal exposure in girls only. Girls with higher thimerosal exposure had lower scores on a finger-tapping test (fine motor skills) and the Boston Naming Test (language skills). Differences in the scores were small and thought to be of doubtful clinical relevance. There was no difference in results observed for other language tests. At the 5% statistical significance level, 4 significant associations would be expected out of 72 statistical tests. Given that less than 4 significant associations were identified, authors concluded that results might be attributable to chance, especially because they were not consistent with results of other studies.
- Uno, Y., Uchiyama, T., Kurosawa, M., Aleksic, B., & Ozaki, N. (2015). Early exposure to the combined measles-mumps-rubella vaccine and thimerosal-containing vaccines and risk of

autism spectrum disorder. *Vaccine*, *33*(21), 2511-2516. https://doi.org/10.1016/j.vaccine.2014.12.036

  - In a case control-study conducted in Japan with 189 cases and 224 controls, there was no significant differences in MMR vaccination and thimerosal dosage (from thimerosal-containing vaccines) between cases and controls at any age. The OR of MMR vaccination and thimerosal dosage associated with ASD were 0.88 (95% CI: 0.35-2.22) and 1.21 (95% CI: 0.86-1.68) at age 18 months, 0.72 (95% CI: 0.42-1.24) and 1.3 (95% CI: 1.0-1.8) at 24 months and 1.04 (95% CI: 0.65-1.67) and 0.84 (95% CI: 0.63-1.12) at 36 months.

- Verstraeten, T., Davis, R. L., DeStefano, F., Lieu, T. A., Rhodes, P. H., Black, S. B., Shinefield, H., & Chen, R. T. (2003). Safety of thimerosal-containing vaccines: a two-phased study of computerized health maintenance organization databases. Pediatrics, 112(5), 1039-1048.
  - This was a retrospective cohort of children in the Vaccine Safety Datalink. In Phase 1, there were 124,170 infants born during 1992-1999 at 2 health maintainence organizations (HMO). In phase 2, there were 16,717 children born during 1991-1997 at one HMO. In Phase 1 of the evaluation, each 12.5 ug increase in cumulative thimerosal exposure at 3 months (but not at 7 months) waswas positively associated with tics (RR: 1.89, 95%CI: 1.05-3.38) at HMO A, but not in HMO B. Each 12.5 ug increase in thimerosal at 3 months (RR: 1.13, 95%CI: 1.01-1.27) and at 7 months (RR: 1.07, 95%CI: 1.01-1.13) was associated with increased risk of language delay at HMO B but not HMO A. In Phase 2, at a third HMO, no significant associations were found. There was no increased risk of autism in any of the analyses.
- Yoshimasu, K., Kiyohara, C., Takemura, S., & Nakai, K. (2014). A meta-analysis of the evidence on the impact of prenatal and early infancy exposures to mercury on autism and attention deficit/hyperactivity disorder in the childhood. Neurotoxicology, 44, 121-131. https://doi.org/10.1016/j.neuro.2014.06.007
  - In a meta-anlysis of 8 case-control studies and 3 cohort studies, no association between thimerosal exposures and ASD (OR: 1.03, 95% CI: 0.89-1.18) or attention deficit hyperactivity disorder (ADHD) (OR: 0.91, 95% CI: 0.70-1.13) was observed. However, some of these studies included assessed thimerosal exposure from anti-immunoglobins rather than vaccines.

Ecological studies have found that thimerosal exposure does not explain the rise in autism

- Fombonne, E., Zakarian, R., Bennett, A., Meng, L., McClean-Heywood, D (2006). Pervasive developmental disorders in Montreal, Quebec, Canada: prevalence and links with immunizations. *Pediatrics*, 118(1):e139-150.
  - This study in Quebec, Canada demonstrated increasing prevalence rates of pervasive developmental disorders (PDD) and autism despite reduced exposures to thimerosal-containing vaccines over an 11-year period (1987-1998).

