October 11, 2019

Eric Garcetti, Mayor of Los Angeles Los Angeles City Council 200 N. Spring Street Los Angeles, CA 90012

RE: Oil and Gas Extraction in Los Angeles and Public Health Evidence

As scientists and health professionals with expertise in the impacts of oil and gas extraction on human populations or the environment, we are writing to ensure that the City of Los Angeles possesses analyses grounded in the most available, current and relevant epidemiological research as it considers policies to protect Los Angeles residents from environmental health risks with respect to oil and gas operations. We have reviewed the analysis and recommendations of the City's recently-released report on oil and draw attention here to the existing evidence that demonstrates health impacts associated with upstream petroleum extraction among residents living ½ to 3 miles from drill sites. Current evidence suggests environmental and health risks further than the 600-ft recommendation proposed to be considered by the city. Many communities near oil extraction in Los Angeles are home to vulnerable populations, who may face cumulative environmental burdens.

Recent reviews of scientific literature show growing evidence of adverse exposure and health impacts associated with petroleum extraction (Johnston, Lim, & Roh, 2018; Shonkoff, Hays, & Finkel, 2014). Los Angeles sits atop one of the largest urban oil fields in the country with over nearly 2500 active wells. A single drill site typically operates for decades and the extraction process produces emissions of multiple health-hazardous air pollutants, including benzene, toluene, ethylbenzene, xylene, formaldehyde, hydrogen sulfide, and methylene chloride. Many of these compounds are known to be toxic to human health, carcinogenic, cause respiratory harm, or are endocrine disrupting chemicals and can cause long-term developmental or reproductive harm—a consideration for health across generations (Zielinska, Campbell, & Samburova, 2014; Moore, Zielinska, Pétron, & Jackson, 2014; Field, Soltis, & Murphy, 2014; Colborn, Schultz, Herrick, & Kwiatkowski, 2013). These chemicals can migrate off-site due to fugitive emissions, spills, leaks, or accidents.

Despite relatively few studies having been conducted in Los Angeles, the current body of knowledge drawing from scientific studies on upstream oil and gas extraction from across diverse areas of the US and globally, indicate a substantive base of evidence to inform public health efforts by the City of Los Angeles. For example, despite diversity in extraction techniques, geology and local populations, scientific studies have consistently identified drilling activities significantly associated with adverse birth outcomes in Pennsylvania (Casey et al., 2015; Hill, 2012; Stacy et al., 2015), Colorado (McKenzie et al., 2014; McKenzie, Allshouse, & Daniels, 2019), Texas (Whitworth, Marshall, & Symanski, 2017; Walker Whitworth, Kaye Marshall, & Symanski, 2018) and Oklahoma (Janitz, Dao, Campbell, Stoner, & Peck, 2019). While the exposure measurements in these studies vary based on the community, such

## adverse perinatal effects are associated with maternal proximity of $\frac{1}{2}$ mile to 3 miles from drill activity.

Recent health surveys near petroleum extraction sites have reported symptoms of throat and nasal irritation, eye burning, sinus problems, headaches, skin problems, severe fatigue, loss of smell, cough, nosebleeds and psychological stress (Steinzor, Subra, & Sumi, 2013; Rabinowitz et al., 2015) (Elliott et al., 2018) (Jemielita et al., 2015) (Casey, Wilcox, Hirsch, Pollak, & Schwartz, 2018). Among adults, risk factors for cardiovascular disease increases with the intensity of oil and gas activity nearby (L. M. McKenzie et al., 2019). These symptoms were more common in individuals living near oil and gas facilities compared to those farther away. Others identify neurological symptoms, kidney damage and thyroid problems among residents living in oil extraction regions when compared to those living farther away. Stress, including social and economic stress, can make these health conditions worse (Morello-Frosch, Zuk, Jerrett, Shamasunder, & Kyle, 2011)

Additional studies demonstrate a higher burden of cancer mortality in communities exposed to oil extraction (San Sebastián M, Armstrong B, A, & C., 2001) (Moolgavkar, Chang, Watson, & Lau, 2014) (L. M. McKenzie et al., 2017) (Finkel, 2016). For example, in Colorado, scientists found that children diagnosed with leukemia had a 4.6 increased odds of living in an area with dense petroleum extraction (L. M. McKenzie et al., 2017).

