United States House of Representatives
Select Panel of the Committee on Energy and Commerce
"Bioethics and Fetal Tissue"
Wednesday March 2, 2016

Response to Additional Questions for the Record
Submitted by: Kathleen M. Schmainda, PhD
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The Honorable Marsha Blackburn

1. At the hearing, the claim was made that without fetal tissue, Zika virus research could not go forward. Only days later, the Washington Post cited a Cell Stem Cell research project in which induced pluripotent stem cells were engineered to study the characteristics of the virus's infectious potential in developing neural tissue. Since the breakthrough study produced vital information, why the insistence that fetal tissue is required to develop a vaccine or to study the infection's progress?

The answer following, does not get at the ***motivation*** for the insistence on fetal tissue, but gives you more background on the licit alternatives. The insistence seems to be motivated from a desire to continue the same research and cell sources (i.e., tradition, what's worked in the past), resistance to change (it might delay experiments), and likely an ideological undertone (failure to recognize the basis of the controversy, or to give any credence or consideration to alternative ethical viewpoint. This last point also seems to underlie the large-scale lack of acknowledgement for the successful research and proven cures using ethical alternatives.)

While the earliest attempts at growing viruses did use cultures of unpurified human fetal tissue, most research, as well as vaccine production, quickly shifted to purified cell lines which lent themselves to considerably less variability and provided large numbers of quality-controlled cells, providing reproducible results. In the 1960's and 1970's, cell culture work operated under an assumption that younger cells grew better, faster, and longer, so fetal cells obtained from abortion were sometimes used to create these cell lines (indicating they were developed as a lineage from a specific, original source of cells grown in the lab.) A few human fetal cell lines (WI-38, MRC-5) are still in use for some vaccine production. However, <u>few vaccines are now produced using fetal cell lines, and none using fetal tissue</u>. Newer cell lines, e.g., A549 cells (adult human),[1] Sf9 cells (insect),[2] EB66 (duck),[3] and better culture techniques make reliance on fetal cells an antiquated science. In addition, the CDC and other leading medical authorities have noted since 2001 that "No new fetal tissue is needed to produce cell lines to make these vaccines, now or in the future."[4]

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[1] See e.g., Shabram P and Kolman JL, Evaluation of A549 as a New Vaccine Cell Substrate: Digging Deeper with Massively Parallel Sequencing, *PDA J Pharm Sci Technol* 68, 639, 2014

[2] See e.g., Glenn GM et al., Safety and immunogenicity of a Sf9 insect cell-derived respiratory syncytial virus fusion protein nanoparticle vaccine, *Vaccine* 31, 524, 2013; AND Khan AS, FDA Memo: Cell Substrate Review for STN 125285, January 14, 2013; accessed at: http://www.fda.gov/downloads/BiologicsBloodVaccines/Vaccines/ApprovedProducts/UCM339125.pdf

[3] See e.g., Brown SW, Mehtali M, The Avian EB66(R) Cell Line, Application to Vaccines, and Therapeutic Protein Production, *PDA J Pharm Sci Technol*. 64, 419, 2010

[4] See, *e.g.*, "Vaccine Ingredients – Fetal Tissues," The Children's Hospital of Philadelphia, 2014; accessed July 21, 2015 at www.chop.edu/centers-programs/vaccine-education-center/vaccine-ingredients/fetal-tissues; CDC quote originally accessed July 2015 at: http://www.ascb.org/newsfiles/fetaltissue.pdf

To summarize, early fetal tissue and cell lines used for vaccine development were developed using suboptimal methods. Consequently, these cell lines should not be considered a "gold standard" mode of vaccine development. Rather their continued use would be considered to be "bad science". Currently, there are plenty of ethical alternatives available for cell line development, all using better methodology.

The example referenced in the question is another clear answer for the lack of need for freshly aborted fetal tissue in virus and vaccine studies. Scientists developed a successful model system to show that the Zika virus can infect and damage some developing brain cells.[5] The established experimental model, which the authors of the paper note can now be used for further investigations of developing brain as well as screening therapeutic compounds, was not developed using fetal tissue. The successful system uses human induced pluripotent stem cells (iPS cells), which are ethically created from skin or other normal cell types; the development of iPS cells earned the 2012 Nobel Prize for Dr. Shinya Yamanaka of Japan.

Another recent study by a Brazilian group confirmed the susceptibility of developing human brain cells to Zika virus infection, with potential damage to infected brain cells. Again, the successful study did not use human fetal tissue, but rather human iPS cells.[6]

Human iPS cells have demonstrated excellent potential to model developing brain, producing what are termed "organoids" for detailed study of the various cell types, brain structures, and even abnormal development that can occur. In particular, one model system using human iPS cells to produce brain organoids has been shown also to be an accurate model to study Microcephaly, the brain development condition that seems to be associated with infection by Zika virus in the womb.[7] And a newly-published paper further validates the superior ability of human iPS cells to model brain development. While this new reference does discuss Zika in particular, it convincingly demonstrates that this model system for brain development – which does not use aborted human fetal tissue – can be used to model normal human brain development, the timing of brain development associated with production of various neuronal cell types, and even to compare human brain development versus that of monkeys.[8] (Note that the development of tissue organoids has become a primary focus of the newly established National Center for Advancing Translational Sciences (NCATS) at the National Institutes of Health (NIH), thus lending further support for this avenue of research.)

