Supplementary Table 1. Cited Studies of Metal Inhalation or Intranasal Instillation in Relation to Impacts on Shared Characteristics of Neurodevelopmental Disorders and Neurodegenerative Diseases.

Study	Metal	Species and Sex	Route of Exposure	Exposure Parameters	Effects
Wang et al., 2007	Fe	male CD-ICR mice	Intranasal instillation	40 mg Fe_2O_3/kg 280 nm	Increased Fe in olfactory bulb and trigeminus of brain stem; neuronal fatty degeneration in CA3 region of hippocampus
Wu et al., 2013	Fe	4 wk old male Sprague Dawley rats	Intranasal instillation	20 ug Fe3O4 for 6 consecutive days 30 nm	Increased Fe in olfactory bulb, hippocampus, striatum, cortex and cerebellum with > 50% still evident 14 days post-instillation. Increase in oxidative damage markers in striatum and hippocampus
Wang et al., 2016	Fe	male CD-ICR mice	Intranasal instillation	40 mg Fe_2O_3/kg 40 vs. 280 nm	Size- and time-dependent translocation pattern; particle-like substances identified in olfactory bulb axons and in hippocampal mitochondria and lysosomes; self-coating of nanoparticles with apotransferrin occurred in brain
Sutunkova et al., 2016	Fe	Outbred white female rats	Nose only inhalation	1.14 mg/m3 Fe_2O_3 14 nm for 4 hr/day 5 days/week for 3, 6 or 10 mos	NPs located within myelin sheath in brain
Hopkins et al., 2018	Fe	Adult female C57B6 mice	Whole body inhalation	40 $\mu g/m^3$ Fe_2O_3 6hr/day 5 days/week for 5 weeks	Fe reached brain via olfactory nerves; increased ratio of activated to resting microglia
Askri et al., 2018	Fe	Male Wistar rats	Intranasal instillation	10 mg/kg Fe_2O_3 day for 7 days 30 nm	Marked increases in brain dopamine and norepinephrine levels but no changes in anxiety-like behavior or learning/memory
Lubcynska et al., 2017	Fe	Children 1-9 yr of age	Ambient airborne	50-500 ng/m^3	Inverse association between Fe and fine motor function
Zhang et al., 2012	Cu	Female CD-1 (ICR) mice	Intranasal instillation	Purchased Cu NPs at 1 or 40 mg/kg body weight instilled 7 or 10 times 23 nm	Alterations in dopaminergic function in striatum, olfactory bulb, hippocampus, cerebral cortex, and cerebellum and in serotonergic function in olfactory bulb, hippocampus, cerebral cortex and cerebellum
Liu et al., 2014	Cu	Female CD-1 (ICR) mice	Intransal instillation	Purchased Cu NPs at 1 or 40 mg/kg body weight for administered 3 times in 5 days 23 nm	Mitochondrial shrinkage in olfactory cells and dissociation of endoplasmic reticulum ribosomes in hippocampus; increased numbers of astrocytes in CA1 region of hippocampus
Bai et al., 2014	Cu	Female CD-1 (ICR) mice	Intranasal instillation	Purchased Cu NPs at 1 or 40 mg/kg body weight instilled 21 times 23 nm	Altered distribution of brain trace elements; reductions in neurons in
Pujol et al., 2016	Cu	8-12 year old children	Ambient airborne	Mean of 8.7 ng/m^3	Airborne Cu was associated with poorer motor performance and incomplete development of basal ganglia

Alemany et al., 2017	Cu	7-12 year old children	Ambient airborne	Mean of 7.8 ug/m^3	Indoor Cu was associated with inattentiveness especially in children with modifications of the *ATP7B* gene