Air surrounding oil and gas production areas is particularly vulnerable to toxic emissions. With relevance to drilling operations in California, a recent review concluded that the production phase, with the lengthy operation timeframes, episodic peak emission events, and largest number of hazardous air pollutants sourced to the various equipment and operations, has the potential to emit the highest concentrations of hazardous air pollutants over the longest time period (Garcia-Gonzales, Shonkoff, Hays, & Jerrett, 2019). Air quality is further compromised by truck traffic to and from the drilling site or operation of diesel equipment (Goodman et al., 2016) (Allshouse, McKenzie, Barton, Brindley, & Adgate, 2019) (Blair, Brindley, Dinkeloo, McKenzie, & Adgate, 2018). Exposure to these air pollutants have been shown to be higher in areas near drilling sites (Lisa M. McKenzie, Witter, Newman, & Adgate, 2012) (Colborn et al., 2013) (Pétron et al., 2012) (Macey et al., 2014) – including in Los Angeles (Collier-Oxandale et al., 2018; Shamasunder et al., 2018). The scientific literature demonstrates adverse human health impacts from exposure to these chemicals (Lisa M. McKenzie et al., 2012) (Atsdr, 1999). Recent literature identifies noise as an important co-exposure near operations (Richburg & Slagley, 2019) (Radtke, Autenrieth, Lipsey, & Brazile, 2017). Acute inhalation exposures to petroleum hydrocarbons have found increased risks of eye irritation and migraine headaches (Kim et al., 2009) (Tunsaringkarn, Ketkaew, Siriwong, & Rungsiyothin, 2013) (Tustin et al., 2017), as well as asthma symptoms (Rasmussen et al., 2016) (White et al., 2009) (Wichmann et al., 2009).

Studies of animals living in oil producing regions have shown an increased accumulation of toxins in various organs, in particular toxic metals as well as damage to the kidney (Miedico et al., 2016) (Al-Hashem, 2011). Toxic metals and petroleum hydrocarbons have also been measured in soil and water near oil extraction sites (Johnston et al., 2018), including diverse locations such as Texas (Bojes & Pope, 2007,) China (Zhang et al., 2013) (Fu, Cui, & Zang, 2014) (Wang, Cao, Liao, Huang, & Tang, 2015), Nigeria (Asia, Jegede, Jegede, Ize-Iyamu, & Akpasubi, 2007) and Iraq (Alawi & Azeez, 2016).

Hydrogen sulfide (H<sub>2</sub>S) is an odorant gas associated with oil drilling. Most human organ systems are susceptible to the toxic effects of H<sub>2</sub>S, particularly mucus membranes, including the central nervous system, the respiratory system, the cardiovascular system and the gastrointestinal system (Reiffenstein, Hulbert, & Roth, 1992). At ambient levels, odorant chemicals may produce irritation of the eyes, nose, and throat. Such compounds can induce symptoms such as nausea, vomiting, headaches, stress, negative mood, and a stinging sensation (Schiffman, Miller, Suggs, & Graham, 1995) (Wing et al., 2008). Odors that are viewed as unpleasant, embarrassing, or sickening may interfere with mood, beneficial uses of property, and social activities. There is evidence that chronic exposure to elevated ambient concentrations contribute to harm to the respiratory system in both adults and children in addition to elevated cough, headaches and wheezing (Jaakkola, Paunio, Virtanen, & Heinonen, 1991) (Marttila, Jaakkola, Vilkka, Jappinen, & Haahtela, 1994).

Buffers or setbacks have been shown to be a meaningful public health policy approach to limit human health exposures to harmful contaminants (Fry, 2013) (Haley, McCawley, Epstein, Arrington, & Bjerke, 2016) (Lisa M McKenzie, Allshouse, Burke, Blair, & Adgate, 2016) (Banan & Gernand, 2018). From a public health perspective, given the existing evidence on adverse health risks from oil and gas development, it is important to reduce exposures to harmful pollutants at home, in schools and at work places.