- Madsen, K. M., Lauritsen, M. B., Pedersen, C. B., Thorsen, P., Plesner, A. M., Andersen, P. H., & Mortensen, P. B. (2003). Thimerosal and the occurrence of autism: negative ecological evidence from Danish population-based data. Pediatrics, 112(3 Pt 1), 604-606. https://doi.org/10.1542/peds.112.3.604
    - There was no trend towards an increase in autism during the period when thimerosal was used in Denmark, from 1971- 1990. From 1991-2000, the incidence of autism increased and continued to rise after removal of thimerosal from vaccines.
- Schechter, R., & Grether, J. K. (2008). Continuing increases in autism reported to California's developmental services system: mercury in retrograde. *Arch Gen Psychiatry*, *65*(1), 19-24. https://doi.org/10.1001/archgenpsychiatry.2007.1
    - An ecological study in the US evaluated prevalence of children with autism reported to California's Department of Developmental Services and thimerosal exposure based on receipt of recommendations of vaccines. The prevalence of autism consistently increased during 1989-2003, despite the reduction in exposure to thimerosal starting in 1999. These data are inconsistent with the hypothesis that thimerosal exposure is a primary cause of autism.
- Stehr-Green, P., Tull, P., Stellfeld, M., Mortenson, P. B., & Simpson, D. (2003). Autism and thimerosal-containing vaccines: lack of consistent evidence for an association. *Am J Prev Med*, *25*(2), 101-106. https://doi.org/10.1016/s0749-3797(03)00113-2
    - This study evaluated incidence of autism disorder in three countries: Sweden, Denmark, and the United States (California). In all 3 countries, incidence of autism disorder rose during 1985-1989 and accelerated in the early 1990s. Thimerosal exposure from vaccines in both Sweden and Denmark decreased in the late 1980s and was eliminated in the early 1990s. Ecological data presented is not consistent with the hypothesis that exposure to thimerosal-containing vaccines is responsible for increased rates of autism.

Studies by non-CDC authors using data from the Vaccine Adverse Event Reporting System (VAERS) and the Vaccine Safety Datalink (VSD) suggest an association between thimerosal-containing vaccines and neurodevelopmental disorders, including autism spectrum disorders.

Several non-CDC studies have been conducted using data from VAERS and VSD. These studies have significant methodological limitations.

VAERS data are based on spontaneous reports, accepted from anyone (e.g., healthcare provider, patient, public), and include unverified diagnoses. VAERS serves to detect signals that require further investigation, but in general, VAERS cannot assess causality. In addition, many factors may influence reporting to VAERS over time, including introduction of new vaccines, changes in awareness of VAERS among healthcare providers and the public, and changes in perceptions of risks of vaccines over time, which may influence reporting practices and lead to reporting bias.

Diagnostic criteria for ASD and access to developmental services have also changed over time. Therefore, conducting case-control studies and ecological analyses using VAERS data without accounting for these factors introduces substantial biases to the results. Other methodological concerns include reliance on aggregate data for analyses, inability to control for confounding factors, substantial risk for misclassification of thimerosal exposure (e.g., analyses based on indirect measures of thimerosal exposure, inability to determine whether the vaccine received was thimerosal-containing or not, inability to determine the child's entire antecedent immunization history), imprecise denominator estimates, and outcome misclassification (e.g., use of US Department of Education special education categories as a proxy for medical diagnoses). For several papers where an incidence rate is calculated for an outcome in thimerosal-exposed and thimerosal-unexposed children, the source of denominator data is cited as "Biological Surveillance Summaries of the CDC"; however, as CDC did not provide manufacturer-level data (based on agreements with manufacturers) that would allow for determining which doses were thimerosal-containing, the accuracy of the reported incidence rates is unclear. In many instances, the methods used are not clearly described and basic descriptive data (e.g., reported counts of adverse events, vaccine doses, or number of individuals in each exposure group) are not presented.

The VSD data used for the below studies were collected pre-2001 from 3 VSD-participating sites. The studies relied exclusively on automated diagnostic codes, without chart review or standardized neurodevelopmental testing to confirm diagnosis or establish onset of symptoms in relation to vaccination. A previous screening analysis conducted by CDC using VSD data (Verstraeten, et al.) described limitations in these source data, including the use of automated diagnostic codes (which differed between the sites), differences in neurodevelopmental services offered between sites which could influence diagnostic practices, and inability to control for additional confounders that are not available through electronic health records (CDC subsequently implemented two cohort studies [Price et al, Thompson, et al] through the VSD with standardized neurodevelopmental testing and additional primary data collection to overcome these limitations). Additional methodologic limitations to the below studies include lack of control for confounding factors, lack of individual-level thimerosal exposure (and thus high risk for misclassification), differences in cases and control populations, small sample sizes that could lead to unstable effect estimates, and multiple testing (which could increase risk for false positives) without clarity of whether any corrections were applied.

