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# Professor Arun Kumar Nigam: A Tribute

**V.K. Gupta**[1] **and Rahul Mukerjee**[2]

[1]*Former ICAR National Professor, IASRI, New Delhi – 110012*
[2]*Professor, IIM, Calcutta*

## 1 Profile of Arun Nigam

As either a student or a close associate and admirer, it indeed is a Herculean task to sketch the profile of an academician describing and doing justice to his monumental achievements and qualities as a researcher, teacher and a human being. We are deeply honoured and privileged, and it is a matter of great pleasure for us to have got an opportunity to make this valiant attempt to write about Professor Arun Kumar Nigam. Professor Nigam's research contributions are so enormous and have generated such a profound worldwide impact on statistical sciences and its innovative and diversified applications to other areas, especially health, hygiene, education, gender inequality, nutrition and hunger, that it is impossible to sketch even a brief account of it in the limited space of this write-up. Moreover, like everyone in our society, we are so deeply indebted to him for his humanitarian qualities that we struggle for words which aptly and sufficiently express our feelings and emotions about him.

Dr. Arun Kumar Nigam, a distinguished research professor of the highest level of international eminence, is a living legend with brilliance in the areas of survey sampling, design of experiments and applied statistics, and now in health, nutrition, hunger, hygiene and education. It is by no means an exaggeration to say that Professor Nigam has established himself as a living encyclopaedia on nutrition, hunger and child health in particular and innovative application of survey sampling in medical sciences in general. He is not only a giant of statistical sciences, but also an embodiment of humanitarian traits such as gentleness, kindness and humbleness. He is, indeed, a great visionary with unlimited intuition and these traits make him a researcher and academician par excellence.

Professor Arun Kumar Nigam, popularly known as Arun, was born at Unnao district of Uttar Pradesh, India on April 21, 1943. He received his bachelor's degree from Agra University in 1960 and master's degree in mathematical statistics from Lucknow University in 1962. During 1963-64, he completed professional statisticians' certificate course and research diploma in agricultural statistics from Institute of Agricultural Research Statistics (IARS) [now Indian Agricultural Statistics Research Institute, (IASRI)], New Delhi. Arun received his Ph.D. degree

Corresponding Author: V.K. Gupta
E-mail: vkgupta_1751@yahoo.co.in

in Statistics from Banaras Hindu University (BHU), Varanasi, in 1970. He started his research and teaching career as a research apprentice at IARS in 1964 and then as a lecturer at BHU in 1966.

From Varanasi, Arun moved to IASRI, New Delhi, in 1972 as an associate professor. At IASRI he made fundamental contributions to design of experiments and survey sampling. He also developed indices for evaluation of field experiments and animal experiments by using well defined weights for various evaluation indicators. He sought an early retirement from IASRI in 1987 as a professor and moved to Lucknow, UP, where he joined Lucknow University as a visiting professor for six months. During 1988-1994, he worked as UGC Research Scientist C at Lucknow University. From 1990 to 2008, he was honorary director of the Institute of Applied Statistics and Development Studies (IASDS), Lucknow, and then he was the executive president of IASDS during 2008-2010. Since 2010, he has been consultant advisor at IASDS. It was at IASDS that Arun did his pioneering cutting-edge research on child health, nutrition, hunger, hygiene and education.

Arun's scientific work is a judicious blend of theory and applications. His research interests vary from basic research in design of experiments, survey sampling and biostatistics to health, nutrition, agriculture, econometrics, micro planning, etc. He has been actively involved in large scale surveys, with influential work on analysis of survey data, monitoring and evaluation, project formulation via quantitative and qualitative insights, and so on.

Arun is internationally acclaimed for his monumental contributions to design of experiments. His pathbreaking work on design of mixture experiments is now a standard reference and has been widely cited in text books, notably the one by John Cornell. He is also well-known for his fundamental research on efficiency balanced, partially efficiency balanced and simple partially efficiency balanced designs. He has also made significant contributions towards obtaining orthogonal main effect plans for mixed factorials and resolution IV plans.

Arun's work on controlled sampling in Biometrika (1982) and Journal of the Royal Statistical Society, Series B (1984) very innovatively apply incidence matrices of block designs to survey sampling, and constitute a major step forward from the ideas of M.C. Chakrabarti in 1963. His subsequent research on controlled selection with J.N.K. Rao has been quoted as a breakthrough in A. Chaudhuri's book on survey sampling: "In the context of controlled sampling the most outstanding and decisive achievement has been by Rao and Nigam (1990) who almost have spelled the last word in this context by showing that this problem has the easiest solution on application of the linear programing approach by dint of the simplex method". In the context of variance estimation of a non-linear statistic from a large-scale complex survey data, his research with V.K. Gupta in Biometrika (1987) extends the concept of balanced repeated replications (BRR) to unequal number of selections per stratum by building a mapping of mixed orthogonal arrays of strength two on to the BRR.

