

# Quantifying the release of silver from nanotechnology-based consumer products for children

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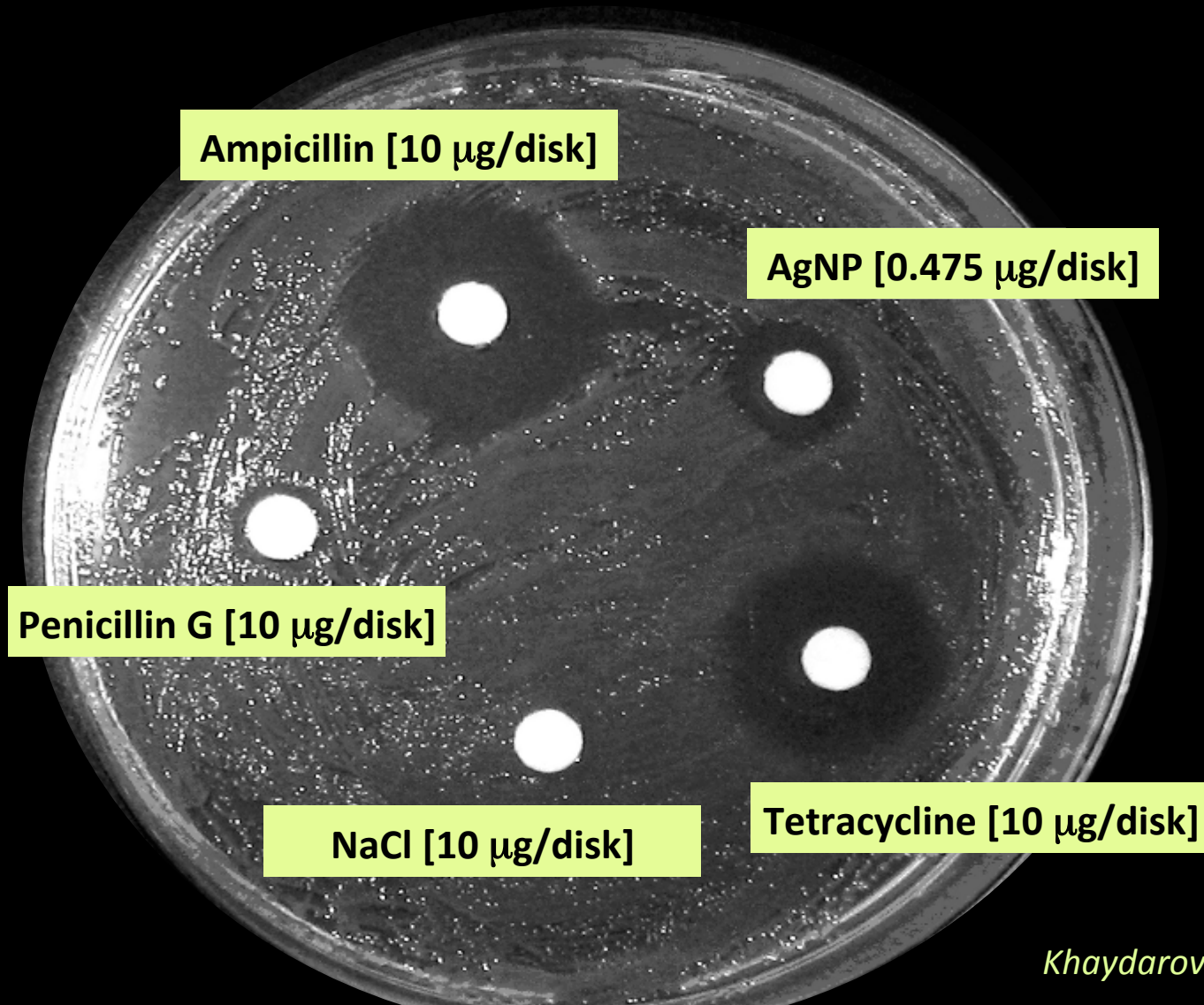
<sup>3</sup>U.S. Consumer Product Safety Commission



QEEN Workshop  
7 July 2015

# Nanosilver has antimicrobial properties

Growth inhibition in *E. coli* K12 culture:

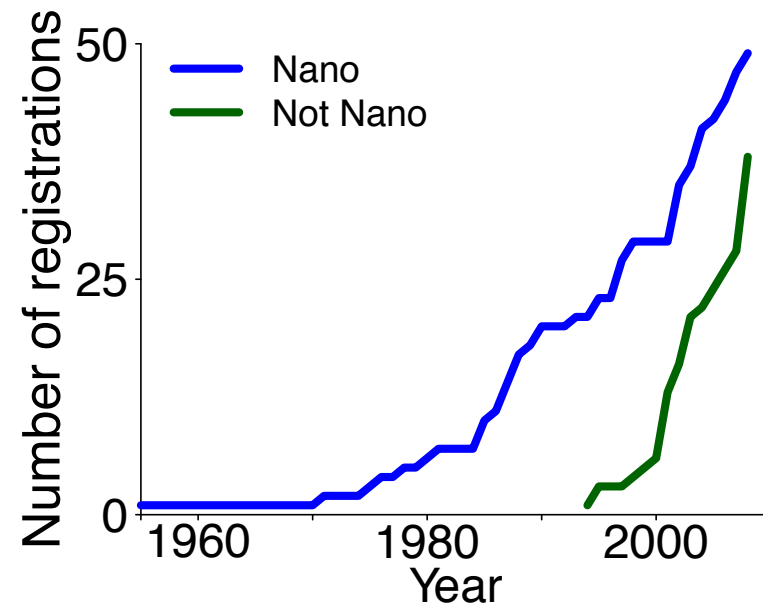


# Nanosilver: one of the most popular nanomaterials

Hundreds of consumer products



Registration of biocidal silver products in the U.S.