Persson et al., 2003	Zn	Male Sprague Dawley Rats	Intranasal instillation	$ZnCl_2$ 0.03 μg (5 μCi) per 10 μl	Uptake in olfactory epithelium along primary olfactory neurons to olfactory bulb where Zn found bound to cellular and cytosolic constituents, including metallothionein
Kao et al., 2012	Zn	Male Sprague Dawley rats	Whole body chamber	ZnO for 4 hr on 3 consecutive days = 2 x 10^6, 3.4 x 10^6 and 6.6 x 10^6 particles/cm^3 14 nm	Demonstrates olfactory bulb-brain translocation requiring endocytosis for interneuron translocation of particles
Liu et al., 2020	Zn	Male Wistar rats	Intranasal instillation	ZnO NPs at 20 μg/body weight for 5, 10 or 15 days	Deposition of Zn in olfactory bulb, and striatum; increases in malondialdehyde, TNF-α and IL-1β and decreased glutathione in multiple brain regions; swollen mitochondria and Golgi apparatus and particle deposition in nerve fibers in olfactory bulb; vacuolated mitochondria and cell degeneration in hippocampus, reduction in mitochondrira and particles in nerve fibers in striatum and cerebral cortex
Dorman et al., 2002	Mn	Male CD rats	Nose only	$MnHPO_4$ 0.39 mg $^{54}Mn/m^3$ 1.68 μm	Mn uptake via olfactory route
Normandin et al., 2002	Mn	Male Sprague Dawley rats	Whole body inhalation	$MnPO_4$ at 30, 300 or 3000 ug/m^3 for 6 hr/day for 5 day/week for 13 weeks ≤ 6 um	Increase in Mn in all brain regions. No effect on neuronal loss in caudate/putamen or globus pallidus, nor in locomotor activity or tremor assessment
Dobson et al., 2003	Mn	Male Crl:CD (SD)BR rats	Whole body inhalation	$MnSO_4$ at 0.03, 0.3, or 3.0 ug/m^3 for 6 hr/day for 7 day/week for 2 weeks 1.5-2 um	Increased glutamine synthetase in olfactory bulb and hypothalamus at medium and high doses; reductions in glutathione and increase in metallothionein mRNA in hypothalamus
Dorman et al., 2004	Mn	Male and female CD rats	Whole body inhalation	$MnSO_4$ at 0.01, 0.1, or 0.5 mg Mn m^3 for 6 hr/day 5 day/week for 90 days; ~2 um	Young male olfactory bulb Mn concentrations > young female or aged male
Erikson et al., 2004	Mn	Male and female CD rats	Whole body inhalation	$MnSO_4$ at 0.01, 0.1, or 0.5 mg Mn m^3 for 6 hr/day 5 day/week for 90 days; ~2 um	Sex- and dose-dependent alterations in glutamine synthetases and glutathione levels in cerebellum, hippocampus, hypothalamus, olfactory bulb and striatum
Lewis et al., 2005	Mn	Male and female Fischer 344/N rats and FVB/N mice	Nose only	$MnCl_2$ at 2.3 mg/m^3 for rat and 2.0 mg/m^3 for mice for 6 hr/day for 5 days/week for 10 days;	Uptake in trigeminal nerve of both mice and rats with clearance half-time of 7-8 days

				3.1 μm for rat and 1.98 μm for mice	
Erikson et al., 2005	Mn	Male and female CD rats	Whole body inhalation	$MnSO_4$ at 0.05, 0.5 or 1.0 mg Mn/ m^3 from gestational day 0 to postnatal day 19 for 6 hr/day for 7 days/week; ~2 um	Region- and sex-dependent alterations in glutamine synthetase, glutathione, metallothionein and tyrosine hydroxylase that persisted at least to 3 weeks post-exposure
Tapin et al., 2006	Mn	Male Sprague Dawley rats	Whole body inhalation	$MnSO_4$ at 30, 300 or 3000 ug/m^3 for 6 hr/day for 5 day/week for 13 weeks ≤ 6 um	Reductions in neurons in globus pallidus at two highest doses; reductions in locomotor activity and total ambulatory count reduced at all 3 doses.