## Sincerely,

Jill Johnson, PhD, Assistant Professor of Preventive Medicine, University of Southern California

Bhavna Shamasunder, PhD, MES, Associate Professor, Urban and Environmental Policy, Occidental College

Ed Avol, MD., Professor of Clinical Medicine and Chief, Environmental Health Division, Department of Preventive Medicine, University of Southern California

Joan Casey, PhD, Assistant Professor, Environmental Health Sciences, Mailman School of Public Health, Columbia University

Lara Cushing, PhD, MPH, Assistant Professor, San Francisco State University

Shohreh Farzan, PhD, Assistant Professor of Preventive Medicine, University of Southern California

Meredith Franklin, PhD, Associate Professor of Preventive Medicine, University of Southern California

Erika Garcia, PhD, MPH, Postdoctoral Scholar, Department of Preventive Medicine, University of Southern California

Jimmy Hara, MD, Clinical Professor of Family Medicine at the David Geffen School of Medicine at UCLA, Residency Director Emeritus for the Kaiser Permanente Los Angeles Family Medicine

Megan Herting, PhD, Assistant Professor of Preventive Medicine, University Southern California

Martha Matsuoka, PhD, MCP, Associate Professor, Urban & Environmental Policy and Executive Director, Urban & Environmental Policy Institute, Occidental College

Rachel Morello-Frosch, PhD, MPH, Professor, School of Public Health and Department of Environmental Science, Policy and Management, University of California, Berkeley

Jyoti Puvuula, MD, Harbor-UCLA Department of Family Medicine & Doctors for Global Health

Linda Rudolph, MD, MPH, Senior Advisory, Public Health Institute

James Sadd, PhD, Professor of Environmental Science, Occidental College

Ted Schettler MD, MPH, Science Director, Science and Environmental Health Network

## (Affiliations for identification purposes only)

CC:

Mike Feuer, Los Angeles City Attorney Uduak-Joe Ntuk, Los Angeles Petroleum Administrator

## References

- Al-Hashem, M. A. (2011). Evidence of hepatotoxicity in the sand lizard Acanthodactylus scutellatus from Kuwait's Greater Al-Burgan oil field. *Ecotoxicol Environ Saf*, 74(5), 1391-1395. doi:10.1016/j.ecoenv.2011.02.021
- Alawi, M. A., & Azeez, A. L. (2016). Study of polycyclic aromatic hydrocarbons (PAHs) in soil samples from Al-Ahdab oil field in Waset Region, Iraq. *Toxin Reviews*, 35(3-4), 69-76. doi:10.1080/15569543.2016.1198379
- Allshouse, W. B., McKenzie, L. M., Barton, K., Brindley, S., & Adgate, J. L. (2019). Community Noise and Air Pollution Exposure During the Development of a Multi-Well Oil and Gas Pad. *Environ Sci Technol*, 53(12), 7126-7135. doi:10.1021/acs.est.9b00052
- Asia, I., Jegede, S., Jegede, D., Ize-Iyamu, O., & Akpasubi, E. (2007). The effects of petroleum exploration and production operations on the heavy metals contents of soil and groundwater in the Niger Delta. *International Journal of Physical Sciences*, 2(10), 271-275.
- Atsdr. (1999). Toxicological Profile for Total Petroleum Hydrocarbons (TPH). Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services (September), 315-315.
- Banan, Z., & Gernand, J. M. (2018). Evaluation of gas well setback policy in the Marcellus Shale region of Pennsylvania in relation to emissions of fine particulate matter. *Journal of the Air & Waste Management Association*, 68(9), 988-1000.