\*Not nano: ionic silver, macro-scale, unknown.  
*Adapted from Nowack et al. (2011)*

Project on Emerging Nanotechnologies compiled 1800+ “nanoproducts”  
and 400+ silver nanoproducts

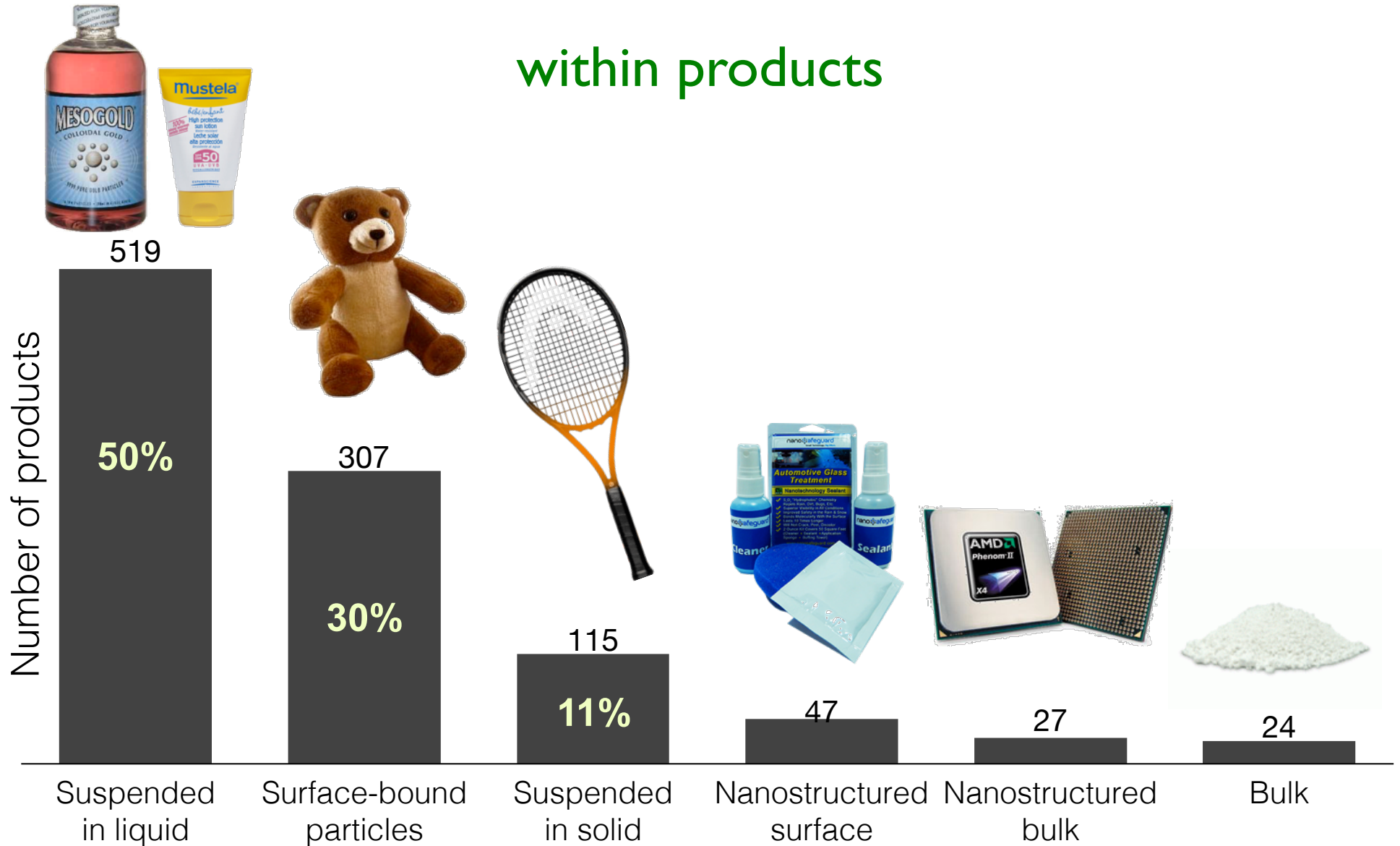
# Major Nanomaterial Compositions (in numbers of consumer products)



Number of products

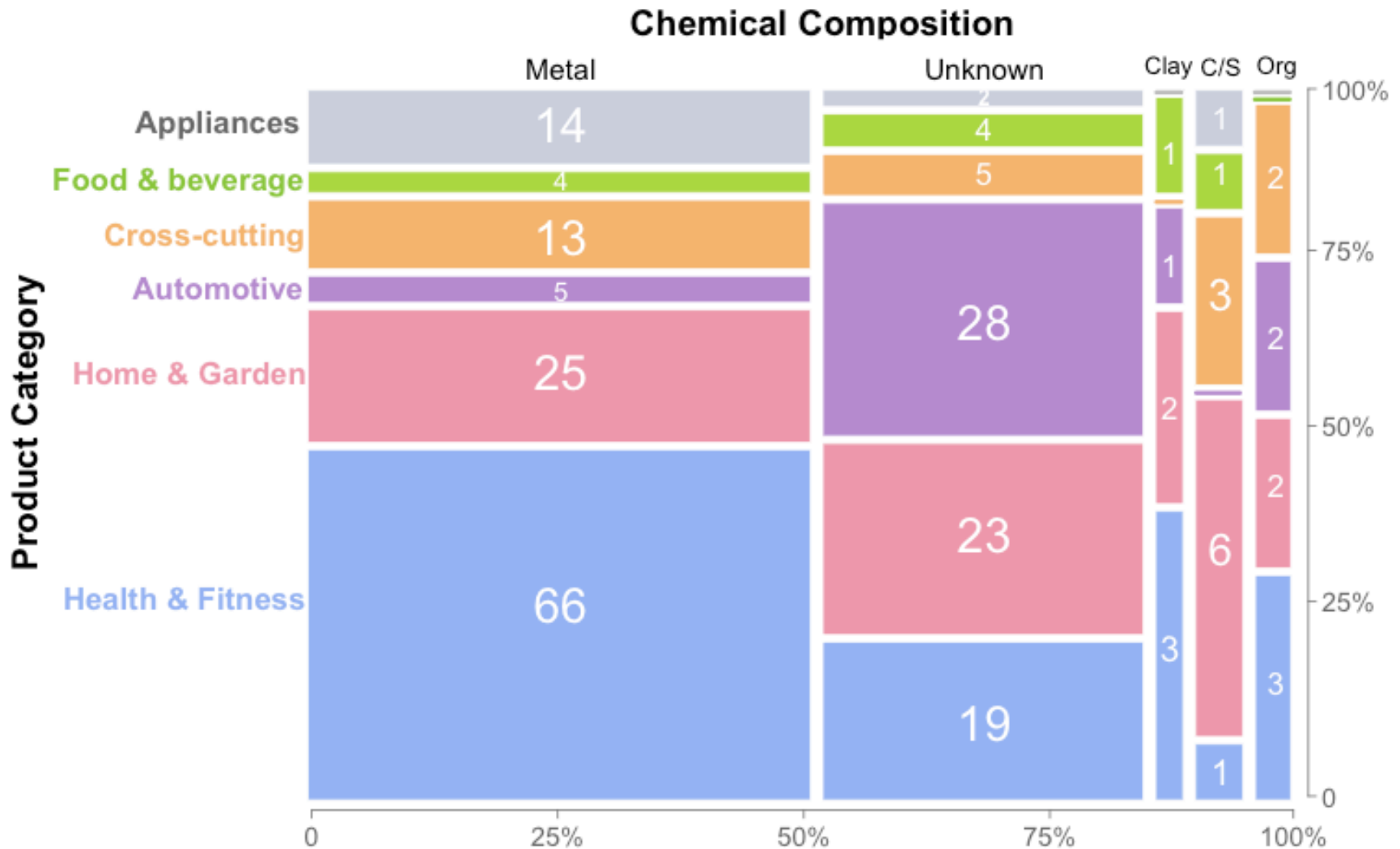


# Locations of nanomaterials within products



Vance et al.  
BJNano, Submitted

# Consumer products with inhalation potential (consumer exposure in indoor environments)



# Children are at higher risk than adults

- Higher surface area to body mass ratio
- Higher metabolic rate
- Organs and tissues are still under development
- Hand-to-mouth activity
- More years ahead of them to develop health conditions from chronic exposure

*Becker et al. (2010), Xue et al. (2007), Cohen  
Hubal et al. (2000)*

# Children's consumer product inventory

Compiled an inventory with 82 products.