Arun has made substantial innovative advances towards generating appropriate statistical methodologies for conducting large scale surveys and analyzing the data in the areas like food insecurity, hunger, maternal child health and nutrition, sex ratios, adolescent anemia and reproductive sexual health, gender disparity, intra-household consumption expenditure, diseases in community clusters, urban infrastructure development including water supply, sanitation and drainage, waste management, and hygiene. He has a very broad experience of completing over 80 research projects mostly from leading international agencies like UNICEF, WFP, ADB, World Bank, USAID, etc. As chairman / member of several scientific committees of leading professional institutions, Arun has provided consultancy to organizations like (i) Lal Bahadur Shastri National Academy of Administration, for finalizing methodology for their all India reports on land reforms; and (ii) Intra-Health International on evidence reviews of large-scale projects implemented in India and project formulation/finalization for their Vistaar project.

Deriving estimates with inadequate sample size had been rampant by most user agencies till Arun convinced them about the hazards associated with such faulty analysis. For instance, for estimating prevalence of Bitot's spots, NNMB's district nutrition profile surveys take less than 400 children in each district. Because of grossly inadequate sample size, district nutrition profiles report the prevalence close to zero in most districts. The required sample size is 14000 plus. NNMB have now discontinued giving these estimates.

Arun was first in the country to use randomized response (RR) technique in a study on targeted intervention among truck operators in Lucknow district sponsored by State AIDS Control Society/World Bank and obtained estimates of percentage among truckers indulging in high risk (unsafe) sexual behavior. RR technique was also used to assess child sexual abuse in a state level study in U.P. In a Central Statistical Office sponsored study, Arun prepared a district wise food insecurity atlas of U.P. Small area estimates were derived to obtain district level estimates of the percentage of population with chronic energy deficiency. Arun also contributed towards state level assessment of anemia and vitamin A deficiency, and analysis of the sustainability of the effect of IFA even after its withdrawal. He showed considerable gaps in reporting under nutrition under field conditions, and indicated that the percentages of children left out by IAP classification were very high across all the districts. This was perhaps one important reason for persistent under nutrition in the country despite massive efforts.

Arun's effort in the U.P. nutrition survey sponsored by UNICEF was the first ever to give nutritional status of women and children by districts/regions. The report of the basic survey along with the report on secondary data analysis of major causes of malnutrition and their inter-relationships were converted into a State of Art document "Nutritional Status of Women and Children in U.P." which was published in 1999 by Department of Women and Child Development under their banner. This document was further used as a reference document by multiple agencies including UNICEF. For the first time in the country, Arun evaluated associated risk factors of underweight, stunting and wasting, using logistic regression. Analysis of the data showed that the maximum under nutrition is at 11-12 months and not around 24 months as

erroneously shown earlier. This had interesting policy implications: focus on children under 2 years of age; under 1 year for prevention and between 1-2 years for controlling under nutrition. Arun made pioneering recommendations through his impact assessment studies on ICDS food fortification and fortified food for education Program. An analysis of the nutritive values of food items taken during the last 24 hours at home and in mid-day meal indicated that children were still far below the recommended dietary levels in iron and vitamin A and there was every need to supplement the diets with fortified foods.

Arun has been actively involved in capacity building of leading international organizations for evidence-based decision making through impact assessment, and comparison of key indicators in the pre- and post- stage of the project. He succeeded in convincing the funding agencies of the necessity of carrying out a proper baseline. He also persuaded several agencies to refrain from reporting by sub-groups like caste, religion, gender, age group, grades of nutritional status, grades of anemia etc., as such estimates are highly imprecise due to inadequate sample size. He also advocated the use of small area estimation methodology for providing reports for such sub-groups. His work on primary education found place in the state plan of action on primary education formulated by the U.P. government. Subsequently, he guided two path breaking projects on estimating population of children by single age, gender and caste, at district, block and town area levels, for U.P. state education for all project board. These findings were extensively used by UNICEF and the state government for education for all project, to ensure enrollment at 6 years and retention in subsequent years.

It has been a matter of pride and honour for us to have attempted to prepare this write-up on Professor Nigam, an academician of the highest order of eminence and, at the same time, a great and true friend, philosopher and guide. We earnestly wish him a very long and healthy life so that the scientific fraternity keeps benefiting from his wisdom and brilliance and the statistical sciences keep growing further, and we keep getting the benefit of witnessing innovative intertwining of statistical sciences in areas that truly serve the society especially the rural population.

## 2 Research publications

### 2.1 Books

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## 2.2 Research articles in journals


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### 2.3 Monographs, Technical reports

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