Journal of Trace Elements in Medicine and Biology 62 (2020) 126649

Contents lists available at ScienceDirect

Journal of Trace Elements in Medicine and Biology

journal homepage: www.elsevier.com/locate/jtemb

Impact of catch-up vaccination on aluminum exposure due to new laws and post social distancing

James Lyons-Weiler *, Grant McFarland, Elaine La Joie

The Institute for Pure and Applied Knowledge, Pittsburgh, PA, United States

ARTICLE INFO

Keywords:
Aluminum
Vaccines
COVID-19
Vaccination

ABSTRACT

Background: The COVID-19 pandemic has placed significant stressors on the medical community and on the general public. Part of this includes patients skipping well-child visits to reduce risk of exposure to SARS-CoV-2 virus. Published estimates of the duration of whole-body aluminum (Al) toxicity from vaccines in infants from birth to six months indicate that CDC's recommended vaccination schedule leads to unacceptably long periods of time in which infants are in aluminum toxicity (as measured by *%AlumTox*).

Methods: We utilize these established clearance and accumulation models to calculate expected per-body-weight whole-body toxicity of aluminum from vaccines considering for children of all ages under CDC's Catch-Up schedule from birth to ten years, assuming social distancing for 6 months. Our updated Pediatric Dose Limit (PDL) model assumes a linear improvement in renal function from birth to two years.

Results: Our results indicate that due diligence in considering alternative spacing and use of non-aluminum containing vaccines when possible will reduce whole body toxicity and may reduce risk of morbidity associated with exposure to aluminum.

Conclusions: While reduction or elimination of aluminum exposure from all sources is always a good idea, our results indicate that careful consideration of expected aluminum exposures during regular and Catch-Up vaccination is found to be especially important for infants and children below 2 years of age. We urge caution in the mass re-starting of vaccination under CDC's Catch-Up schedule for children under 12 months and offer alternative strategies to minimize per-day/week/month exposure to aluminum hydroxide following the COVID-19 period of isolation.

1. Introduction

Social distancing practices due to the COVID-19 pandemic have reduced the rate of vaccination for other childhood illnesses because some parents are delaying "well child" visits, during which vaccinations are given [27]. As of the date of this study, estimates of the duration of social distancing range from two to eighteen months. The American Academy of Pediatrics recommends prioritization of vaccination of younger children but not older children during the current period of social distancing [1]. It is not clear if this is the most rational appropriation of access to vaccination services by pediatricians given (a) there are no data available on the effects of vaccination (for other pathogens) on SARS-CoV-2 infection severity in young children, (b) immunization against influenza in particular may exacerbate COVID-19 severity [2], (c) the effect of compounded dosing of aluminum (Al) adjuvants and other excipients in vaccines on suspected autoimmunity induced by SARS-CoV-2 infection via Pathogenic Priming leading to enhanced disease [3,4] is unknown.

During vaccine development, safety data are collected for individual vaccines for brief periods of time during randomized clinical trials. Our understanding of long-term safety, however, relies on retrospective studies from vaccine adverse event systems such as the Vaccine Adverse Events Reporting System (VAERS; US Department of Health and Human Services, 2020) [28] and the Vaccine Safety Datalink (VSD; [5]). These resources have serious limitations, including that users of VAERS data must first acknowledge that the recorded data cannot be used to infer causal linkage between adverse events of any particular kind and any individual vaccine.

In 2013, The National Academy of Sciences' Institutes of Medicine called for a study examining the question: For children who receive the currently recommended immunization schedule, do short- or long-term health outcomes differ for those who receive fewer immunizations per

* Corresponding author.
E-mail address: jim@ipaknowledge.org (J. Lyons-Weiler).

https://doi.org/10.1016/j.jtemb.2020.126649
Received 2 June 2020; Received in revised form 15 August 2020; Accepted 16 September 2020
Available online 21 September 2020

visit (e.g., when immunizations are spread out over multiple occasions), or for those who receive their immunizations at later ages but still within the recommended ranges (The [6]). To date, studies on the combined effects of receipt of multiple vaccines at one time are few. A study of the apparent effects of receipt of more than one vaccine by Miller [7] using VAERS data concluded that combining more than one vaccine per pediatric office visit was unsafe, because nearly all of the morbidity and mortality reported in VAERS involved receipt of more than one vaccine in the visit before the onset of symptoms of the alleged vaccine injury.

Aluminum toxicity is especially expected from exposures from vaccines in part due to the form of aluminum used as adjuvant (aluminum hydroxide). Past studies employ aluminum hydroxide to effect autoimmune conditions in animal models to test treatments for those conditions (examples include mouse models of atherosclerosis (Zhu et al.2014), Systemic Lupus Erythematosus (Kelly-Scumpia et al. [8], allergic rhinitis [9] and asthma [10]).

Based on previous models of whole-body clearance of aluminum hydroxide from vaccines, Lyons-Weiler and Ricketson [11] published the first-ever estimate of pediatric dose limit (PDL) of aluminum hydroxide for the CDC vaccination schedule. They found repeated instances of acute (whole-body) toxicity resulting from vaccine administration according to the schedule recommended by CDC Advisory Committee on Immunization Practices (CDC/ACIP) but did not assess expected chronic toxicity. McFarland et al. [12] modeled accumulation and clearance comparing three vaccine schedules, and found that it can be expected that children receiving the CDC recommended schedule will experience chronic aluminum toxicity (as measured by *%AlumTox*) during at least 70 % of their days up to the age of 7 months, and 1 of 4 (25 %) of days up to age 2 years. This result did not accommodate for the fact that at birth, infants have only 20 % glomerular filtration rate compared to two-year olds [13], and thus the results were considered conservative.