Finally, development of a vaccine against Zika also would not need any aborted human fetal tissue. Modern vaccine development does not rely on fetal tissue or human fetal cell lines. Another recent example of this is the announced success of a field test of a vaccine against Dengue virus, a close relative of Zika.[9] The vaccine provided 100% protection,[10] but was developed using monkey cells and a mosquito cell line.[11]

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[5] Tang H *et al*., Zika Virus Infects Human Cortical Neural Progenitors and Attenuates Their Growth, *Cell Stem Cell* 18, 2016; *in press,* doi: 10.1016/j.stem.2016.02.016

[6] Garcez PP *et al*., Zika virus impairs growth in human neurospheres and brain organoids, *PeerJ Preprints* 4:e1817v3; doi: 10.7287/peerj.preprints.1817v3

[7] Lancaster MA *et al.*, Cerebral organoids model human brain development and microcephaly, *Nature* 501, 373, 19 Sept 2013

[8] Otani T *et al*., 2D and 3D Stem Cell Models of Primate Cortical Development Identify Species-Specific Differences in Progenitor Behavior Contributing to Brain Size, *Cell Stem Cell* published online March 31, 2016, doi: 10.1016/j.stem.2016.03.003.

[9] Kirkpatrick BD *et al*., The live attenuated dengue vaccine TV003 elicits complete protection against dengue in a human challenge model, *Sci. Transl. Med*. 8, 330ra36, 2016.

[10] Check Hayden E, Dengue vaccine aces trailblazing trial, *Nature*, 16 March 2016, doi: 10.1038/nature.2016.19576

[11] Men R et al., Dengue Type 4 Virus Mutants Containing Deletions in the 39 Noncoding Region of the RNA Genome: Analysis of Growth Restriction in Cell Culture and Altered Viremia Pattern and Immunogenicity in Rhesus Monkeys, *J.*

2. At the hearing, you made an important statement regarding the Polio vaccine. Can you explain for the Panel, what tissues were actually used for the Polio vaccine?

The earliest attempts at growing viruses sometimes used cultures of mixed fetal tissue, but not individual cultured cells. For example, the proof of principle experiment showing that polio virus could be grown in non-nervous tissue culture in 1949, used human fetal tissue.[12] But it is not true that the 1954 Nobel prize given to Enders et al. was for production of polio vaccine, nor even for growth of enough virus used to produce the polio vaccine. The fact is, the original Salk and Sabin vaccines were both produced using laboratory-cultured monkey tissue.[13] Later, poliovirus was produced in human fetal cell lines (WI-38, 1961,[14] fetal female lung; MRC-5, 1966, [15]fetal male lung), but also in HeLa cells,[16] a human cancer cell line that is not made from fetal tissue. Most modern manufacturers of polio vaccine now use other specific cell types including monkey cells; most do not use any human fetal cells, and none use freshly aborted fetal tissue. No current vaccines are made using fresh aborted fetal tissue.

In the 1960's and 1970's, cell culture work operated under an assumption that younger cells were better, grew faster, lived longer, so fetal cells obtained from abortion were sometimes used. These cells[17]adapted to lab culture and continued to grow, becoming known as a "cell line" because they developed as a lineage from different, specific cells grown in the lab. While a few human fetal cell lines (WI-38, MRC-5) are still in use for some vaccine production,[18] few vaccines are now produced using fetal cell lines, and **none using fetal tissue**.

Finally, there remain significant, unresolved questions on the public health dangers of products resulting from use of aborted fetal cell lines; these potential health concerns should also be investigated, as well as identification of non-controversial replacements for such fetal cell lines.

Virology 70, 3930, 1996; and Medina F et al., Dengue Virus: Isolation, Propagation, Quantification, and Storage, *Current Protocols in Microbiology* 15D.2.1-15D.2.24, November 2012

[12] Enders JF *et al.*, Cultivation of the Lansing strain of poliomyelitis virus in cultures of various human embryonic tissues, *Science* 109, 85, 1949

[13] Salk JE, Recent Studies on Immunization against Poliomyelitis, *Pediatrics* 12, 471, 1953; and Salk JE *et al*., Formaldehyde Treatment and Safety Testing of Experimental Poliomyelitis Vaccines, *Am. J. Public Health* 44, 563, 1954; and Salk JE *et al*., Studies in Human Subjects on Active Immunization Against Poliomyelitis II. A Practical Means for Inducing and Maintaining Antibody Formation, *Am. J. Public Health* 44, 994, 1954; and Sabin AB, Present status of attenuated live-virus poliomyelitis vaccine, *JAMA* 162, 1589, 1956

[14] Original fetal cell cultivations 1961, original poliovirus growth 1962 in WI-1, standardized in WI-38; Hayflick L, Moorhead PS, The serial cultivation of human diploid cell strains, *Experimental Cell Research* 25, 585, 1961; Hayflick L *et al*., Preparation of poliovirus vaccines in a human fetal diploid cell strain, *Am. J. Hyg.* 75, 240, 1962; Hayflick L, The limited in vitro lifetime of human diploid cell strains, *Exp. Cell Res.* 37, 614, 1965.

