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Anindita Majumdar & Asif Qureshi

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Thinking about infertility from a mixed-methods perspective: the need to look at toxicity in rural India

Anindita Majumdar [a], Asif Qureshi [b]

a Assistant Professor, Department of Liberal Arts, Indian Institute of Technology Hyderabad, Kandi, India

b Associate Professor, Department of Civil Engineering, Indian Institute of Technology Hyderabad, Kandi, India. *Correspondence:* asif@ce.iith.ac.in

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In this paper, we suggest that the interlinkages between environmental toxicity and reproductive debility in India need greater scrutiny from the perspective of a mixed-methods approach including environmental science, toxicology, and social science. The mixed-methods approach in the study of infertility has included collaborations between anthropologists, social scientists, and clinicians working in the area of assisted reproduction.[1,2] We suggest that such an approach is the way forward in addressing issues that disciplinary boundaries may prevent researchers from fully exploring. Thus, while infertility remains an important and emerging area of focus within the social sciences, epidemiology, and obstetrics and gynaecology, in practice the fixation with fertility and population control restricts the study of infertility to a niche population, and to the administration of assisted reproductive technologies. It is important to note that the linkages with medicine and social sciences do provide greater insight into the study of infertility[3,4]; however, experimental methods and laboratory tests may help engage with people's experiences in a robust and inclusive manner.[5] Such an intervention, using scientific laboratory methods and social science analysis, needs to go beyond participant observation in the laboratory,[6] to include a collaborative approach.

An emerging concern, globally, is the impact of environmental toxins on fertility and is based on research findings emerging from professional epidemiological research, as well as toxicology studies.[7,8] In India, most research findings include analysis of government survey data on fertility and birth control to arrive statistically at estimations regarding infertility.[9,10] Epidemiological and toxicology studies are engaged in unearthing scientific correlations between environmental pollution and reproductive health, while study extrapolations from government survey data, such as the National Family Health Survey (NFHS), highlight the need for undertaking more inclusive questionnaires that look beyond birth control and other population indices.[11]

In this paper, we illustrate the need for a collaborative research agenda by bringing together the perspectives of an environmental scientist and an anthropologist in engaging with infertility in South Asia. Within South Asian studies, social science research has chronicled the reproductive lives inhabited by women in rural India,[12,13] yet very little has been said about infertility and its impact on people's lives. Until recently, the obsession with fertility and sterilisation has led to an almost stereotypical representation of rural Indians as "hyperfertile". In new research, there is an exploration of how such stereotypical imagery of populations and people can lead to detrimental policy and medical interventions.[14,15] This paper seeks to address this lacuna by specifically focusing on infertility in rural India.

There are two primary reasons for the focus on rural infertility through a mapping of pesticide use and impact: first, the limited engagement of the public sector with fertility care and management has been repeatedly noted.[16,17] In both

statistics and policy framing, the reproductive health of marginal groups has been rendered invisible by "reproductive imageries", such as target ethnic/ religious/economically disadvantaged women being identified as "hyperfertile",[15] or those living in low-income settings[18] as targeted groups for population control and intrusive surgical interventions.[19] Research findings highlight that obstetric violence against women from disadvantaged groups is usually enacted through hospital staff who lack training in patient sensitivity.[20] This lack of empathy on the part of medical staff extends to a lack of knowledge about specific reproductive ailments that may be linked to infertility.[14] In a survey of 12 district hospitals, 24 community and 48 primary health centres, and 48 sub-centres, in two districts each from North, South, East, West, Northeast, and Central India between November 2012 and February 2013, conducted as part of a scoping analysis on prevention and management of infertility, it was found that none of the staff received any in-service training on infertility management, and a majority had inadequate related facilities.[21] Second, infertility treatment primarily targets urban environments.[22] 9.8% of urban women aged 22–49 years were childless compared to 6.3% of similarly aged rural women in 1998–1999.[23] The supposed high numbers of infertile women in urban India have led, in turn, to the emergence of an "ART [assisted reproductive technologies] industry" that is largely privatised and rests on "inflated success rates" of pregnancies and aggressive advertising.[22] Most social science literature on infertility and health infrastructure in India has also focused on urban private operators and clinics.[24] The National ART Registry (NARI) listed a 16% growth of *in vitro* fertilisation (IVF) providers in India over a three-year period, from 113 IVF centres in 2007, to 132 in 2009,[25] with no data listing the rural-urban differentiation of clinics and infertility treatment. In fact, there continue to be very little data available on the number of clinics and their reach in India.