Concern over aluminum exposure from any source is warranted given cumulative toxicity from cumulative exposures. Commercial and prescribed infant formulas, for example, inexplicably continue to contain aluminum [14].

Toxicity from aluminum from vaccines and other parenteral sources (breast milk, formula, or water) can be expected to be different because of the difference in absorption, distribution, elimination, and retention between ingestion and injection. It is commonly perceived that children receive more aluminum from oral sources than from vaccines; however, McFarland et al. [12] also found that infants up to six months are exposed internally to far more aluminum from vaccines (100 % absorption) than from oral exposure (about 0.3 % absorption), contradicting the common misconception that the reverse is true once body weight and pass-through intestinal clearance of aluminum from parenteral sources are considered.

The effects of CDC/ACIP's Catch-Up vaccination schedule recommendations [15] on acute and chronic aluminum whole-body toxicity are completely unstudied. To assess what might be expected under a delayed start to vaccination due to changing state policies and legislation, models of Lyons-Weiler and Ricketson [11] and McFarland et al. [12] were used and updated to study generic Catch-Up schedule-related aluminum acute and chronic whole-body aluminum toxicities, and compared them to three alternative schedules, optimized to reduce aluminum hydroxide exposure.

2. Materials and method

Given that the full background of the models and methods are described in Lyons-Weiler and Ricketson [11] and in McFarland et al. [12], we limit our description to an updated function reflecting the development of glomerular filtration rates. Full models of aluminum clearance are provided in Lyons-Weiler and Ricketson [11] and McFarland et al. [12].

The Pediatric Dose Limit (PDL) for aluminum exposure in vaccines is an estimate of the amount of aluminum that might be considered safe for injection given the FDA's regulated 850 mcg limit for adults (detailed in Lyons-Weiler and Ricketson [11] and McFarland et al. [12]. An adjustment for the immature glomerular filtration rate is modeled as a linear function of PDL, Given an infant's body weight up to 730 days of life.

$$PDL = Weight * \frac{14.2ug}{Kg} * Min(1, 1 - 0.8 * \frac{730Days - Age(Days)}{730Days})$$

This formula applies due to the fact that at birth, infants only have 20 % glomerular filtration efficiency [12]. The specific manner in which the CDC Catch-Up schedule and five specific scenarios (Use Cases) are modeled for this study are also detailed.

The measure of whole-body aluminum toxicity, *%AlumTox*, is otherwise calculated as per McFarland et al. [12]. The summary presentation of *%AlumTox* is presented over the 730-day period.

Some vaccines in the CDC Schedule and the CDC Catch-Up schedule come formulated in two options, with aluminum (ACVs), and without aluminum. The three schedules examined therefore were: Schedule A: the CDC 2019 Schedule, assuming all vaccines that may contain aluminum are selected; Schedule B: the CDC Catch-Up Schedule using ACVs, Schedule C: the CDC Catch-Up Schedule modified only by assuming the use of non-aluminum containing vaccines whenever possible, and Schedule D: an Alternative Catch-Up Schedule. In the Alternative Schedule, vaccines were given such that only one Al-containing vaccine was given at a time and HepB was not included (to minimize Al exposure when kidney function is the most limited). To determine the effects of late-start and hiatuses of vaccination on expected whole-body aluminum toxicity, as detailed below, some of the analyses in the present study assume late-onset vaccination start; others assume a six-month delay in vaccination due to a nationwide drop in vaccination rates associated with social distancing for six months duration.

We explore these scenarios and schedules using five Use Case Scenarios meant to provide examples of real-life instances in which specific individuals' aluminum uptake, clearance and toxicity can be easily modeled. Each of the five use cases are also compared to the baseline CDC recommended on-time schedule given without delay or hiatus. Other scenarios can be explored via modification of our Spreadsheet (Supplementary Material).

The five use cases are as follows:

Use Case #1

A never-vaccinated 6-month old male who enters the CDC schedule at the age of six months. This situation may result during a custody situation in which parents disagree on the choice to vaccinate or not, and the court decides in favor of the parent who would opt for vaccination, and orders the CDC Catch-Up Schedule

Use Case #2

A never-vaccinated 18-month old male who enters the CDC schedule at the age of 18 months. Like Use Case 1, this is a likely scenario given a ruling by a court in favor of vaccination.

Use Case #3

A never-vaccinated 4 years 8 months old male who enters the CDC schedule at the age of 4 years 8 months. This situation may result when a State has revoked rights to philosophical or religious exemptions to that state's vaccination requirements for public school attendance.

Use Case #4

A never-vaccinated 7-year old male who enters the CDC schedule at the age of 7 years. Like use Case #3, this situation is likely to occur due to revocation of rights to exemptions.

Use Case #5

A male child vaccinated until three months of age, with vaccination re-start following a six-month hiatus. This is situation reflecting one possible outcome due to social distancing such as is ongoing due to COVID-19.