[15] Jacobs JP *et al.*, Characteristics of a Human Diploid Cell Designated MRC-5, *Nature* 227, 168, 1970

[16] Scherer WF *et al*., Studies on the propagation in vitro of poliomyelitis viruses. IV. Viral multiplication in a stable strain of human malignant epithelial cells (strain HeLa) derived from an epidermoid carcinoma of the cervix, *J. Exp. Med*. 97, 695, 1953

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[18] CDC, Appendix B: Vaccine Excipient & Media Summary, Epidemiology and Prevention of Vaccine-Preventable Diseases, The Pink Book: Course Textbook - 13th Edition, 2015; accessed at: http://www.cdc.gov/vaccines/pubs/pinkbook/index.html

3. At the hearing, you made a statement about how many fetuses it would take to provide a therapeutic intervention for the European Parkinson's experiments. Can you provide the source for this information? Also, can you elaborate on the ethical implications for any therapy that depends on a significant volume of fetal tissue?

Clinical trials were performed in Sweden, for which cells from at least 3-4 fetuses were needed to treat each Parkinson's patient. This study was the topic of a New York Times article[19], and described by those who performed the study in a scientific paper published in that same year[20]. While the authors claimed procedural success, no significant benefit to the patients was reported.

Overall, between 1988 and 1994, roughly 140 Parkinson's disease patients received fetal tissue (**up to six fetuses per patient**), with varying results.[21] Subsequent reports showed that severe problems developed from fetal tissue transplants. One patient who received transplant of fetal brain tissue (from a total of 3 fetuses) died subsequently, and at autopsy was found to have various non-brain tissues (*e.g*, skin-like tissue, hair, cartilage, and other tissue nodules) growing in his brain.[22]

In 2001, the first report of a full clinical trial[23] (funded by NIH) using fetal tissue for Parkinson's patients was prominently featured in the *New York Times*,[24] with doctors' descriptions of patients writhing, twisting, and jerking with uncontrollable movements; the doctors called the results "absolutely devastating", "tragic, catastrophic", and labeled the results "a real nightmare."

A second large, controlled study published in 2003 showed similar results (funded by NIH), with over half of the patients developing potentially disabling tremors caused by the fetal brain tissue transplants.[25] The results of these two large studies led to a moratorium on fetal tissue transplants for Parkinson's. Long-term follow-up of a few of the patients in these large studies showed that even in fetal tissue that grew in patients' brains, the grafted tissue took on signs of the disease and were not effective.[26]

A primary point of providing this information is that despite the many failed experiments, and loss of many lives in the process, many continue to contend that such studies should continue because there is still hope that one day they will prove successful. It is therefore necessary to consider a future where this proved true. Given that tissue transplants from 3-4 fetuses were needed to treat each Parkinson's patient, 4 million babies would need to be aborted to treat the 1 million patients currently living with this disease, in the US alone. Imagine the magnitude of the demand for fetuses to cure yet another disease such as Alzheimer's, which affects 44 million persons worldwide? Continuing down this path of pursuing treatments that require abortion-derived fetal tissue would create the industrialized harvesting of preborn babies.

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[19] Kolata, F., Fetal Tissue Seems to Aid Parkinson Patient, in The New York Times. February 2, 1990.
[20] Lindvall O et al., Neural transplantation in Parkinson's disease: the Swedish experience. Prog Brain Res. 82, 729-34 (1990).
[21] Reviewed in: Fine A, Transplantation of fetal cells and tissue: an overview, *Can Med Assoc J* 151, 1261, 1994
[22] Folkerth RD, Durso R, Survival and proliferation of nonneural tissues, with obstruction of cerebral ventricles, in a parkinsonian patient treated with fetal allografts, *Neurology* 46, 1219, 1996
[23] Freed CR *et al.*, Transplantation of embryonic dopamine neurons for severe parkinson's disease, *N Engl J Med* 344, 710, 2001
[24] Gina Kolata, "Parkinson's Research Is Set Back by Failure of Fetal Cell Implants," *New York Times* March 8, 2001; accessed at: http://www.nytimes.com/2001/03/08/health/08PARK.html
[25] Olanow CW *et al.*, A Double-blind Controlled Trial of Bilateral Fetal Nigral Transplantation in Parkinson's Disease, *Ann Neurol* 54, 403, 2003
[26] Braak H, Del Tredici K, Assessing fetal nerve cell grafts in Parkinson's disease, *Nature Medicine* 14, 483, 2008