- Blair, B. D., Brindley, S., Dinkeloo, E., McKenzie, L. M., & Adgate, J. L. (2018). Residential noise from nearby oil and gas well construction and drilling. *J Expo Sci Environ Epidemiol*, 28(6), 538-547. doi:10.1038/s41370-018-0039-8
- Bojes, H. K., & Pope, P. G. (2007). Characterization of EPA's 16 priority pollutant polycyclic aromatic hydrocarbons (PAHs) in tank bottom solids and associated contaminated soils at oil exploration and production sites in Texas. *Regul Toxicol Pharmacol*, 47(3), 288-295. doi:10.1016/j.yrtph.2006.11.007
- Casey, J. A., Wilcox, H. C., Hirsch, A. G., Pollak, J., & Schwartz, B. S. (2018). Associations of unconventional natural gas development with depression symptoms and disordered sleep in Pennsylvania. *Scientific Reports*, 8(1), 11375.
- Colborn, T., Schultz, K., Herrick, L., & Kwiatkowski, C. (2013). An Exploratory Study of Air Quality near Natural Gas Operations. *Human and Ecological Risk Assessment: An International Journal*, 20(1), 86-105. doi:10.1080/10807039.2012.749447
- Collier-Oxandale, A. M., Gordon Casey, J., Piedrahita, R. A., Ortega, J., Halliday, H., Johnston, J., & Hannigan, M. (2018). Assessing a low-cost methane sensor quantification system for use in complex rural and urban environments. *Atmospheric Measurement Techniques*, 11(6), 3569.
- Elliott, E. G., Ma, X., Leaderer, B. P., McKay, L. A., Pedersen, C. J., Wang, C., . . . Deziel, N. C. (2018). A community-based evaluation of proximity to unconventional oil and gas wells, drinking water contaminants, and health symptoms in Ohio. *Environmental Research*, 167, 550-557. doi:<u>https://doi.org/10.1016/j.envres.2018.08.022</u>
- Field, R., Soltis, J., & Murphy, S. (2014). Air quality concerns of unconventional oil and natural gas production. *Environmental Science: Processes & Impacts, 16*(5), 954-969.
- Finkel, M. L. (2016). Shale gas development and cancer incidence in southwest Pennsylvania. *Public Health*, 141, 198-206. doi:<u>https://doi.org/10.1016/j.puhe.2016.09.008</u>
- Fry, M. (2013). Urban gas drilling and distance ordinances in the Texas Barnett Shale. *Energy Policy*, 62, 79-89.
- Fu, X., Cui, Z., & Zang, G. (2014). Migration, speciation and distribution of heavy metals in an oilpolluted soil affected by crude oil extraction processes. *Environ Sci Process Impacts*, 16(7), 1737-1744. doi:10.1039/c3em00618b
- Garcia-Gonzales, D. A., Shonkoff, S. B. C., Hays, J., & Jerrett, M. (2019). Hazardous Air Pollutants Associated with Upstream Oil and Natural Gas Development: A Critical Synthesis of Current Peer-Reviewed Literature. Annu Rev Public Health, 40, 283-304. doi:10.1146/annurevpublhealth-040218-043715
- Goodman, P. S., Galatioto, F., Thorpe, N., Namdeo, A. K., Davies, R. J., & Bird, R. N. (2016). Investigating the traffic-related environmental impacts of hydraulic-fracturing (fracking) operations. *Environ Int*, 89-90, 248-260. doi:10.1016/j.envint.2016.02.002
- Haley, M., McCawley, M., Epstein, A. C., Arrington, B., & Bjerke, E. F. (2016). Adequacy of current state setbacks for directional high-volume hydraulic fracturing in the Marcellus, Barnett, and Niobrara Shale Plays. *Environmental Health Perspectives*, 124(9), 1323-1333.
- Jaakkola, J. J., Paunio, M., Virtanen, M., & Heinonen, O. P. (1991). Low-level air pollution and upper respiratory infections in children. *American Journal of Public Health*, 81(8), 1060-1063. doi:10.2105/AJPH.81.8.1060
- Jemielita, T., Gerton, G. L., Neidell, M., Chillrud, S., Yan, B., Stute, M., . . . Panettieri, R. A., Jr. (2015). Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates. *PLoS One*, *10*(7), e0131093. doi:10.1371/journal.pone.0131093
- Johnston, J. E., Lim, E., & Roh, H. (2018). Impact of upstream oil extraction and environmental public health: A review of the evidence. *Science of The Total Environment*.
- Kim, B. M., Park, E. K., LeeAn, S. Y., Ha, M., Kim, E. J., Kwon, H., . . . Ha, E. H. (2009). BTEX exposure and its health effects in pregnant women following the Hebei Spirit oil spill. *Journal of Preventive Medicine and Public Health*, 42(2), 96-103. doi:10.3961/jpmph.2009.42.2.96