Results for female children will track males but the male-based estimates will be slightly conservative for females.

3. Results

Compared to the study by McFarland et al. [12], which found that infants exposed to the CDC 2019 schedule can be expected to be in aluminum toxicity at least 70 % of days up to seven months, our updated results which adjust for age-dependent glomerular filtration rates indicate that infants can be expected to be in aluminum whole-body toxicity (body burden > PDL) 100 % of days for the first year (Fig. 1).

As measured by *%AlumTox* for the overall Catch-Up schedule variant comparisons, our results show that the CDC 2019 schedule begun at birth and with no delays can be expected to incur the largest amount of whole-body chronic aluminum toxicity, with the greatest toxicity occurring in the first six months of life. An infant whose vaccination is delayed for six months after birth avoids the high-toxicity experienced by infants whose schedules were not delayed, but the relative accumulation and clearance curves compared to the %50th *tile* PDL adjusted for glomerular filtration rate shows multiple instances of acute toxicity, with peaks between six and eight months exceeding the FDA limit of 850 μg per vaccine dose, and remaining above the PDL, with intermittent high peaks, up until age fifteen months.

The four *%AlumTox* curves for the 2019 CDC schedule and the various Catch-Up schedules show that the delay in vaccination led to a reduction in the percentage of days a child will be in aluminum toxicity (from 52 % to 21 %) over the full 800 days (2.2 years) considered (Fig. 2). The CDC Low Al Schedule results leads to further reduction (to 15 % *%AlumTox*), and the Alternative Catch-Up schedule leads to only 5% of days in aluminum toxicity.

The next three use cases delay vaccine exposure to increasingly older age and show overall variation in the expected *%AlumTox* and in the differences expected per schedule. Note *%AlumTox* is decreased overall compared to Use Case #1, as expected with older children given body weight of child at increasing age and increased kidney function up to two years of age.

Notice differences in Y-axis scaling (*%AlumTox*) in Figs. 3–5. Individuals beginning vaccination at age 18 months avoid the toxicity associated with the 2019 CDC schedule from birth to age 18 months, but they can expect increased toxicity due to make-up schedule vs. what an 18-month old on the 2019 CDC schedule experiences. Individuals aged 4 years 8 months or above can expect less toxicity (considering the

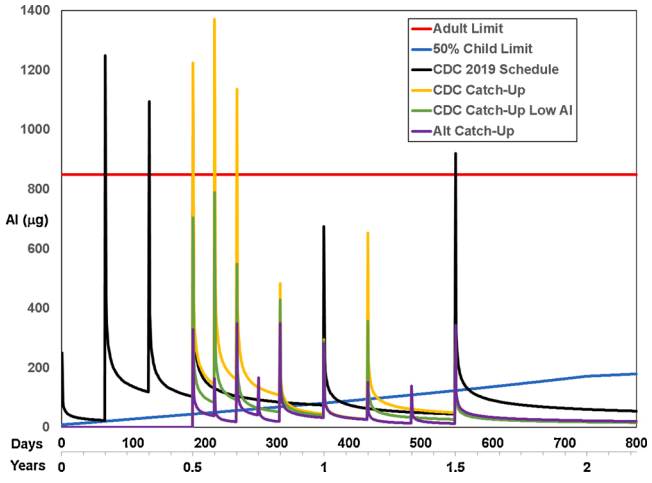

Fig. 1. Use Case 1. Expected whole-body accumulation and clearance of aluminum hydroxide under the 2019 CDC Schedule, no delay, starting at birth (Black), CDC Catch-Up schedule begun at 6 months (Yellow) compared to the glomerular filtration rate (GFR)-adjusted PDL (Blue) for the 50th %tile bodyweight, first 800 days of life. Alternative schedules (CDC Catch-Up Low Al vaccine options (Green), and our Alternative Catch-Up Schedule (Purple) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

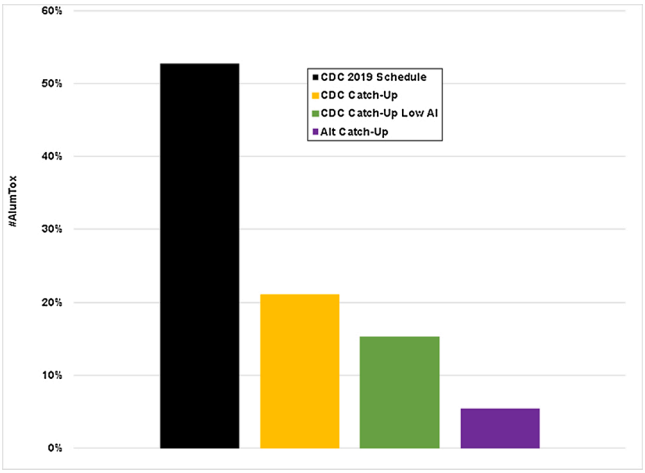

Fig. 2. Use Case 1 *%AlumTox*. Al toxicity comparison of CDC 2019 Schedule, no delay, begun at birth, (Black) vs. delayed vaccination begun at age 6 months: CDC Catch-Up Schedule (Yellow) and the two alternative schedules (CDC Catch-Up Low Al (Green) and Alternative Catch-Up Schedule (Purple). Y-axis is percent of days with aluminum toxicity (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