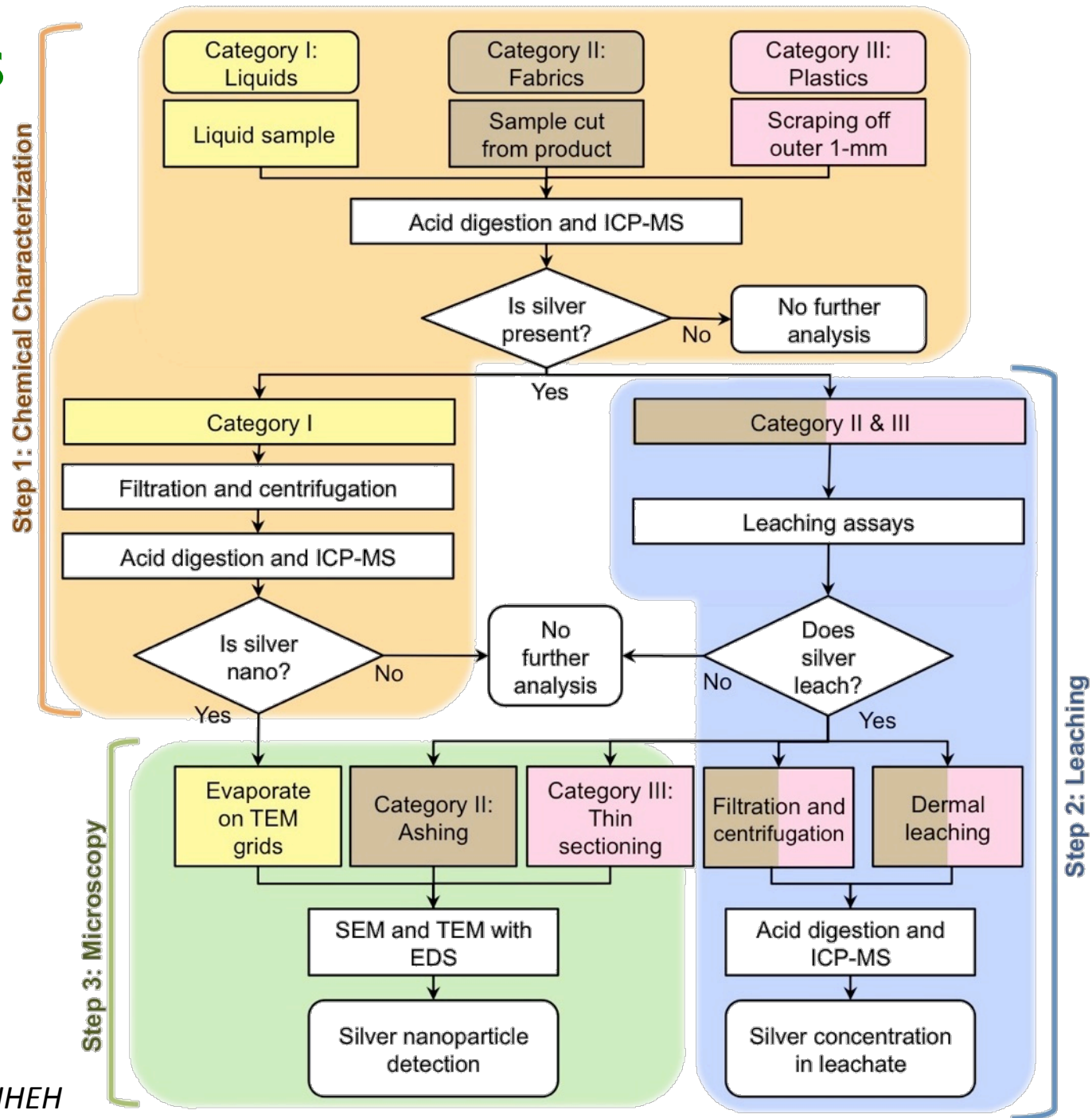
14 products were selected and 13 were purchased:

- Stuffed bear
- Textiles (clothing, blanket, mitts)
- Breast milk storage bags
- 2 sippy cups
- Disinfecting spray
- Surface wipes
- Scrubber sponge
- Humidifiers