Rural lifestyles and pesticide toxicity

Rural environments in India have been identified as "toxic landscapes" due to rampant use of pesticides.[26] The overall use of chemical pesticides in India has steadily increased from 56,280 megatonnes in 2014–2015 to about 60,599 megatonnes in 2019–2020.[27] Most important indigenously produced pesticides were orthophosphates and organochlorines (e.g. 2,4-D (2,4-dichlorophenoxyacetic acid), acephate, profenofos, cypermethrin, chlorphyriphos). Pesticide exposure leads to overall health impairment, including immune suppression, hormone disruption, adverse intellectual development, reproductive abnormalities, and cancer.[28] The herbicide 2,4-D has been associated with poor semen quality.[29] Significant asthenospermia (reduced sperm motility), necrospermia (low content of live and high content of immotile sperms), and teratospermia (abnormal sperm morphology) were found in 32 farm sprayers exposed to 2,4-D compared to control subjects.[30] Abnormal spermatozoa rose in abundance and permanence. The authors recommended routine clinical and toxicological check-ups, protection from exposure and intervals with no exposure; however, teratospermia was observed to remain after a short recovery period.[30] In another study, semen concentrations, percentage of sperms with normal morphology, and percentage of motile sperms were lower in subjects with elevated levels of herbicides alachlor and atrazine and insecticide diazinon, and poor sperm quality was observed in subjects with elevated levels of 2,4-D and another herbicide, metolachlor.[29] However, the only detrimental exposure-related parameters mentioned in Indian national health surveys and rural health missions are the consumption of tobacco and alcohol.

Two hundred and sixty-three million of the Indian population are either cultivators or agricultural labourers, of whom 252 million live in rural areas.[31] Occupational exposure is problematic, probably more so than dietary exposure, for Indian rural farmers. The dearth of studies on pesticide exposure-related infertility is alarming. Although studies linking farm exposure to pesticides with male fertility, abortions, stillbirths, neonatal mortality, and congenital disorders were reported as early as 1991,[32] there have been fewer explorations of this subject since then and more on dietary and residential exposure to pesticides and fertility (for example, Golatker[33] and Pant[34]). Male infertility in seven towns/cities has been reviewed to be 35–76% (i.e. 35–76% of the men suffered from sperms being impaired or immotile).[33] These studies either analysed semen from male patients or conducted a retrospective analysis of older semen evaluation reports. In comparison, studies on pesticides and farmer suicide or symptoms of

exposure unrelated to fertility, e.g. burning eyes, dizziness, tremors, are much more recent.[35,36] The data discussed in these studies require more in-depth exploration. Most of the studies on agrarian toxicity have been conducted on male farmers through a biased understanding of farming in India as a predominantly male profession. And yet the value of these studies cannot be discounted completely as they highlight the need to focus also on reproductive health issues amongst men, arising from occupational hazards. There is an urgent need to engage with the identification of categories of affected populations, in terms of both rural and urban toxicity, and infertility, as well as to critically analyse the testing mechanisms being used to arrive at particular figures. The latter is a possibility that we wish to explore through the mixed-methods approach by engaging in a more inclusive and expansive examination of infertility in India.