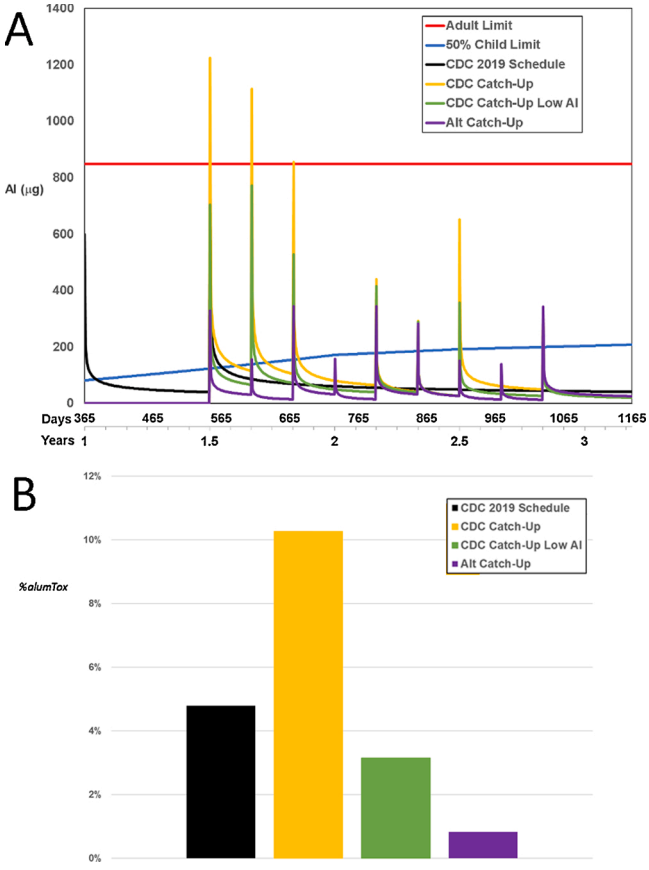

Fig. 3. (A) Use Case #2 AL toxicity comparison of 2019 CDC Schedule, no delay, begun at birth (aluminum toxicity from birth to 18 months not shown), showing aluminum toxicity from 12 months to 3 years (Black) vs. delayed vaccination begun at age 18 months: CDC Catch-Up Schedule (Yellow) and the two alternative schedules (CDC Catch-Up Low Al (Green) and Alternative Catch-Up Schedule (Purple). (B) *%AlumTox* for each schedule between age 18 months and 3.3 years (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

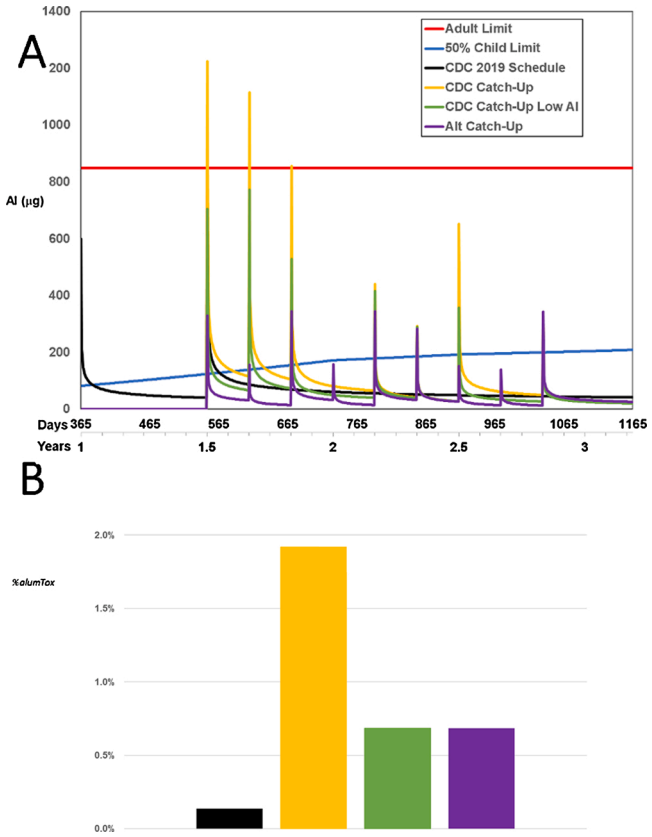

Fig. 4. 4a and 4b. Use Case #3 (A) AL toxicity comparison of 2019 CDC Schedule, no delay, begun at birth, (aluminum toxicity from birth to age 4 years 8 months not shown), showing aluminum toxicity from age 4 years 8 months to 6.6 years (Black) vs. delayed vaccination begun at aged 4 years 8 months. (B) CDC Catch-Up Schedule (Yellow) and the two alternative schedules (CDC Catch-Up Low Al (Green) and Alternative Catch-Up Schedule (Purple) Fig. 4b shows *%AlumTox* has decreased with age of child (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