Elder et al., 2006	Mn	Male Fischer 344 rats	Intranasal inhalation	MnO at ~500 ug/m^3 for 6 hr/day 5 days/week for 11 or 12 days	Increased Mn in olfactory bulb as well as in striatum, frontal cortex and cerebellum as well as increases in TNF-α mRNA and protein, MIP-2, GFAP and neuronal cell adhesion molecule mRNA in olfactory bulb
Dorman et al., 2006	Mn	Rhesus monkeys	Whole body inhalation	$MnSO_4$ at 0.06, mg Mn/ m^3 for 6 hr/day for 5 days/week for 65 days; ~1-2 um	Direct olfactory transport in a non-human primate
Erikson et al., 2006	Mn	Male and female CD rats	Whole body inhalation	$MnSO_4$ at 0.05, 0.5 or 1.0 mg Mn/ m^3 from gestational day 0 to postnatal day 19 for 6 hr/day for 7 days/week; ~2 um	Region-dependent alterations in glutamine synthetase, glutathione, metallothionein and tyrosine hydroxylase (not differentiated by sex
Erikson et al., 2007	Mn	Rhesus monkeys	Whole body inhalation	$MnSO_4$ at 0.06, 0.3 or 1.5 mg Mn/ m^3 for 6 hr/day for 5 days/week for 65 days; ~2 um	Brain region-dependent alterations in metallothionein, glutamate transporters, glutathione and tyrosine hydroxlase
Erikson et al., 2008	Mn	Rhesus monkeys	Whole body inhalation	$MnSO_4$ at 1.5 mg Mn/m^3 for 6 hr/day 5 days/week for 15, 33 or 65 days; ~2 um	Brain region-dependent alterations in metallothionein, glutamate transporters and glutathione levels, and reductions in tyrosine hydroxylase protein levels in globus pallidus
Colin-Barenque et al., 2011	Mn	Male CD-1 mice	Whole body inhalation	0.02 M $MnCl_2$ 1 hr 2x/week for 12 weeks	Swelling of mitochondria, endoplasmic reticulum and Golgi apparatus, nuclear invaginations and vacuolization of olfactory neurons; increases in apoptosis and necrosis of olfactory bulb neurons
Moberly et al., 2012	Mn	Male and female OMP-spH mice	Intranasal instillation	Single exposure to 2-200 μg $MnCl_2$	Reduction in odorant-evoked neurotransmitter release even at 2 μg $MnCl_2$
Sanchez-Betancourt et al., 2012	Mn	Male Wistar rats	Whole body inhalation	0.04 M $MnCl_2$ and 0.02 M Mn $(OAc)_3$ for 1 hr 3x week for 6 mos; droplets in a 0.5-5 um range	Reductions in beam walking and single pellet reaching behaviors and 76% loss of dopaminergic neurons in substantia nigra pars compacta but not in globus pallidus or striatum

Carvalho et al., 2014	Mn	7-12 year old children	Ambient airborne	Mn hair measurement of 11.48 μg/g	Hair Mn was inversely associated with IQ and measures of inhibition responses, strategic visual information and verbal working memory
Saputra et al., 2016	Mn	Male Sprague Dawley rats	Nose only inhalation	$MnCl_2$ at 39 mg/m^3 for 4 hr day for 5 days/week for 3 weeks; 1.2 um	Alterations in dopamine transporter and dopamine receptor protein expression levels in striatum; no effect on rotarod
Foster et al., 2018	Mn	Male F344 rats	Intranasal instillation	40 μL of a 200 mM solution of $MnCl_2$	Reduction in olfactory discrimination; inflammation of olfactory epithelium
Yargicoglu et al., 1999	S	Male Swiss albino rats	Whole body inhalation	SO_2 at 10 ppm for 1 hr/day for 7 days/wk for 6 wks	Increased brain levels of Cu,Zn-SOD activity and thiobarbituric acid reactive substances and decreased brain levels of glutathione peroxidase
Kilic, 2003	S	Male Swiss albino rats	Whole body inhalation	SO_2 at 10 ppm for 1 hr/day for 7 days/wk for 6 wks	Increased brain levels of Cu,Zn-SOD activity and thiobarbituric acid reactive substances and decreased brain levels of glutathione peroxidase; altered visual evoked potentials
Meng and Zhang, 2003	S	Male and female Kunming albino mice	Whole body inhalation	SO_2 at 22, 56 or 112 mg /m^3 for 6 hr/day for 7 days	Sex- and concentration-dependent increases in brain thiobarbituric acid reactive substances and reductions in glutathione