The results and conclusions described in the below summaries are as reported in the published papers, and do not convey CDC's official interpretation of the data.

Several studies were examined as part of the Institute of Medicine review on vaccines and autism and were determined by the committee to be "uninterpretable, and therefore, noncontributory with respect to causality".

- Geier, M. R., & Geier, D. A. (2003). Neurodevelopmental disorders after thimerosal-containing vaccines: a brief communication. *Experimental biology and medicine (Maywood, N.J.)*, *228*(6), 660–664. https://doi.org/10.1177/153537020322800603

    - This retrospective study compared the incidence of neurodevelopmental disorders in children who had a VAERS report submitted following receipt of thimerosal-containing DTaP vaccines (n=6,575) and thimerosal-free DTaP vaccines (n=1,516). There were 88 children for whom a neurodevelopmental disorder was reported toVAERS during 1992-2000. Risk of autism was six times higher (RR: 6.0) among children who received a thimerosal-containing DTaP compared to children who received a thimerosal-free DTaP.

- Geier, D. A., & Geier, M. R. (2003). An assessment of the impact of thimerosal on childhood neurodevelopmental disorders. *Pediatric rehabilitation*, *6*(2), 97–102. https://doi.org/10.1080/1363849031000139315

    - This study evaluated mercury doses of thimerosal in childhood vaccines and VAERS reports of autism. Odds ratio of autism increased by 0.029 per ug of mercurcy. Odds of autism were higher following thimerosal-containing DTaP compared to thimerosal-free DTaP vaccines. Additionally, the study evaluated the prevalence of neurodevelopmental disorders reported by the 2001 US Department of Education Report and the average amount of mercurcy that children received as part of their childhood immunization schedule in birth cohorts compared to a baseline measurement in 1984. Odds ratio of autism (OR: 2.5) and speech disorders (OR: 1.4) were elevated compared to 1984 baseline measurement.

- Geier, D. A., & Geier, M. R. (2004). A comparative evaluation of the effects of MMR immunization and mercury doses from thimerosal-containing childhood vaccines on the population prevalence of autism. *Med Sci Monit*, *10*(3), Pi33-39. https://medscimonit.com/abstract/index/idArt/11608

    - This ecological study evaluated the mean amount of ethylmercurcy in childhood vaccines and coverage of MMR vaccines with the number of cases of various disabilities reported by the United States Department of Education system over time using data from 1981—1985 and 1990—1996. Results suggest that there is a correlation between increasing doses of thimerosal-containing vaccines and autism, and a correlation between increasing doses of measles-containing vaccines and autism.

- Geier MR, Geier DA. (2003). Thimerosal in childhood vaccines, neurodevelopmental disorders, and heart disease in the United States. J Amer Phys Sur 8(1):6-11.

    - This ecological study examined the link between thimerosal, the rising rates of neuodevelopmental disorders, and heart disease in the United States, using data from VAERS, the 2001 US. Department of Education report, and CDC's Biologic Surveillance summaries. The birth cohort years analyzed were 1984, 1985, 1990, 1991, 1992, 1993, and 1994. The authors calculated relative risks by comparing

adverse events across various levels of merucury exposure. Results suggest increase relative risks for neurodevelopmental disorders and heart disease with increasing doses of mercury.

Other studies using data from VAERS or VSD are described below.