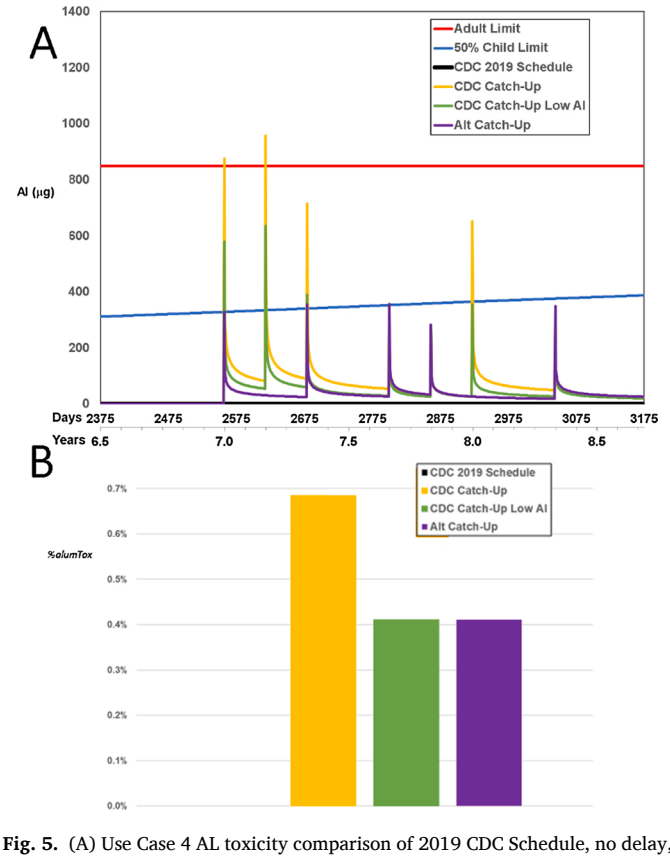

Fig. 5. (A) Use Case 4 AL toxicity comparison of 2019 CDC Schedule, no delay, begun at birth, (aluminum toxicity from birth to age 7 years not shown), showing aluminum toxicity from age 7 to 9 years (Black) vs. delayed vaccination begun at age 7 years: (B) CDC Catch-Up Schedule (Yellow) and the two alternative schedules (CDC Catch-Up Low Al (Green) and Alternative Catch-Up Schedule (Purple) Note that no vaccinations are given during this time period on the 2019 CDC Schedule. (B) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

interrupted time period) than the 2019 CDC Schedule. By age 7 years, the onset is expected to have minimal effect with *%Alumtox* being no more than 0.7 % of days.

Use Case 5 introduces a new consideration—children who have begun the CDC schedule but were interrupted for 6 months beginning at age 3 months.

The four values of *%AlumTox* for the CDC schedule and the various Catch-Up schedules show that the six-month interruption in vaccination led to an increase in the percentage of days a child will be in aluminum toxicity (from 52 % to 56 %) over the full 800 days (2.2 years) if CDC Catch-Up schedule followed. (Fig. 6b). The Low Al CDC Schedule results leads to a toxicity reduction (to 38 % *%AlumTox*), and the Alternative Catch-Up schedule leads to 7.8 % of days in aluminum toxicity over the modeled period of time.

4. Discussion

Aluminum is not safe, as has been previously indicated [16,17]. While standard pharmacokinetics models presume that plasma clearance reflects low toxicity, numerous studies now point to rapid specific tissue localization as problematic, with serum/plasma clearance without clearance from the body as a source of concern. The conclusion, therefore, of Movsas et al. [16] that the zero net change in plasma-level aluminum concentrations in preterm infants before and after vaccination with no evidence of decreased body burden is not valid; the toxicity of aluminum is a concern that involves aluminum:tissue interactions.

Whole body clearance is relevant for considering aluminum toxicity because aluminum effects multiple systems. It clears from the plasma very quickly, with a significant amount adhering to tissue, where many biomedical researchers and physicians suspect autoimmunity to self-antigens is likely to be realized. The rapid plasma clearance has been mistaken for evidence of body removal and low toxicity, which is incorrect: Movsas et al. [16] measured no change in aluminum plasma levels in neonates post-vaccination with no measured excretion in urine, pointing to body burden and tissue toxicity as a highly relevant concern. Aluminum toxicity involves direct disruption of cellular processes, not processes mediated by signals in plasma or blood (e.g. [18,19],). The prolonged duration of body burden of aluminum is especially disconcerting: In a study of rabbits, Flarend et al. [20] found that less than 5% of aluminum hydroxide injected had left the body after 28 days.

Aluminum from vaccines localize to the bone, tying up transferrin (Mitkus, 2011), which is essential for localizing dietary iron to bone marrow for red blood cell production. Thus, pediatric vaccination with aluminum adjuvants may be a concern for anemia. The bone marrow itself is also a key locale for the maturation and functioning of the human immune system; thus immune-cell cytotoxic effects of localized aluminum is a cause for concern. There has been, since 1985, evidence that aluminum enters the brain; the localization of the brain is cause for concern for neurodevelopment [21]. Non-specific conditions associated with aluminum adjuvants include Gulf War Syndrome (Petrik et al. [22]; chronic fatigue syndrome [23], and macrophagic myofasciitis [24]. Specific neurological effects likely due to aluminum toxicity/sensitivity in macrophagic myofascitis include most patients indeed had specific