- Macey, G. P., Breech, R., Chernaik, M., Cox, C., Larson, D., Thomas, D., & Carpenter, D. O. (2014). Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study. *Environ Health*, 13, 82-82. doi:10.1186/1476-069X-13-82
- Marttila, O., Jaakkola, J. J. K., Vilkka, V., Jappinen, P., & Haahtela, T. (1994). The South Karelia Air Pollution Study: The Effects of Malodorous Sulfur Compounds from Pulp Mills on Respiratory and Other Symptoms in Children. *Environmental Research*, 66(2), 152-159. doi:10.1006/enrs.1994.1051
- McKenzie, L. M., Allshouse, W. B., Burke, T., Blair, B. D., & Adgate, J. L. (2016). Population size, growth, and environmental justice near oil and gas wells in Colorado. *Environmental Science & Technology*, 50(21), 11471-11480.
- McKenzie, L. M., Allshouse, W. B., Byers, T. E., Bedrick, E. J., Serdar, B., & Adgate, J. L. (2017). Childhood hematologic cancer and residential proximity to oil and gas development. *PLoS One*, 12(2), e0170423. doi:10.1371/journal.pone.0170423
- McKenzie, L. M., Crooks, J., Peel, J. L., Blair, B. D., Brindley, S., Allshouse, W. B., ... Adgate, J. L. (2019). Relationships between indicators of cardiovascular disease and intensity of oil and natural gas activity in Northeastern Colorado. *Environ Res*, 170, 56-64. doi:10.1016/j.envres.2018.12.004
- McKenzie, L. M., Witter, R. Z., Newman, L. S., & Adgate, J. L. (2012). Human health risk assessment of air emissions from development of unconventional natural gas resources. *The Science of The Total Environment*, 424, 79-87. doi:10.1016/j.scitotenv.2012.02.018
- Miedico, O., Iammarino, M., Paglia, G., Tarallo, M., Mangiacotti, M., & Chiaravalle, A. E. (2016). Environmental monitoring of the area surrounding oil wells in Val d'Agri (Italy): element accumulation in bovine and ovine organs. *Environ Monit Assess, 188*(6), 338. doi:10.1007/s10661-016-5317-0
- Moolgavkar, S. H., Chang, E. T., Watson, H., & Lau, E. C. (2014). Cancer mortality and quantitative oil production in the Amazon region of Ecuador, 1990-2010. *Cancer Causes Control*, 25(1), 59-72. doi:10.1007/s10552-013-0308-8
- Moore, C. W., Zielinska, B., Pétron, G., & Jackson, R. B. (2014). Air impacts of increased natural gas acquisition, processing, and use: A critical review. *Environmental Science and Technology*, 48(15), 8349-8359. doi:10.1021/es4053472
- Morello-Frosch, R., Zuk, M., Jerrett, M., Shamasunder, B., & Kyle, A. D. (2011). Understanding the cumulative impacts of inequalities in environmental health: implications for policy. *Health Aff* (*Millwood*), 30(5), 879-887. doi:10.1377/hlthaff.2011.0153
- Pétron, G., Frost, G., Miller, B. R., Hirsch, A. I., Montzka, S. A., Karion, A., . . . Tans, P. (2012).
  Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study. *Journal of Geophysical Research: Atmospheres*, *117*(D4), n/a-n/a. doi:10.1029/2011JD016360
- Rabinowitz, P. M., Slizovskiy, I. B., Lamers, V., Trufan, S. J., Holford, T. R., Dziura, J. D., ... Stowe, M. H. (2015). Proximity to natural gas wells and reported health status: results of a household survey in Washington County, Pennsylvania. *Environmental Health Perspectives*, 123(1), 21-26. doi:10.1289/ehp.1307732 [doi]
- Radtke, C., Autenrieth, D. A., Lipsey, T., & Brazile, W. J. (2017). Noise characterization of oil and gas operations. *J Occup Environ Hyg*, *14*(8), 659-667. doi:10.1080/15459624.2017.1316386
- Rasmussen, S. G., Ogburn, E. L., McCormack, M., Casey, J. A., Bandeen-Roche, K., Mercer, D. G., & Schwartz, B. S. (2016). Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations. *JAMA Intern Med*, 176(9), 1334-1343. doi:10.1001/jamainternmed.2016.2436
- Reiffenstein, R. J., Hulbert, W. C., & Roth, S. H. (1992). Toxicology of hydrogen sulfide. *Annual review* of pharmacology and toxicology, 32(1), 109-134. doi:10.1146/annurev.pa.32.040192.000545
- Richburg, C. M., & Slagley, J. (2019). Noise concerns of residents living in close proximity to hydraulic fracturing sites in Southwest Pennsylvania. *Public Health Nurs*, 36(1), 3-10. doi:10.1111/phn.12540