- Geier, D., & Geier, M. R. (2004). Neurodevelopmental disorders following thimerosal-containing childhood immunizations: a follow-up analysis. *Int J Toxicol*, *23*(6), 369-376. https://doi.org/10.1080/10915810490902038
    - This study compared adverse reports of neurodevelopmental disorders submitted to VAERS during 1997-2000for children who received thimerosal-containing DTaP vaccines to children who received thimerosal-free DTaP vaccines. Increased odds ratios for autism (OR: 1.8, 95% CI: 1.0-3.3), speech disorders (OR: 2.1, 95% CI: 1.1, 4.0), intellectual disability (OR: 2.6, 95% CI: 1.2-5.7), and personality disorders (OR: 8.2, 95% CI: 1.1-60) were observed in children receiving thimerosal-containing DTaP vaccines compared to thimerosal-free DTaP vaccines.
- Geier, D. A., & Geier, M. R. (2004). An evaluation of serious neurological disorders following immunization: a comparison of whole-cell pertussis and acellular pertussis vaccines. *Brain Dev*, *26*(5), 296-300. https://doi.org/10.1016/s0387-7604(03)00169-4
    - This retrospective cohort evaluated VAERS reports submitted within 3 days following immunization of whole cell (n=1,553) and acellular pertussis vaccines (n=3,772) between 1997-1999. There were increases in emergency room visits, life threatening reactions, hospitalization, disabilities, deaths, seizures, encephalitis, autism, sudden infant death syndrome, and speech disorders following vaccination with whole cell pertussis compared to acellular pertussis .
- Geier, D. A., & Geier, M. R. (2005). A two-phased population epidemiological study of the safety of thimerosal-containing vaccines: a follow-up analysis. *Med Sci Monit*, *11*(4), Cr160-170. https://medscimonit.com/abstract/index/idArt/15878
    - This study was conducted in two phases in which risk of neurodevelopmental disorders was evaluated following receipt of thimerosal-containing vaccines. The first phase consisted of evaluation of VAERS reports of neurodevelopmental disorders following thimerosal-containing vs thimerosal-free DTaP vaccines. Results suggested more frequent reports of autism, speech disorders, intellectual disability, personality disorders, and thinking abnormalities following thimerosal-containing vaccines. The second phase evaluated whether there was an association between risk of neurodevelopmental disabilities and higher cumulative exposure to thimerosal in the first 1, 2, 3, and 6 months of life, as determined by vaccine records and the mean thimerosal dosage reported by manufacturers to the FDA for each vaccine, . There were associations found in 12 categories out of a possible 44 outcome categories examined, including increased risk for developmental delay, tics, attention deficit disorder, language delay, speech delay, and neurodevelopmental delay in general.

- Geier, D. A., & Geier, M. R. (2006). An assessment of downward trends in neurodevelopmental disorders in the United States following removal of thimerosal from childhood vaccines. *MEDICAL SCIENCE MONITOR*, *12*(6), CR231-CR239.
    - This ecological study examined reports to VAERS from 1991—2004 to evaluate the effect of the removal of thimerosal from vaccines (beginning in 1999) on reports of neurodevelopmental disorders. VAERS reports of neurodevelopmental disorders peaked during 2001-2002. The maximum proportion of neurodevelopmental disorders reported to VAERS were in 1998. Vaccines administered after 1998 had decreasing proportions of neurodevelopmental disorders reported to VAERS.
- Geier, D. A., & Geier, M. R. (2006). An evaluation of the effects of thimerosal on neurodevelopmental disorders reported following DTP and Hib vaccines in comparison to DTPH vaccine in the United States. *J Toxicol Environ Health A*, *69*(15), 1481-1495. https://doi.org/10.1080/15287390500364556
    - This case-control study compared odds of autism, speech disorders, intellectual disability, infantile spasms, and thinking abnormalities reported to VAERS in children who received separate DTP + Hib vaccine (higher thimerosal dose) to children who received the combined DTPH (lower thimerosal dose) from 1994-1998. Baseline characteristics between the two groups were not compared. Significantly increased odds ratios for autism, speech disorders, intellectual disability, infantile spasms, and thinking abnormalities were found following DTP + Hib vaccines compared to DTPH vaccines.
- Geier, D. A., & Geier, M. R. (2006). A meta-analysis epidemiological assessment of neurodevelopmental disorders following vaccines administered from 1994 through 2000 in the United States. *Neuro Endocrinol Lett*, *27*(4), 401-413.
    - This study used VAERS data to compare reports of neurodevelopmental disorders following DTP vs DTPH vaccines (1994-1997) and thimerosal-containing DTaP vs thimerosal-free DTaP vaccines (1997-2000). The study found increased risks of autism, speech disorders, personality disorders, thinking abnormalities, ataxia, neurodevelopmental disorders, intellectual disabilities among children who received thimerosal-containing vaccines.
- Geier, D. A., Hooker, B. S., Kern, J. K., King, P. G., Sykes, L. K., & Geier, M. R. (2013). A two-phase study evaluating the relationship between thimerosal-containing vaccine administration and the risk for an autism spectrum disorder diagnosis in the United States. *Translational neurodegeneration*, *2*(1), 25. https://doi.org/10.1186/2047-9158-2-25
    - Analysis of VAERS revealed a 2-fold increased risk ratio for autism spectrum disorder following administration of thimerosal-containing DTaP vaccines compared to thimerosal-free DTaP vaccines. In the Vaccine Safety Datalink (VSD), cases diagnosed with ASD were significantly more likely to have received higher doses of mercury (Hg) from thimerosal-containing hepatitis B vaccines during specific intervals in their first six months of life compared to children without ASD. Compared to no mercurcy