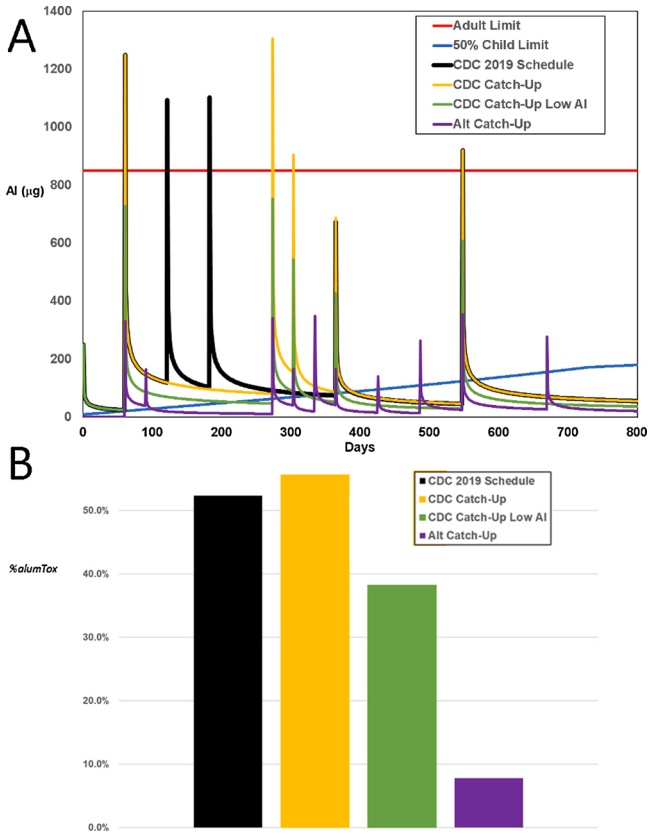

Fig. 6. (A) Use Case 5, Al toxicity birth to 2.2 years. Comparison of 2019 CDC Schedule, no delay, begun at birth, (Black) vs. 2019 CDC schedule begun at birth, stopped at three months, then restarted six months later at 9 months of age, on the CDC Catch-Up Schedule (Yellow) or the two alternative schedules (CDC Catch-Up Low Al (Green) and Alternative Catch-Up Schedule (Purple). (B) Use Case #5, Al exposure birth to 2.2 years. Comparison of 2019 CDC Schedule, no delay, begun at birth, (Black) vs. 2019 CDC schedule begun at birth, stopped at three months, then restarted six months later at 9 months of age, on the CDC Catch-Up Schedule (Yellow) or the two alternative schedules (CDC Catch-Up Low Al (Green) and Alternative Catch-Up Schedule (Purple) (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.).

cognitive deficits, including either (a) both impairment of executive function and selective attention or (b) significant weakness without executive function impairment, well as episodic memory impairment affecting verbal, but not visual, memory [25]. Mounting evidence of persistence of aluminum with multiple points of toxic impact on immune system components provides additional solid ground for concern over chronic toxicity [24].

Our past analyses [11,12] are cause for heightened concern for individuals up to two years on the CDC schedule. We had in our previous study anticipated that the result of McFarland et al. [12] would be conservative; our results now update those results. Here, we have explored the expected effects of CDC's Catch-Up Schedule in comparison to other scenarios. It is clear that the younger the patient, the greater the concern over aluminum toxicity, given the effect of bodyweight, immature kidney function before age 2 years, and the repeated instances of acute toxicity. As children age, the *%AlumTox* is greatly reduced by bodyweight.

Bodyweight dominates the consideration of the effects of delayed vaccination and vaccination re-start. Notably, however in Case 2 (age 18 months start), *%AlumTox* increases from 5% to over 10 % of days. In Case 3 (age 4 years 8 months start), the delayed start under the Catch-Up plans eliminates all of the toxicity experienced under the 2019 CDC schedule from birth to age four, but increases days in toxicity between about ages 4–6 from nearly none to almost 2%. In Case 4 (age 7 years start), the delayed start under the Catch-Up plans eliminates all of the Al toxicity experienced under the 2019 CDC schedule from birth to age seven. There is no aluminum toxicity for children aged 7 and up expected under the 2019 CDC on-time schedule, and the Catch-Up plans lead to less than 0.7 % days in aluminum toxicity.

Bodyweight and intracorporeal aluminum uptake considerations have led to improved understanding of the relative amount of aluminum from food, water, formula and breastmilk relative to vaccines over naïve expectations. The updated knowledge includes that vaccinated infants up to six months of age acquire far more aluminum from vaccines than from food, water and anything made with water such as baby formula [12][26].

One of our results especially indicates a need for an alert on restarting vaccinations. We found that children who begin the 2019 CDC schedule at birth but whose vaccinations are interrupted early (as in Case 5 with six-month delay at three months) can expect more toxicity over their first two years of life on the CDC Catch-Up schedule (56 % days) than on the 2019 CDC schedule (52 % days). The CDC Catch-Up schedule using low-Al containing vaccines lowers aluminum toxicity to 38 % of days, and the alternative schedule that uses only one Al containing vaccine at a time lowers aluminum toxicity further to 7.8 % of days. Pediatricians and public health officials should give this particular result due consideration when approaching patients who have delayed start or interrupted vaccinations due to social distances. Using modeling as we have is possible on a patient-by-patient basis. Such a shift in strategy could have a significant reduction in aluminum-adjuvant related autoimmune conditions and other conditions that are expected from aluminum exposure.

For all scenarios, it is unknown how the timing of spikes of increased toxicity correlating with later rather than earlier stages of immune and neurological development may affect type and severity of associated adverse events.