The absent infertile: family planning in state and policy documents

Overall, the continued representation of the rural population as "fertile", and requiring continued family planning interventions, creates health inequity across the urban-rural and rich-poor divides. This bias is misplaced and has led to an absence of policy interventions in providing equitable health services in the holistic care of infertile women and men in India (and across the world[1,2]). Thus, the overwhelming thrust in health policies related to reproduction in India is geared towards reducing the fertility rate (childbirths per woman), lowering infant mortality, healthy sexual practices and promoting positive attitudes towards family planning.[37] For instance, both women's and men's schedules in the last National Family and Health Survey (NFHS) factsheet[37] contain information on marriage, fertility, child health, nutrition, contraception, sexual behaviour, reproductive health, HIV/Aids, domestic violence, and decisions regarding contraception, but nothing on infertility. The overall goal appears to be to provide a safe and healthy environment when birth occurs and to promote family planning practices to lower the birth rate. The National Rural Health Mission[38] is additionally geared towards providing health services, safe drinking water, sanitation, and control of vector-borne diseases. While practices alluded to in these documents to achieve lower birth rates are healthy practices, such as contraception and better actions for family planning (sterilisation of male or female), there is no related conversation on how conception, pregnancy, and birthing may be impaired. Thus, there is a missing conversation within NFHS, and the District Level Household Survey (DLHS)-3 data[39] on how environmental exposure to substances such as heavy metals, organic solvents, pesticides, and chemicals associated with consumer and electronic products, such as bisphenol-A and perfluorinated alkyl substances, can impair fertility.[40]

The NFHS is one of the main documents that provide some markers of infertility or childlessness across rural-urban populations. Yet, these data are split across age groups and do not provide a decisive figure on women who suffer from infertility or who are childfree by choice. Categories such as: "percentage who never gave birth", "declared infecund" create a sense of incomplete mapping of data that is otherwise very specific regarding choices exercised in pursuing children through the identification of categories such as: "want another soon", "want another later", "want another, undecided". Such a bias reflects on the modalities of a questionnaire that is certainly skewed, not only in representing the desire for birth but also in the medicalisation and pathologisation of those unable/unwilling to have children. These "indices" and "markers" within the NFHS are not convincing in terms of revealing the extent of infertility, and socio-medical experiences associated with it, especially in rural India. Nonetheless, as mentioned earlier, the NFHS has been the source of extrapolations among statisticians and public health specialists aiming to record infertility and its concomitant markers.[9–11] In the analysis of NFHS data, mixed methods are often used, combining multivariate statistical analysis with public health indices to arrive at otherwise "hidden" figures of data on fertility and birth planning. Yet, the lived experiences with fertility and infertility are still clearly missing in the data analysis and extrapolation. Thus, this particular mixed-methods approach of statistical analysis with public health indices may "speak" but does not necessarily completely represent the on-the-ground realities or experiences.

Why mixed methods?

Highlighting the mixed-methods focus involves looking at how toxicology and professional epidemiology studies can benefit from a more ethnographic, survey-based engagement on the "felt" effects of

environmental pollutants and pesticides on fertility. Here, we suggest that a "popular epidemiology"[41] might be a provocative new form of engaged ethnography, where the community – with the ethnographer and environmental scientist/toxicologist – build an inclusive questionnaire that is open, and constantly developing to accommodate rural communities changing bodily adjustments, and health conflicts with their lived environments. Popular epidemiology accompanied with a robust and linked toxicology study should, ideally, explore childlessness, secondary infertility, miscarriages, painful births, sexual debility – among men and women – and frequency of reproductive tract infections.

The stance towards engaging with popular epidemiology and lab-based toxicology studies emerges from four different concerns within the literature on infertility in India and globally. First, there is an urgent need to assess considerations regarding the "epidemic" proportions attributed to infertility in countries in Asia (along with sub-Saharan Africa) where it is suggested that considerations of overpopulation trump the very real concerns surrounding primary and secondary infertility. Inhorn and Patrizio[1] highlight how infertility is inadequately addressed due to policy and international organisational focus on overpopulation, and on promoting birth control. Ethnographic studies have pointed out the social debility that women, and men, suffer when confronted with years of childlessness, jeopardising marriages, and social security – especially in rural agrarian communities.[4,12,13,42] What are the reasons for primary and secondary infertility amongst men and women in rural, pastoral, and agrarian communities in the developing world? In asking this question, we are purposely refraining from speculating regarding the reasons and causes; instead, we are asking for urgent recognition of the need to understand that infertility is recognised as an important health problem amongst the identified communities, so that relevant research can be initiated.