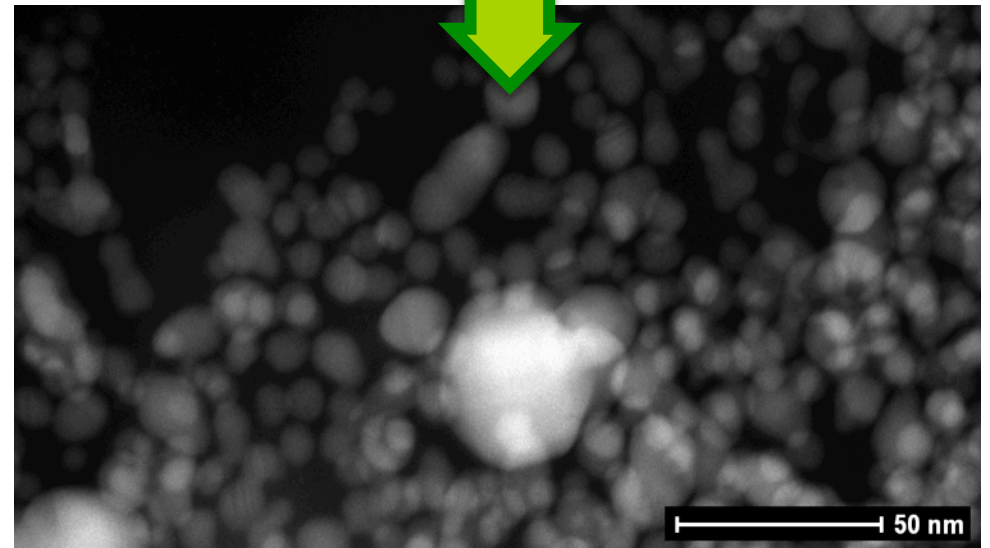
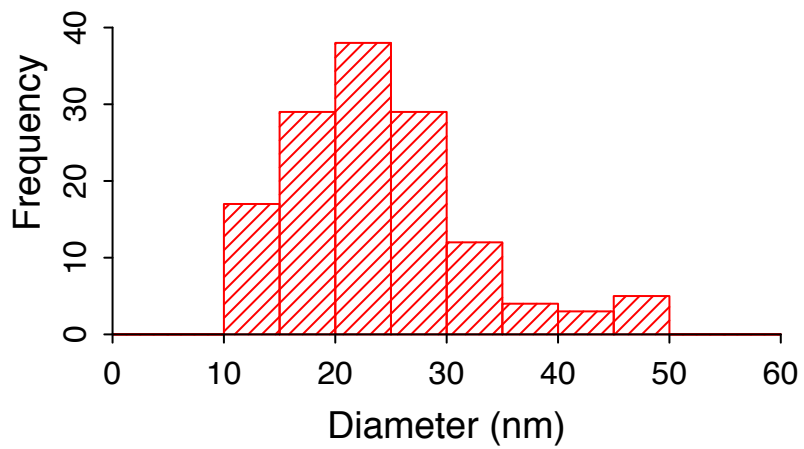
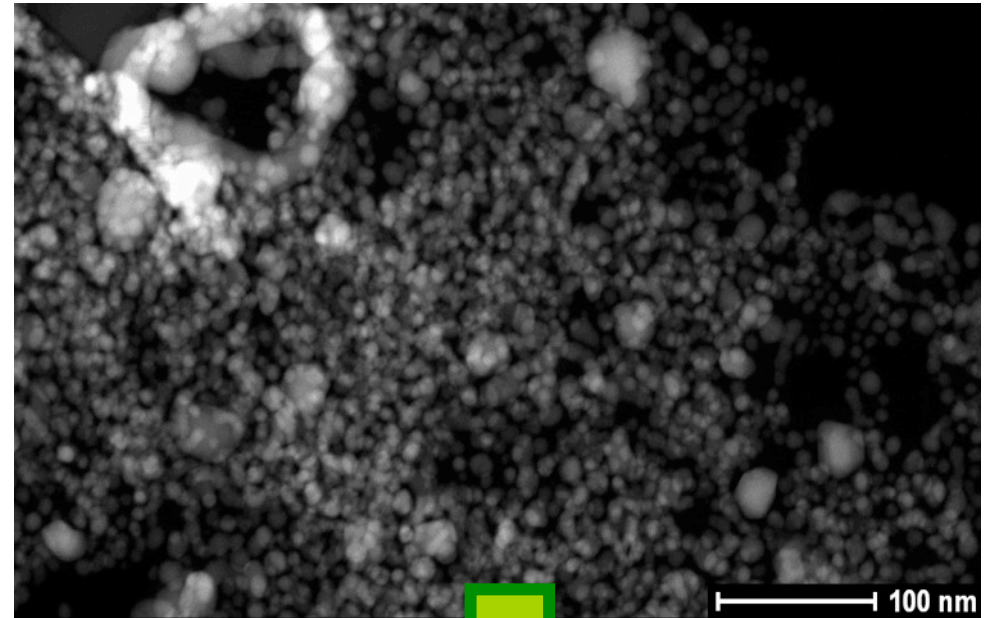