Meng, 2003	S	Male and female Kunming albino mice	Whole body inhalation	SO_2 at 56 mg /m^3 for 6 hr/day for 7 days	Significant reduction in brain in superoxide dismutase and glutathione peroxidase and glutathione, increased thiobarbituric acid reactive substances
Wu and Meng, 2003	S	Male Kunming albino mice	Whole body inhalation	SO_2 at 22, 64 or 148 mg /m^3 for 6 hr/day for 7 days	Dose-dependent changes in brain in glutathione-S-transferase and glucose-6-phosphate dehydrogenase with reductions in glutathione
Meng et al., 2005	S	Male Kunming albino mice	Whole body inhalation	SO_2 at 1.25, 28 or 56 mg /m^3 for 4 hr/day for 7 days	SO_2 inhalation results in transformation to sulfite that accumulates in brain
Meng and Liu, 2007	S	Male Kunming albino mice	Whole body inhalation	SO_2 at 28 or 56 mg /m^3 for 4 hr/day for 7 days	Observations of damage to cerebral cortical neurons, glia and fibers
Qin et al., 2012	S	Male Wistar rats	Whole body inhalation	SO_2 at 3.5, 7 or 14 or 56 mg /m^3 for 4 hr/day for 30 days	Increased mitochondrial biogenesis in cerebral cortex
Yun et al., 2013	S	Male Wistar rats	Whole body inhalation	SO_2 at 3.5 or 7 mg /m^3 for 6 hr/day for 90 days	Inhibition of markers of synaptic plasticity in hippocampus in aged rats with opposite
Yao et al., 2014	S	Male Wistar rats	Whole body inhalation	SO_2 at 3.5 or 7 mg /m^3 for 6 hr/day for 4 weeks or 14 or 28 mg /m^3 for 6 hr/day for 1 week	Differential synaptic injury caused by 1 week vs. 4 week exposure, with inhibition of Arc and glutamate receptors in both 1 and 4 week exposures, but increases in synaptophysin, PSD-95, PKA and PKC only in the 1 week group.
Yao et al., 2015	S	Male Wistar rats	Whole body inhalation	SO_2 at 3.5 or 7 mg /m^3 for 6 hr/day for 90 days	Reductions in target crossing and time spent in target quadrant, in glutamate receptor mRNA in hippocampus and PKA and PKC; increased levels of cytokines in hippocampus

Rollin et al., 1991	Al	Adult female SPF New Zealand white rabbits	In home cage 'dusting'	Al_2O_3 at 0.56 mg Al/m^3 for 8 hr/day 5 days/week for 5 mos	Preferential accumulation of Al in brain relative to kidney, heart or bone
Kwon et al., 2013	Al	Male Sprague Dawley rats	Intranasal instillation	Al NPs at 1, 20 or 40 mg/kg body weight administered every other day for 3 days; 5-100 nm	Al can be taken up by olfactory bulb and distribute to other brain regions where it modulates gene and protein expression of MAPK and its activity
Zhang et al., 2015	Al	Male and female ICR mice	Whole body exposure	Al_2O_3 NPs at 0.5 mg/m^3 for 6 hr/day for 28 days; ~40 nm	Females exhibited increased immobility in a forced swim test; alterations in cortex of both sexes in neurotransmitter and voltage-gated gene expression and metabolomic analyses related to glutamate
Parveen et al., 2017	Si	Male Wistar rats	Intranasal instillation	Si NPs at 150 μg/50 μL daily for 30 days; 80 or 10 nm	Increases in malondialdehyde, H_2O_2, NF-κB, TNF-α, IL-1βand MCP-1 and reductions in glutathione, superoxide dismutase, catalase in cortex, striatum and hippocampus
Lebedova et al., 2018	Pb	Adult female ICR mice	Whole body inhalation	PbO NPs at 406.6 μg/m^3 for 4, 12, 24 or 72 hr or 39.1 or 192.5 μg/m^3 for 24 hr/day 7 days/week for 1, 3, 7 or 11 weeks; 7.64-120 nm	Spongiform changes typical of degeneration in hippocampus including neuronal vacuolization and increase in necrotic neurons after high concentration for 11 weeks
Blahova et al., 2019	Pb	Adult female ICR mice	Whole body inhalation	PbO NPs at 192.5 μg/m^3 for 24 hr/day 7 days/week for 2, 5, 13 or 11 weeks;	Uptake via olfactory nerve; longer exposures increased lipid peroxidation in brain
Sutunkova et al., 2020	Pb	Outbred white female rats from institutional breeding colony	Nose only inhalation	PbO at 1.3 mg/m^3 for 4 hr/day for 5 days/week	Particle deposition in olfactory bulb; no change in locomotor activity; increase in temporal summation of sub-threshold indices in neurobehavioral test, otherwise undefined