exposure, odds of autism were 2.18 (95% CI: 1.74, 2.73), 2.11 (95% CI: 1.68, 2.64), and 3.39 (95% CI: 1.60, 7.18) higher among children receiving 12.5 µg Hg in the first month, 25 µg Hg within the first two months, and 37.5 µg Hg within the first six months, respectively.

- Geier, D. A., Kern, J. K., Hooker, B. S., King, P. G., Sykes, L. K., & Geier, M. R. (2014). Thimerosal-containing hepatitis B vaccination and the risk for diagnosed specific delays in development in the United States: a case-control study in the Vaccine Safety Datalink. *North American journal of medical sciences*, *6*(10), 519–531. https://doi.org/10.4103/1947-2714.143284
    - This case-control study evaluated whether exposure to mercurcy through hepatitis B vaccines is linked to risk of neurodevelopmental delays among children born during 1991-2000 enrolled in the Vaccine Safety Datalink. Cases (n=5,699) diagnosed with specific delays in development were significantly more likely than controls (n=48,528) to have received higher doses of organic mercury from thimerosal-containing hepatitis B vaccines in the first month of life (OR: 1.99, 95% CI: 1.89, 2.11), first two months of life (OR: 1.98, 95% CI: 1.87, 2.09), and first 6 months of life (OR: 3.07, 95% CI: 2.50, 3.77)
- Geier DA, Hooker BS, Kern JK, King PG, Sykes LK, Geier MR. A dose-response relationship between organic mercury exposure from thimerosal-containing vaccines and neurodevelopmental disorders. Int J Environ Res Public Health. 2014 Sep 5;11(9):9156-70. https://doi.org/10.3390/ijerph110909156
    - In this study using data from the Vaccine Safety Datalink among children born during 1991-2000, cases with PDD (OR= 1.054, 95% CI: 1.034, 1.074), specific developmental delay (OR = 1.035, 1.03, 1.04), tic disorder (OR = 1.034, 95% CI: 1.01, 1.06) and hyperkinetic syndrome of childhood (OR = 1.05, 95% CI: 1.04, 1.06) were significantly more likely than controls to have elevated organic-Hg exposure through hepatitis B vaccines. Odds ratios were calculated per ug of organic-Hg.
- Geier DA, Kern JK, King PG, Sykes LK, Geier MR. A case-control study evaluating the relationship between thimerosal-containing haemophilus influenzae type b vaccine administration and the risk for a pervasive developmental disorder diagnosis in the United States. Biol Trace Elem Res. 2015 Feb;163(1-2):28-38. https://doi.org/10.1007/s12011-014-0169-3
    - Children diagnosed with PDD in the Vaccine Safety Datalink (n=534) born during 1991-2000 received significantly higher doses of organic mercury from thimerosal from Hib vaccines compared to controls (n=25,632) in the first 6 months of life (OR: 1.97, p<0.001) and first 15 months of life (3.94, p<0.0001). Odds of PDD increased by 1.97% per ug of mercury exposure.
- Geier, D. A., Kern, J. K., Hooker, B. S., King, P. G., Sykes, L. K., Homme, K. G., & Geier, M. R. (2015). Thimerosal exposure and increased risk for diagnosed tic disorder in the United