# Methods





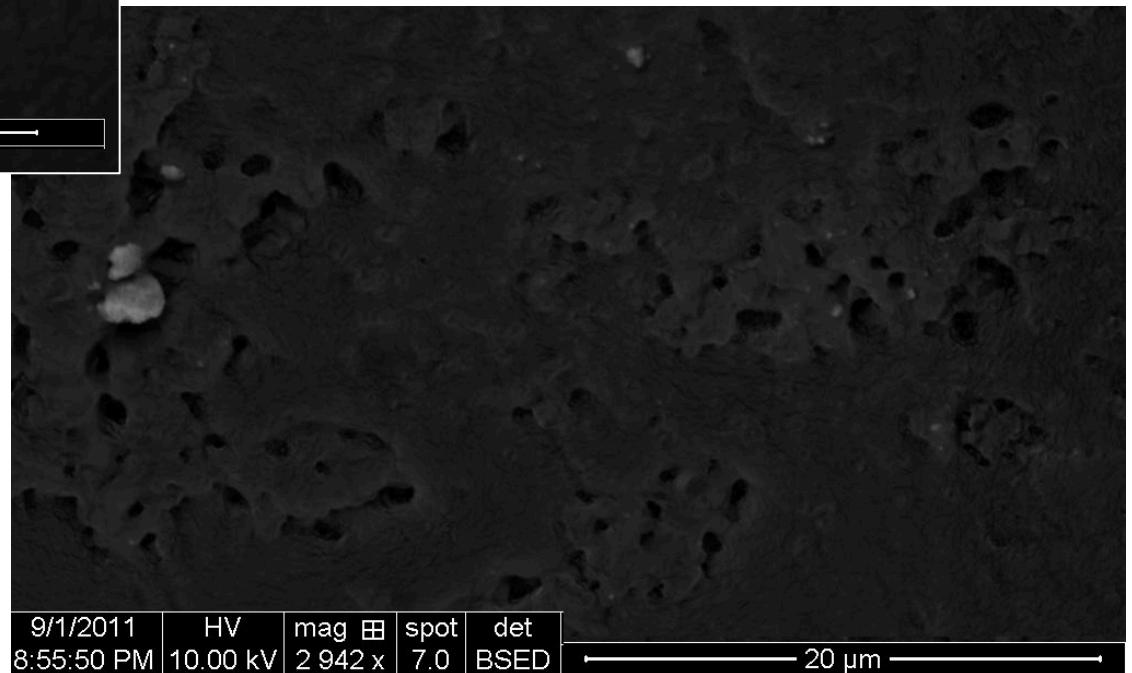
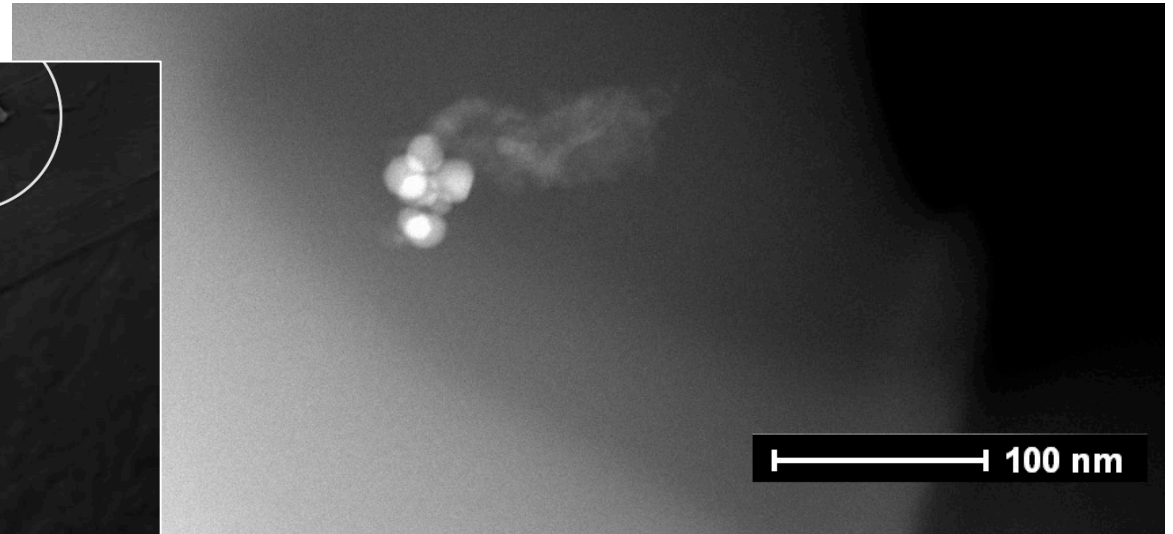
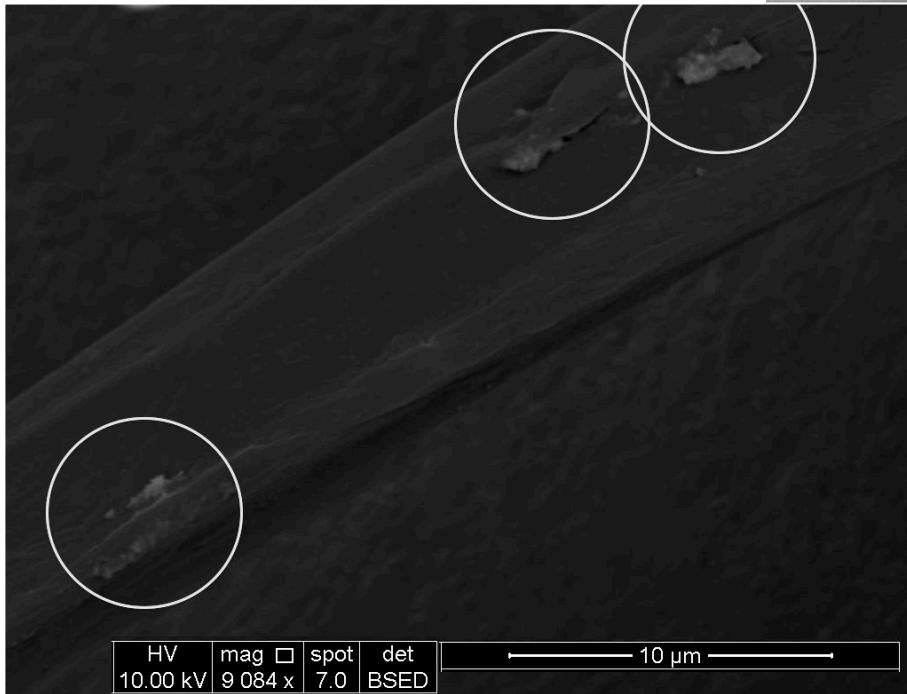