Second, emerging statistical estimates regarding infertility extrapolated from national family and rural health surveys in India tend to focus largely on lifestyle issues as the major cause for infertility. This is particularly problematic, as the conversation on lifestyle is particularly linked to indices, such as age at marriage, obesity, and education. As mentioned earlier, such parameters are extracted from government data and epidemiological studies that tend to focus on dietary patterns and chronicity.[43] Research findings[8,44,45] suggest that lifestyle-linked infertility is a result of stressful urban lifestyles, with a few professional epidemiological studies of how urban pollution impacts fertility in the long-term, and no such corresponding study for rural areas. The idea of low-cost IVF in resource-poor nations in South Asia is met with incredulity due to the paucity of data regarding infertility numbers.

Third, the limitations linked to the study of toxicity in lived experiences do not, as yet, engage in more depth with the reproductive body. This may be due to the findings being restricted to clinical laboratory experimentation with chemicals on particular parts of the body, which, while revelatory, may nonetheless not be very expansive. For instance, in countries such Bangladesh and India, arsenic is a serious health hazard and its epidemiological impact on reproductive health is not completely explored.[46] Similarly, reproductive tract infections among women in rural and semi-urban townships in India are a major cause of reproductive debility largely due to unhygienic toilets and sanitary access – a major cause left unexplored in national data, and in toxicology reports. The need to expand the focus to engage with lived experiences of toxicity, through an exploration of symptomatic bodily discomfiture, navigation of reproductive failures, and other kinds of associated illness narratives, is essential.

Fourth, the chronicling of lived experiences also includes a more effective engagement with lived environments. Ethnographic analysis has pointed towards the need to look at the environment and habitat according to how people experience it.[41,47,48] A coming together of the engineering sciences that propose the viability of built environments benefits from the contribution of anthropological insights from the people living in such infrastructures. Rural infrastructures in India are bound to benefit from such an involvement to understand their environments better.

Conclusions

Popular epidemiology is led by the community and people under study. It is active research that enables scholars to create an ecosystem of participatory engagement in policy shifts and academic research. We suggest that the intervention of the community in creating an open-ended questionnaire is essential to providing a valued

space to infertility within rural health indices, creating an interface with environmental scientists to propose more inclusive built environments, and providing a larger canvas to engage with toxic agrarian practices. Such a questionnaire may include items such as: frequency and amount of pesticide used, the name of pesticide used, use of protective gears, and the gap between periods of pesticide use and exposure. Additional studies generating primary data, for example, relating semen quality to the occurrence of pesticides in human biomarkers such as urine[29] may be undertaken to develop a database and further strengthen evidence-based decision making.

In this paper we argue for two things, in particular, to achieve the objective of identifying infertility and environmental toxicity in rural India as linked health concerns. First, we suggest that a mixed-methods approach provides greater depth in researching infertility in rural communities living with agrarian and environmental toxicity. Our mixed-methods approach seeks to bring together laboratory toxicology studies with an interactive ethnographic engagement wherein communities and people identify and sculpt research indices – also known as popular epidemiology. Second, though limited, we have also highlighted the need to re-engage with the NFHS data through its measurement and analytical themes that categorise fertility and infertility into watertight compartments influenced by decades-old policy discourse on population control. We suggest the urgency of looking at NFHS data from a more critical standpoint, questioning its implicit bias in designing the survey schedule.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Anindita Majumdar http://orcid.org/0000-0003-4976-1129
Asif Qureshi http://orcid.org/0000-0003-3329-0166

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