States: a case-control study. *Interdisciplinary toxicology*, *8*(2), 68–76. https://doi.org/10.1515/intox-2015-0011

  - In a retrospective case-control study using Vaccine Safety Datalink records from infants born during 1991-2000, cumulative thimerosal exposure from hepatitis B vaccines given during the first month (OR: 1.59, p<0.01), first two months (OR: 1.59, p<0.01), and first six months (OR: 2.97, p<0.01) of life was associated with tic disorder. This association was seen in both males and females. There were a total of 344 cases in this study.

- Geier, D. A., Kern, J. K., & Geier, M. R. (2016). A Two-Phase Case-Control Study of Autism Risk Among Children Born From the Late 1990s Through the Early 2000s in the United States. *Med Sci Monit*, *22*, 5196-5202. https://doi.org/10.12659/msm.900257

  - This was a two-phase case control study that used data from VAERS for vaccination years of 1998-2003 to evaluate the effect of reducing thimerosal exposure on autism. There were 73 cases of autism and 11,783 controls. Results showed decreased odds of autism in comparison to controls among children whose vaccines were administered in early 2000s. In Phase 2, there 40 case-control pairs were matched on age, sex, and race/ethnicity. Mean date of birth of ASD cases was more significantly in the past than in controls; odds ratio for ASD decreased with a more recent date of birth (OR: 0.67 per more recent year of birth, 95% CI: 0.46, 0.97).

- Geier, D. A., Kern, J. K., & Geier, M. R. (2017). Increased risk for an atypical autism diagnosis following Thimerosal-containing vaccine exposure in the United States: A prospective longitudinal case-control study in the Vaccine Safety Datalink. *J Trace Elem Med Biol*, *42*, 18-24. https://doi.org/10.1016/j.jtemb.2017.03.005

  - A case-control study evaluated exposure to ethylmercury from thimerosal-containing hepatitis B vaccines administered in the first 1, 2, and 6 months of life. Children were born during1991-2000 and enrolled in the Vaccine Safety Datalink. Cases with atypical autism (n=164) were more likely to have received greater exposure to ethylmercury inthe first 1 month, 2 month, and 6 months of life compared to controls (n=15,216).

- Geier DA, Kern JK, Homme KG, Geier MR (2017). Abnormal Brain Connectivity Spectrum Disorders Following Thimerosal Administration: A Prospective Longitudinal Case-Control Assessment of Medical Records in the Vaccine Safety Datalink. Dose Response. 2017 Mar 16;15(1):1559325817690849. doi: 10.1177/1559325817690849. Erratum in: Dose Response. 2018 Feb 02;16(1):1559325818757904. doi: 10.1177/1559325818757904. PMID: 28539852; PMCID: PMC5433557.

  - In this case-control study, for each additional 25ug of mercury from Hib vaccination, children in the Vaccine Safety Datalink born 1991-2000 had a 1.49 times higher odds of ASD, 1.43 times higher odds of tic disorder, and 1.50 times higher odds of ADD/ADHD. All findings remained statistically significant when stratified by gender. Number of cases per group were small.