The American Academy of Pediatrics recommends continuation of vaccination of young, but not older, children in spite of social distancing. Our findings do not support that such a generalization is warranted: due to body weight and kidney function, younger children are at higher risk of acute and chronic aluminum toxicity compared to older children on the 2019 CDC Schedule as well as the CDC Catch-Up plan. The precise risk will vary with the body weight, kidney function, and the specific past experience of a child with past vaccinations and the duration of the hiatus. Our results indicate therefore that older children may be expected to suffer lower rates of adverse events associated with aluminum exposure due to a later start that aligns with higher body weight and improved glomerular filtration rate than younger children, but rule out neither general toxicity from low-dose exposed nor specific instances of severe vaccine adverse events from aluminum in individual older children due to other factors such as aluminum allergy.

Our results also indicate that younger children, given their lower body weights and their kidney function not fully developed until two years of age, are more likely to experience aluminum toxicity compared to their older peers. These considerations assume a body-weight dose-dependency on the risk of autoimmunity and other disorders that may be expected from injections of aluminum hydroxide, which may vary with genetics [12]. Our measure of whole-body aluminum toxicity, *%AlumTox*, is shown to be a sensitive measure responsive to specific differences in the details of individual specific experiences and past lifetime exposures.

5. Limitations

Our study is limited to the pediatric population and did not consider the singular toxicities of newer vaccine adjuvants in adults not found in pediatric vaccines, such as M59 adjuvant in the FLUAD vaccine, and ASO1 in the SHINGRIX vaccine. It does not consider synergistic toxicity between those adjuvants and aluminum, nor between thimerosal doses

from multi-dose influenza vaccines and aluminum, and it does not specifically model individual risk that might vary with genetics.

6. Conclusion

Parents and pediatricians may reasonably reduce the risk of aluminum toxicity in younger children by exploring the use of low-aluminum vaccines, or by spacing aluminum-containing vaccines out across office visits (contrary to CDC's Catch-Up Schedule). Parents and pediatricians charged with healthcare considerations for infants for whom vaccinations have paused because of Covid-19 should exercise caution and perform due diligence by conducting estimates of whole-body burden aluminum toxicity at vaccination re-start. These considerations should include spacing out aluminum-adjuvant containing vaccines and adopting non-aluminum containing vaccine options whenever available.

Author statement

JLW was responsible for the conceptualization of the project and funding acquisition. All authors shared responsibility for the design of the study, the modeling methodology; data curation; formal analysis; investigation; methodology; project administration; resources; software; supervision; validation; visualization; and for the following roles/ writing - original draft; writing - review & editing.

Funding

This study was funded by donations from the public to The Institute for Pure and Applied Knowledge.

Declaration of Competing Interest

Dr. Lyons-Weiler has served as an expert witness in the National Vaccine Injury Compensation Program.

Grant McFarland and Elaine La Joie have not conflicts of interest to report.