- San Sebastián M, Armstrong B, A, C. J., & C., S. (2001). Exposures and cancer incidence near oil fields in the Amazon basin of Ecuador. . *Occup Environ Med*, 58, 517-522.
- Schiffman, S. S., Miller, E. A., Suggs, M. S., & Graham, B. G. (1995). The effect of environmental odors emanating from commercial swine operations on the mood of nearby residents. *Brain research bulletin*, 37(4), 369-375.
- Shamasunder, B., Collier-Oxandale, A., Blickley, J., Sadd, J., Chan, M., Navarro, S., ... Wong, N. J. (2018). Community-Based Health and Exposure Study around Urban Oil Developments in South Los Angeles. *Int J Environ Res Public Health*, 15(1). doi:10.3390/ijerph15010138
- Shonkoff, S. B., Hays, J., & Finkel, M. (2014). Environmental Public Health Dimensions of Shale and Tight Gas Development. *Environ Health Perspect*, *122*(8). doi:10.1289/ehp.1307866
- Steinzor, N., Subra, W., & Sumi, L. (2013). Investigating links between shale gas development and health impacts through a community survey project in Pennsylvania. NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy, 23(1), 55-83. doi:10.2190/NS.23.1.e
- Tunsaringkarn, T., Ketkaew, P., Siriwong, W., & Rungsiyothin, A. (2013). Benzene Exposure and Its Association with Sickness Exhibited in Gasoline Station Workers. 1-8. doi:10.7726/ijeps.2013.1001
- Tustin, A. W., Hirsch, A. G., Rasmussen, S. G., Casey, J. A., Bandeen-Roche, K., & Schwartz, B. S. (2017). Associations between Unconventional Natural Gas Development and Nasal and Sinus, Migraine Headache, and Fatigue Symptoms in Pennsylvania. *Environ Health Perspect*, 125(2), 189-197. doi:10.1289/ehp281
- Wang, J., Cao, X., Liao, J., Huang, Y., & Tang, X. (2015). Carcinogenic potential of PAHs in oilcontaminated soils from the main oil fields across China. *Environ Sci Pollut Res Int*, 22(14), 10902-10909. doi:10.1007/s11356-014-3954-9
- White, N., teWaterNaude, J., van der Walt, A., Ravenscroft, G., Roberts, W., & Ehrlich, R. (2009).
   Meteorologically estimated exposure but not distance predicts asthma symptoms in schoolchildren in the environs of a petrochemical refinery: a cross-sectional study. *Environmental health : a global access science source*, 8, 45-45. doi:10.1186/1476-069X-8-45
- Wichmann, F. A., M??ller, A., Busi, L. E., Cianni, N., Massolo, L., Schlink, U., ... Sly, P. D. (2009).
   Increased asthma and respiratory symptoms in children exposed to petrochemical pollution.
   *Journal of Allergy and Clinical Immunology*, 123(3), 632-638. doi:10.1016/j.jaci.2008.09.052
- Wing, S., Horton, R. A., Marshall, S. W., Thu, K., Tajik, M., Schinasi, L., & Schiffman, S. S. (2008). Air pollution and odor in communities near industrial swine operations. *Environmental Health Perspectives*, 116(10), 1362-1362.
- Zhang, J., Yang, J. C., Wang, R. Q., Hou, H., Du, X. M., Fan, S. K., . . . Dai, J. L. (2013). Effects of pollution sources and soil properties on distribution of polycyclic aromatic hydrocarbons and risk assessment. *Sci Total Environ*, 463-464, 1-10. doi:10.1016/j.scitotenv.2013.05.066
- Zielinska, B., Campbell, D., & Samburova, V. (2014). Impact of emissions from natural gas production facilities on ambient air quality in the Barnett Shale area: a pilot study. *Journal of the Air & Waste Management Association (1995)*, 64(12), 1369-1383.