# Results: baby blanket

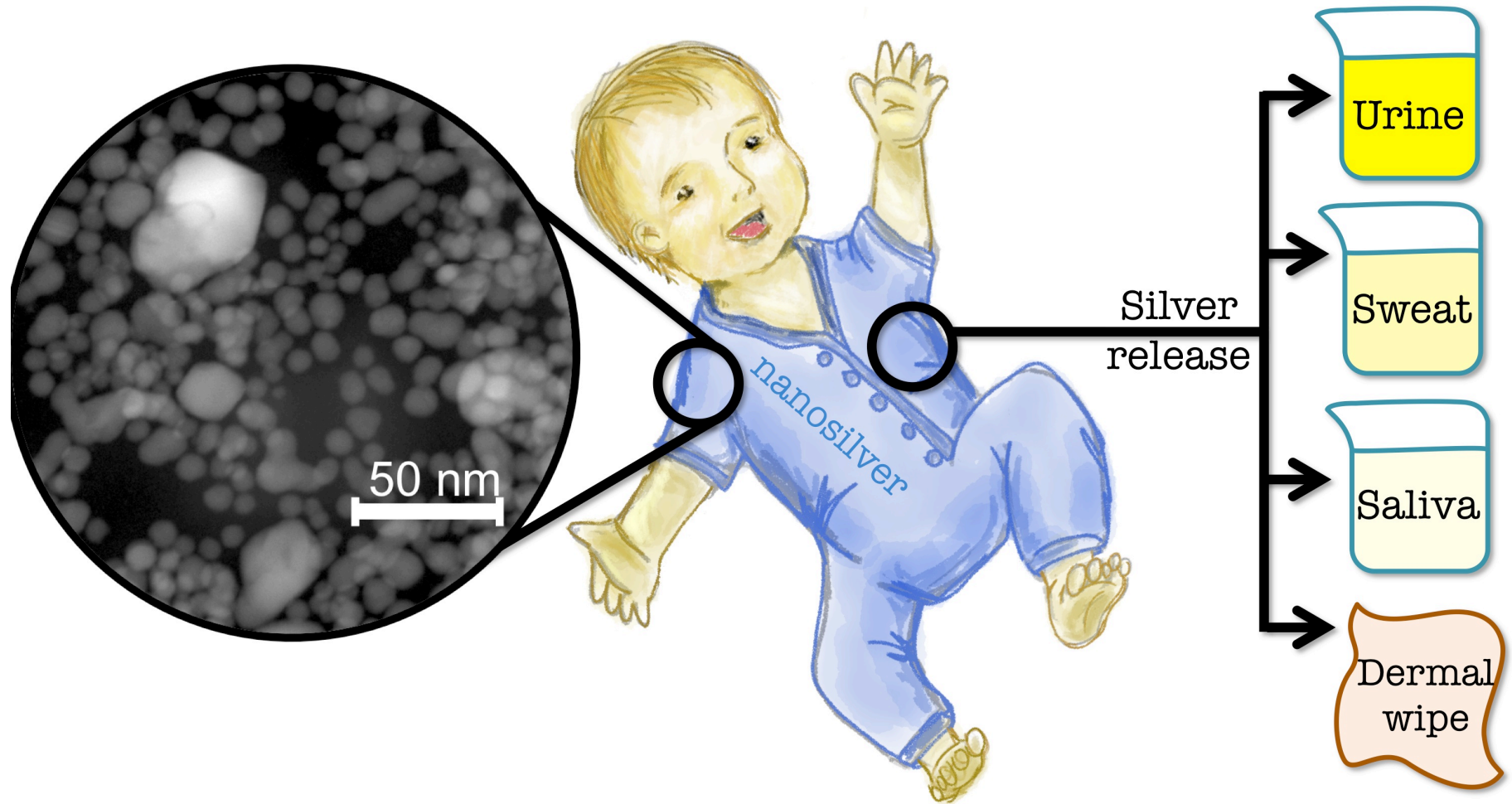




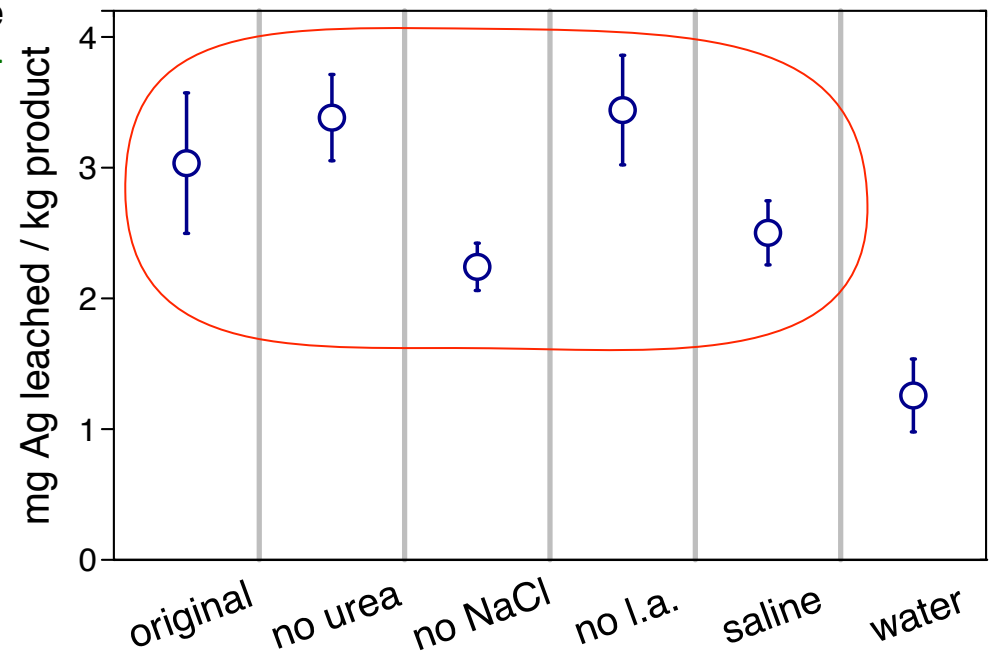
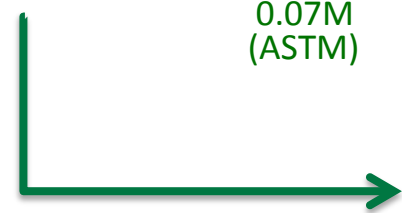
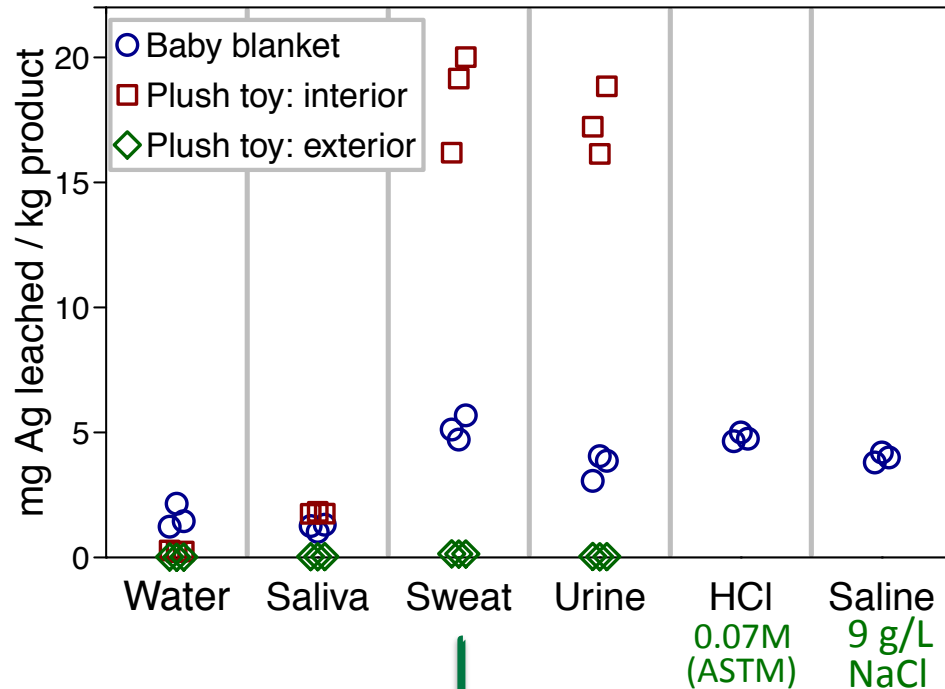
# Results: plush toy



# Exposure to biological liquid media (likely usage scenarios)



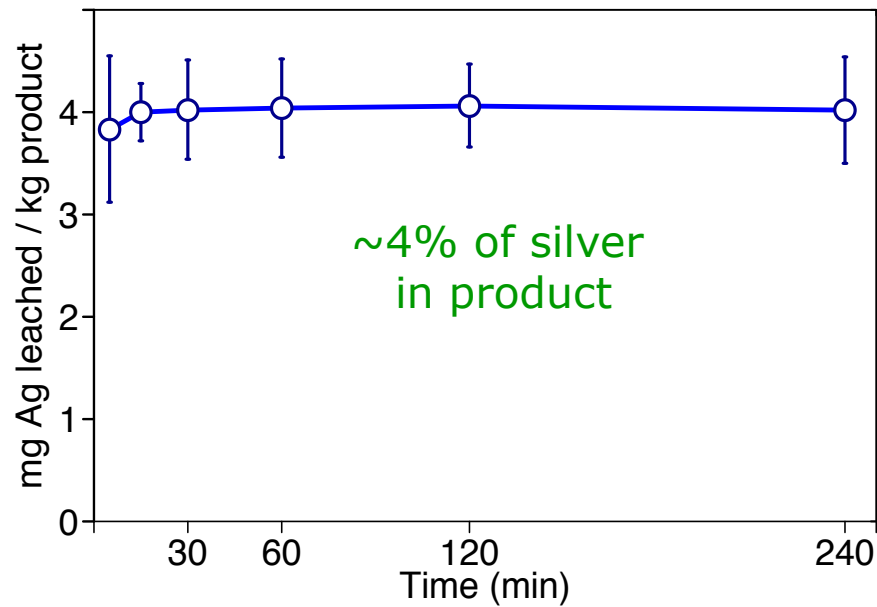
# Results: silver leaching into biological media