References

[1] AAP, COVID-19 Clinical Guidance Q&A, 2020 last visited 4/19/2020, https://services.aap.org/en/pages/covid-19-clinical-guidance-q-a/.
[2] G.G. Wolff, Influenza vaccination and respiratory virus interference among Department of Defense personnel during the 2017-2018 influenza season, Vaccine 38 (2) (2020) 350–354.
[3] J. Lyons-Weiler, Pathogenic priming likely contributes to serious and critical illness and mortality in COVID-19 via autoimmunity, J Transl Autoimmun 3 (2020) 100051, https://doi.org/10.1016/j.jtauto.2020.100051.
[4] F. Cappello, A.M. Gammazza, F. Dieli, et al., Does SARS-CoV-2 trigger stress-induced autoimmunity by molecular mimicry? A hypothesis, J. Clin. Med. 9 (7) (2020) 2038, https://doi.org/10.3390/jcm9072038 (2020).
[5] R.T. Chen, J.W. Glasser, P.H. Rhodes, et al., Vaccine Safety Datalink project: a new tool for improving vaccine safety monitoring in the United States, The Vaccine Safety Datalink Team. Pediatrics 99 (6) (1997) 765–773.
[6] National Academy of Sciences, Institutes of Medicine, The Childhood Immunization Schedule and Safety: Stakeholder Concerns, Scientific Evidence, and Future Studies (2013), 20001, The National Academies Press, Washington, DC, 2013, http://nap.edu/13563.
[7] N.Z. Miller, Combining childhood vaccines at one visit is not safe, J. Am. Phys. Surgeons 21 (2016) (2016) 47–49.
[8] K.M. Kelly-Scumpia, D.C. Nacionales, P.O. Scumpia, et al., In vivo adjuvant activity of the RNA component of the Sm/RNP lupus autoantigen, Arthritis Rheum. 56 (2007) 3379–3386.
[9] M. Yasar, Y. Savranlar, H. Karaman, et al., Effects of propolis in an experimental rat model of allergic rhinitis, Am. J. Otolaryngol. 37 (2016) 287–293.
[10] M.G. Elsakkar, O.A. Sharaki, D.M. Abdallah, Adalimumab ameliorates OVA-induced airway inflammation in mice: role of CD4(+) CD25(+) FOXP3(+) regulatory T-cells, Eur. J. Pharmacol. 786 (2016) 100–108.
[11] J. Lyons-Weiler, R. Ricketson, Reconsideration of the immunotherapeutic pediatric safe dose levels of aluminum, J. Trace Elem. Med. Biol. 48 (2018) 67–73, https://doi.org/10.1016/j.Jtemb.2018.02.025. PMID = 29773196.
[12] G. McFarland, E. La Joie, P. Thomas, J. Lyons-Weiler, Acute exposure and chronic retention of aluminum in three vaccine schedules and effects of genetic and environmental variation, J. Trace Elem. Med. Biol. 58 (2020) 126444, https://doi.org/10.1016/j.jtemb.2019.126444.
[13] R. Hoseini, H. Otukesh, N. Rahimzadeh, S. Hoseini, Glomerular function in neonates, Iran. J. Kidney Dis. 6 (3) (2012) 166–172.
[14] J. Redgrove, I. Rodriguez, S. Mahadevan-Bava, C. Exley, Prescription infant formulas are contaminated with aluminium, Int. J. Environ. Res. Public Health 16 (5) (2019) 899, https://doi.org/10.3390/ijerph16050899 (2019), https://pubmed.ncbi.nlm.nih.gov/30871123/.
[15] US Centers for Disease Control and Prevent, Immunization Schedules: Table 2. Catch-up Immunization Schedule for Persons Aged 4 Months–18 Years Who Start Late or Who Are More Than 1 Month Behind, United States, 2020, 2020. Last accessed 4/13/2020, https://www.cdc.gov/vaccines/schedules/hcp/imz/catchup.html.
[16] T.Z. Movsas, N. Paneth, W. Rumbeiha, J. Zyskowski, I.H. Gewolb, Effect of routine vaccination on aluminum and essential element levels in preterm infants, JAMA Pediatr. 167 (9) (2013), https://doi.org/10.1001/jamapediatrics.2013.108, 870-2.
[17] R.J. Mitkus, D.B. King, M.A. Hess, et al., Updated aluminum pharmacokinetics following infant exposures through diet and vaccination, Vaccine 29 (2011) 9538–9543, https://doi.org/10.1016/j.vaccine.2011.09.124.
[18] S. Han, J. Lemire, V.P. Appanna, C. Auger, Z. Castonguay, V.D. Appanna, How aluminum, an intracellular ROS generator promotes hepatic and neurological diseases: the metabolic tale, Cell Biol. Toxicol. 29 (2013) 75–84. https://www.ncbi.nlm.nih.gov/pubmed/23463459.
[19] J. Lemire, R. Mailloux, S. Puiseux-Dao, V.D. Appanna, Aluminum-induced defective mitochondrial metabolism perturbs cytoskeletal dynamics in human astrocytoma cells, J. Neurosci. Res. 87 (2009) 1474–1483.
[20] R.E. Flarend, S.L. Hem, J.L. White, D. Elmore, M.A. Suckow, A.C. Rudy, E. A. Dandashli, In vivo absorption of aluminium-containing vaccine adjuvants using 26Al, Vaccine 15 (12-13) (1997) 1314–1318.
[21] M.D. Mold, A. Umar, A. King, C. Exley, Aluminium in brain tissue in autism, J. Trace Elem. Med. Biol. 46 (2018) 76–82, https://doi.org/10.1016/j.jtemb.2017.11.012.
[22] M.S. Petrik, M.C. Wong, R.C. Tabata, R.F. Garry, C.A. Shaw, Aluminum adjuvant linked to Gulf War Illness induces motor neuron death in mice, Neuromolecular Med. 9 (1) (2007) 83–100. PMID = 17114826.
[23] G. Crépeaux, R.K. Gherardi, F.J. Authier, ASIA, Chronic fatigue syndrome, and selective low dose neurotoxicity of aluminum adjuvants, J. Allergy Clin. Immunol. Pract. 6 (2) (2018) 707, https://doi.org/10.1016/j.Jaip.2017.10.039. PMID=29525002.
[24] R.K. Gherardi, G. Crépeaux, F.J. Authier, Myalgia and chronic fatigue syndrome following immunization : macrophagic myofasciitis and animal studies support linkage to aluminum adjuvant persistency and diffusion in the immune system, Autoimmun. Rev. 18 (7) (2019) 691–705, https://doi.org/10.1016/j.Autrev. PMID = 31059838.
[25] M.A. Sebaiti, P. Kauv, A. Charles-Nelson, et al., Cognitive dysfunction associated with aluminum hydroxide-induced macrophagic myofasciitis: a reappraisal of neuropsychological profile, J. Inorg. Biochem. 181 (2018) (2018) 132–138.
[26] J.G. Dórea, Exposure to mercury and aluminum in early life: developmental vulnerability as a modifying factor in neurologic and immunologic effects, Int. J. Environ. Res. Public Health 12 (2015) 1295–1313, https://doi.org/10.3390/ijerph120201295.
[27] E. Hlavinka, Pediatricians 'Color Outside the Lines' in COVID-19 Pandemic — but great reduction in patient visits takes economic toll, MedPage Today (2020) (Infectious Disease), https://www.medpagetoday.com/infectiousdisease/covid19/85692, visited 4/13/2020.
[28] US HHS, VAERS, Vaccine Adverse Event Reporting System, 2020. https://vaers.hhs.gov/data.html.