- Geier, D. A., Kern, J. K., Homme, K. G., & Geier, M. R. (2018). The risk of neurodevelopmental disorders following Thimerosal-containing Hib vaccine in comparison to Thimerosal-free Hib vaccine administered from 1995 to 1999 in the United States. *Int J Hyg Environ Health*, *221*(4), 677-683. https://doi.org/10.1016/j.ijheh.2018.03.004
    - This case-control study used VAERS reports to evaluate risk of neurodevelopmental disorders following thimerosal-containg Hib vaccines compared to thimerosal-free Hib vaccines administered from 1995-1999. Children who received thimerosal-containing Hib vaccines were more likely to report neurodevelopmental disorders compared to those who received thimerosal-free versions. These neurodevelopmental disorders included autism (OR: 2.75, 95% CI: 1.18, 7.87), developmental delay (OR: 5.39, 95% CI: 1.38, 46.35), psychomotor disorder (OR: 2.38, 95% CI: 1.13, 5.79), and overall neurodevelopmental disorder (OR: 2.70, 95% CI: 1.50, 5.26).
- Geier, D. A., Kern, J. K., Sykes, L. K., & Geier, M. R. (2018). Mercury-associated diagnoses among children diagnosed with pervasive development disorders. *Metabolic brain disease*, *33*(3), 949–960. https://doi.org/10.1007/s11011-018-0211-9
    - This study was a case-control study using data from the Vaccine Safety Datalink. Cases included 534 children with PDD. Within the first five years of life, cases had a higher incidence of eczema (OR: 2.03), dysarthria (OR: 23.99), epilepsy (OR: 5.35), failure to thrive (OR: 25.3), and cerebral palsy (OR: 4.46). Authors concluded that results provide evidence of biological plausibility that mercury induces PDD diagnosis.
- Geier DA, Kern JK, Hooker BS, King PG, Sykes LK, Geier MR (2016). A longitudinal cohort study of the relationship between Thimerosal-containing hepatitis B vaccination and specific delays in development in the United States: Assessment of attributable risk and lifetime care costs. J Epidemiol Glob Health. 2016 Jun;6(2):105-18. https://doi.org/10.1016/j.jegh.2015.06.002
    - This study from the Vaccine Safety Datalink evaluated a possible relationship between exposure to mercury from thimerosal-containing hepatitis B vaccines in the first 6 months of life and developmental delays. The cohort included children (n=49,835) born during 1991-1994. Infants receiving increased Hg doses from thimerosal-containing hepatitis B vaccines administered within the first month, first 2 months, and first 6 months of life were significantly more likely to be diagnosed with specific delays in development than infants receiving no thimerosal-containing hepatitis B vaccines. The study estimated that an estimated 0.5–1 million additional US children were diagnosed with specific delays in development between 1991-2000 as a consequence of 25 µg or 37.5 µg organic Hg from thimerosal-containing hepatitis B vaccinesadministered within the first 6 months of life.

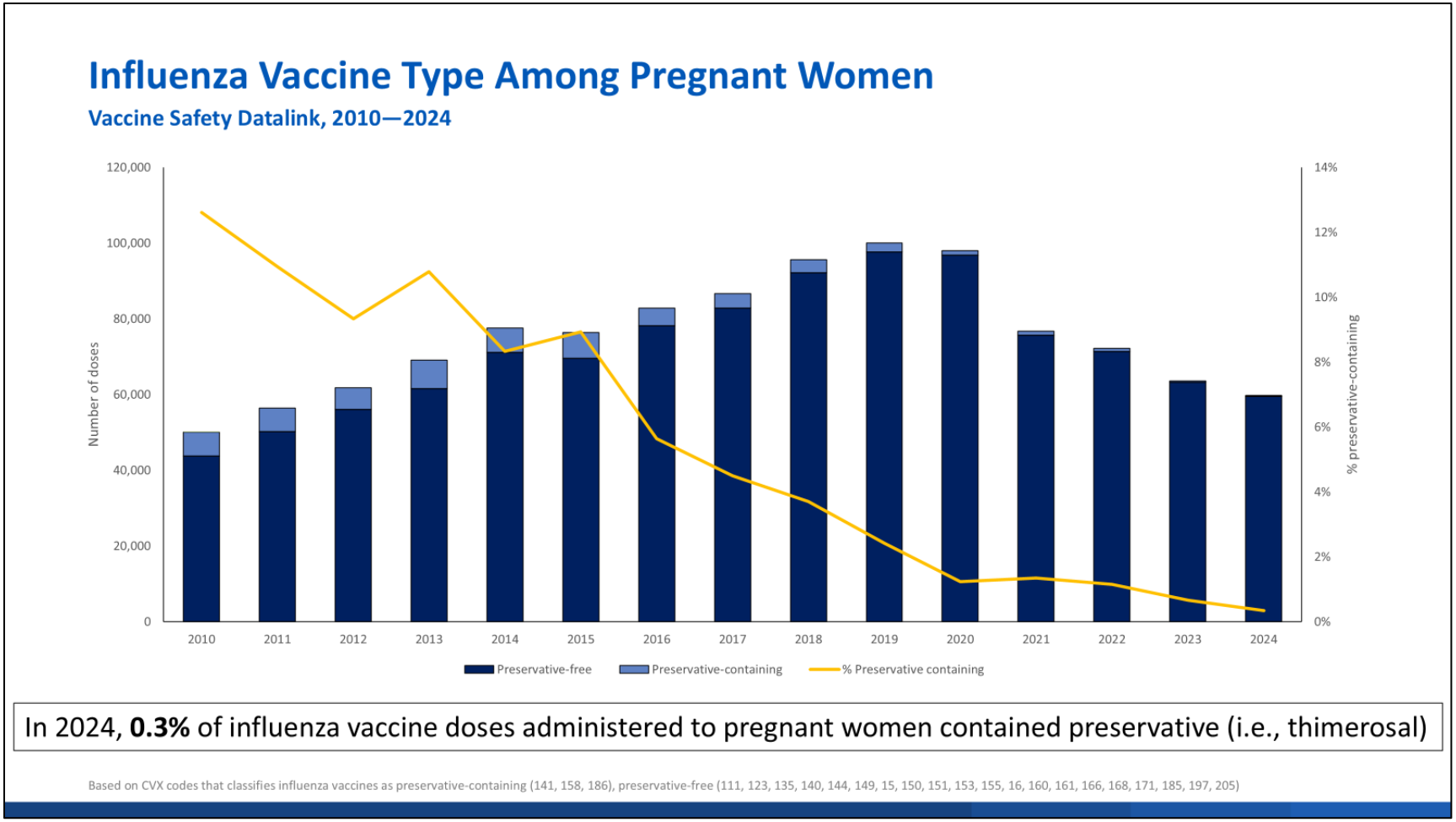
- Geier, D. A., Kern, J. K., Hooker, B. S., Sykes, L. K., & Geier, M. R. (2016). Thimerosal-Preserved Hepatitis B Vaccine and Hyperkinetic Syndrome of Childhood. *Brain sciences*, *6*(1), 9. https://doi.org/10.3390/brainsci6010009