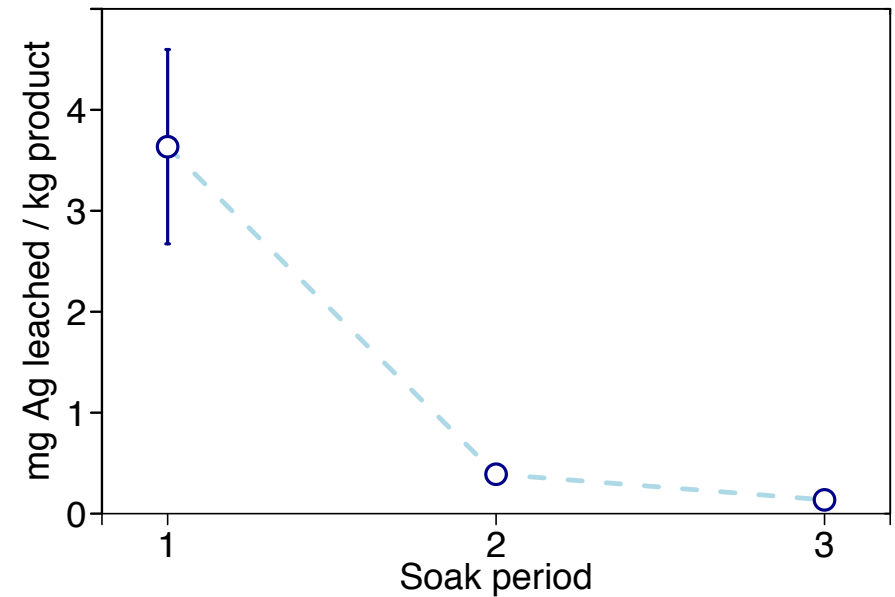


# Results: silver release over time

Blanket samples soaked in synthetic sweat at 37°C:



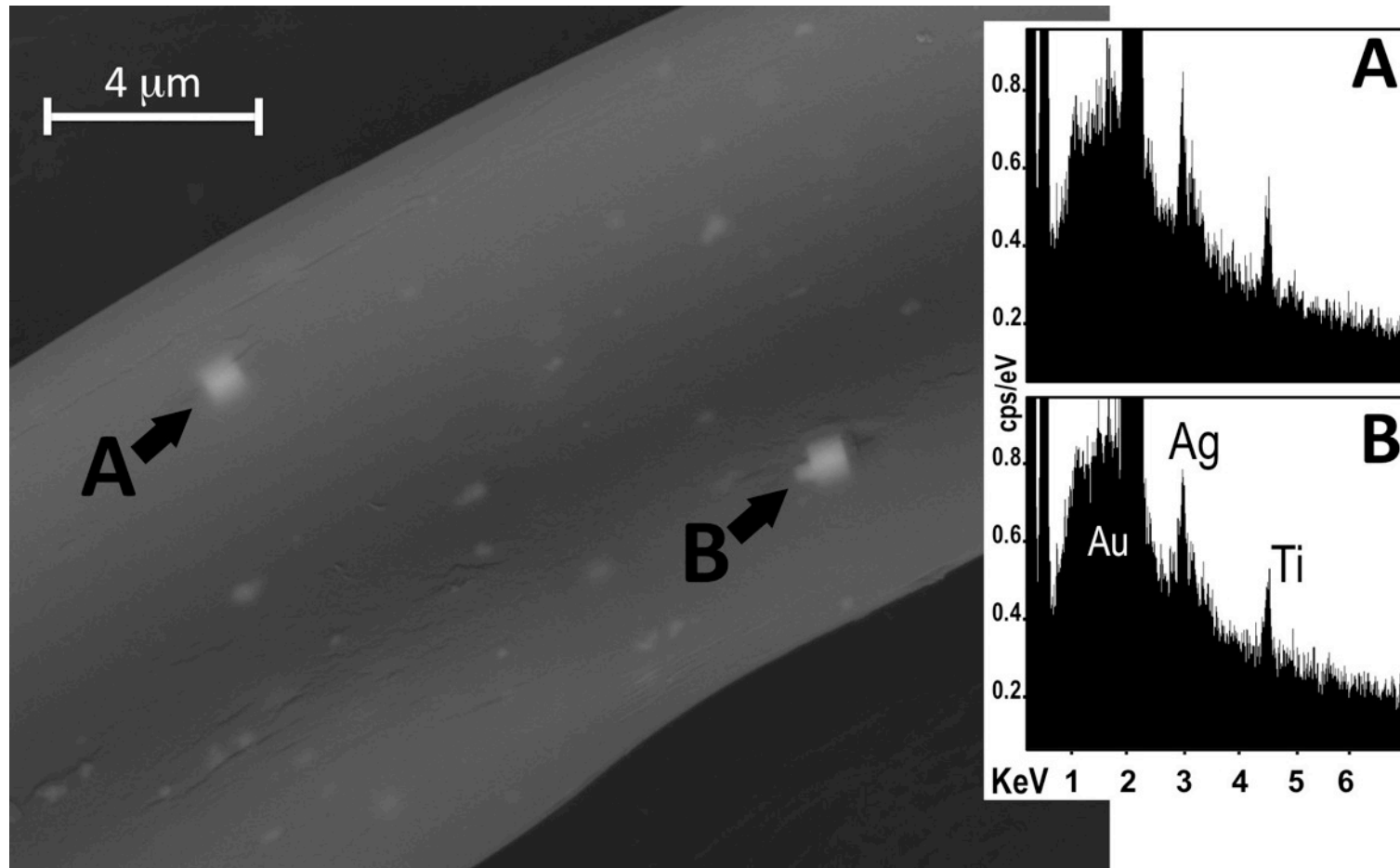
Blanket samples successively soaked in sweat, rinsed, and dried:





# Results: baby blanket

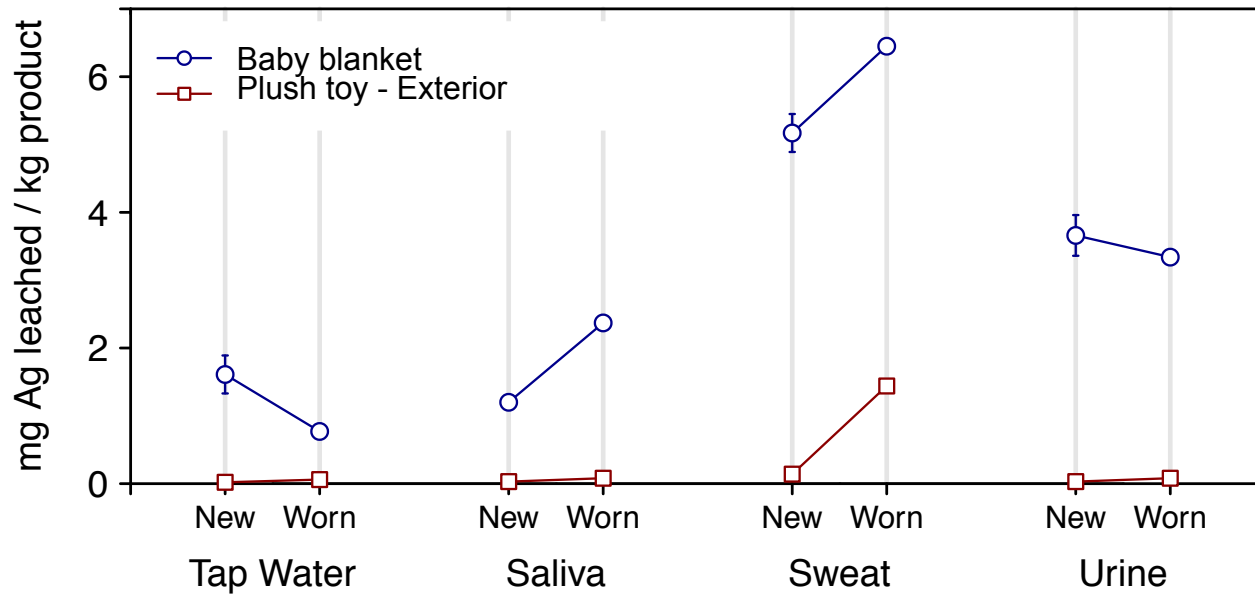
Blanket samples soaked in synthetic sweat (37°C) for 2 hours:



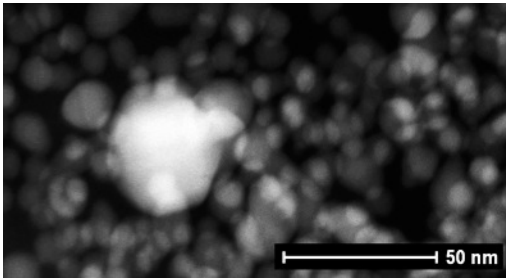




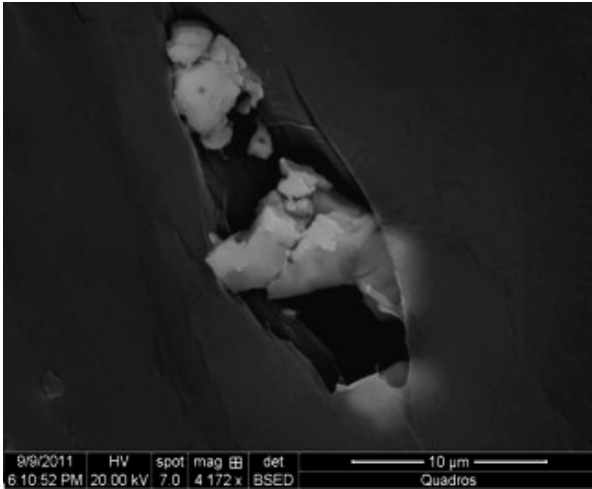
# Results: silver release after aging



# Main findings



Many children's products available in the US market contain silver nanotechnology

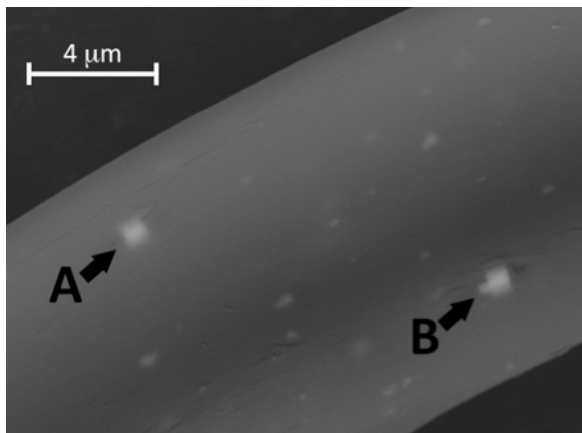


Every product contained silver in at least one component

In many cases, silver was in ionic form (surface wipes) or in micron-size particles (sippy cups).

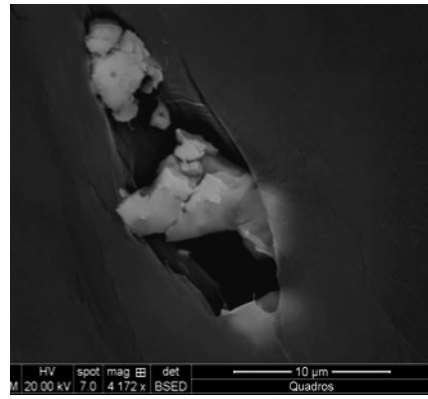
Dissolution is the main silver leaching mechanism, controlled by:

- **Presence of salts**
- **Presence of other components** (e.g., urea, lactic acid)
- **Attachment of particles to product**
- pH
- Dissolved oxygen

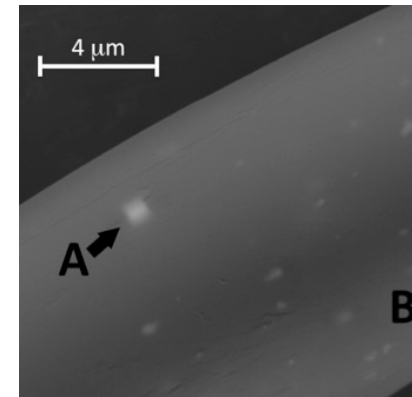


# Conclusions

Nanosilver in products is not always nanoscale (or pure)



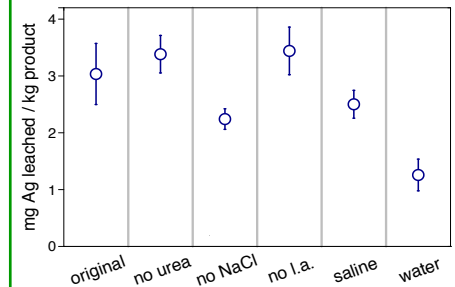
Product characteristics are not easily translated into exposure characteristics



Children will be exposed to low levels of bioavailable **ionic** silver from multiple sources



Silver dissolution depends on the **presence** of NaCl, other ingredients and product characteristics



# Recommendations

*Nanosilver in products is not always nanoscale (or pure)*

**Realistic risk assessment and life-cycle analyses**

*Product characteristics are not easily translated into exposure characteristics*

**Further research into silver speciation and aerosol emissions**

*Children will be exposed to low levels of bioavailable **ionic** silver from multiple sources*

**Low-dose genetic toxicology studies as opposed to LD<sub>50</sub> scenarios**

*Silver dissolution depends on the presence of NaCl, other ingredients and product characteristics*

**Product labeling including concentration and physical characteristics of nanosilver**

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**References:**

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- Cohen Hubal et al. (2000) EHP 108(6)
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