    - This case-control study from Vaccine Safety Datalink data investigated whether early life exposure to mercury from thimerosal-containing hepatitis B vaccines is linked to a diagnosis of hyperkinetic syndrome of childhood. Children diagnosed with hyperkinetic syndrome of childhood were more likely to be exposed to increased mercury from thimerosal-containing hepatitis B vaccines given within the first month (OR: 1.45, 95% CI: 1.30-1.62), first two months (OR: 1.43, 95%CI: 1.28, 1.59), and first 6 months (OR: 4.51, 95% CI: 3.04, 6.71) compared to controls. Cases were born 1991-1997 whereas controls were born 1991-1993.

- Young, H. A., Geier, D. A., & Geier, M. R. (2008). Thimerosal exposure in infants and neurodevelopmental disorders: an assessment of computerized medical records in the Vaccine Safety Datalink. *J Neurol Sci*, *271*(1-2), 110-118. https://doi.org/10.1016/j.jns.2008.04.002

    - This ecological study evaluated possible associations between neurodevelopmental disorders and exposure to mercury from thimerosal-containing vaccines among children in the Vaccine Safety Datalink born during 1990-1996. Exposure to mercury was calculated by birth year from birth – 7 months and birth – 13 months. Results suggest each 100ug difference in mercury significantly increased rate ratios of autism, ADD/ADHD, developmental disorders/learning disorders, disturbance of emotions, and tics.

Figure.


Influenza Vaccine Type Among Pregnant Women
Vaccine Safety Datalink, 2010—2024
120,000
100,000
80,000
60,000
40,000
20,000
0
Number of doses
14%
12%
10%
8%
6%
4%
2%
0%
% preservative-containing
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Preservative-free
Preservative-containing
% Preservative containing
In 2024, 0.3% of influenza vaccine doses administered to pregnant women contained preservative (i.e., thimerosal)
Based on CVX codes that classifies influenza vaccines as preservative-containing (141, 158, 186), preservative-free (111, 123, 135, 140, 144, 149, 15, 150, 151, 153, 155, 16, 160, 161, 166, 168, 171, 185, 197, 205)