Current Science Reports

Predicting Monsoon Onset

Impact of local factors

Weather is a complex, nonlinear system where even minor perturbations in present conditions lead to major outcomes; even decimal approximations in the initial conditions lead to huge deviations in the results.

The Indian monsoon has proved to be especially difficult to forecast. The onset of the monsoon takes place abruptly and its predictability for more than ten days in advance remains an important concern for the subcontinent. Can we improve the prediction skills by updating the variables in the models with more accurate measurements from better coverage of the subcontinent?

Variables like temperature, humidity and wind movement are global influencers of weather models. By including local factors like soil moisture and snow albedo, can we reduce errors in forecasts about the onset of the summer monsoon?

A group of meteorologists from Pune collaborated with a colleague from the UK to investigate. The researchers used different weather prediction models to tackle the two problems: GloSea5, the seasonal weather prediction system from the UK Met Office, and IITM-CFS, the climate forecasting system developed by the Indian Institute of Tropical Meteorology, Pune. Since the IITM model had two initialisation systems, the team tested both.

They compared the prediction skills of the models using the monthly and daily initialisations of land surface data and hindcasting to check against the monsoon over Kerala from 2003 to 2015. They also compared the temperature forecast probability density function and rainfall on 18 May as well as the forecast of the evolution of rainfall, three days before to five days after monsoon onset. The evolution of rainfall was captured better by the models when initial conditions were updated daily. However, the results from hindcasts deviated from the observed datasets. The differences observed in the biases in the prediction over land and over ocean could be explained by differences in the availability of moisture, say the researchers. The models, however, could not capture variations in moisture levels over land, an important feedback component for the monsoon system.

Soil moisture and other land surface variables are directly coupled to the atmosphere through surface fluxes. So the researchers calculated the coupling strengths to understand the effect of the land surface initialization on the biases in rainfall, humidity, vertical velocity and near-surface variables.

They also resolved the total kinetic energy of surface winds into rotational and divergent components. The rotational component, a necessary build-up for the monsoon, was better represented by the IITM model and, therefore, the monsoon onset prediction skill of the model was also better.

While surface temperature and soil moisture in the southern peninsula were correlated with those over the landmass till almost the Gangetic Plains, the models showed biases over central India.

The results suggest that better land surface initialisation and increasing the number of observations have a similar effect on improving the forecast of monsoon onset.

DOI: 10.1002/qj.4475

Improving Shrimp health

Using microalgal feed

Early-stage larvae in shrimp farming are prone to bacterial infection. Conventionally, antibiotic treatments are used to reduce the problem. But the practice promotes multi-drug-resistant bacteria in aquaculture. It also leads to non-compliance with export regulations, threatening the Indian shrimp export market estimated to be worth 6 billion USD.

To protect shrimp larvae from infections, a diet that stimulates the immune system is a better option than using antibiotics.

Microalgae are natural shrimp food, rich in bioactive compounds. Can dietary microalgal concentrates improve disease resistance and larval growth?

Researchers from the ICAR-Central Institute of Brackishwater Aquaculture, Chennai and the ICAR-Central Institute of Fisheries Education, Mumbai chose two microalgae commonly used in aquaculture, *Thalassiosira weissflogii* and *Tetraselmis* sp.

To concentrate the algae, they used chemical flocculation. Adding 10 millimolar sodium hydroxide worked best for the purpose.

The researchers then profiled the nutrients and measured the antioxidant properties of the algae. Both algae were protein-rich, accounting for more than 42% of biomass. Polyunsaturated fatty acids were higher in *Tetraselmis*, mainly because of higher linoleic and alpha-linolenic acids. *Thalassiosira weissflogii* was better than *Tetraselmis* in total phenolic compounds and antioxidant activity.

The researchers then evaluated the bioactivity of the algal extract against the pathogenic *Vibrio* species. The *Tetraselmis* extract showed better bioactivity against *Vibrio harveyi* and *V. parahaemolyticus*, while *Thalassiosira* performed better against *V. campbelli*.

How much microalgae are to be included in shrimp feed?

To find out, the team made seven experimental diets with different concentrations of algae and fed the diets to the post-larvae of *Penaeus vannamei*, a commercially important shrimp species. After six weeks, survival and growth were better in shrimps fed with algal concentrates than in those on a control diet. Shrimps on a diet containing 1% *Tetraselmis* concentrate showed the highest weight profile.

Algal-supplemented diets also improved blood parameters such as total haemoglobin count and content. A gut microbial analysis showed a significantly reduced *Vibrio* load.

Since cultivating the two algal species and making concentrates are not difficult or costly, this study opens a new avenue for functional feeds in the aquaculture industry.

DOI: 10.1007/s10499-023-01114-7

Screening New-born Babies

For inborn metabolic errors

New-born screening can help detect inborn errors in metabolism, including disorders of the endocrine system. If detected early, many of these disorders can be managed. But detecting such problems by DNA testing is tedious and time consuming.

Image: K. Vardeman via Wikimedia Commons

To characterise complex mixtures containing typical biomarkers that signal inborn errors in metabolism, the tandem mass spectrometer is a useful analytical tool. This method, where two or more mass spectrometers are coupled sequentially, was introduced in the 1990's, and is now used worldwide to extract information on many metabolites from small quantities of samples.

Recently, Shaik Mohammad Naushad and team at the YODA Lifeline Diagnostics, Hyderabad used liquid chromatography–tandem mass spectrometry and genetic test data along with machine learning tools to see correlations in metabolites and inborn errors in metabolism.

They used data from 570 babies of up to 7 months of age. The babies showed no symptoms for 2 to 3 months during follow-up. This provided the reference range of metabolites to be expected in the urine of normal new-born babies.

Using liquid chromatography–tandem mass spectrometry, the researchers examined urine samples from the babies for metabolic changes related to prematurity and nutritional status. They also analysed amino acids and acylcarnitine, a non-protein amino acid attached to fatty acids.

C16, an endogenous acylcarnitine with a fatty acid of 16 carbon atoms, and C6DC, an organic acid analyte, showed statistically significant associations with birth weight. The system could also diagnose B12 deficiency with reasonable accuracy.

The team conducted gene sequencing on 30 positive cases of errors in metabolism. They used genetic and metabolic data to train the classification and regression technique, a machine learning algorithm.

They tested the system using samples where molecular analysis was available. Then, using the system, 3000 new-born baby samples from different hospitals were screened for inborn errors of metabolism. Among amino acid disorders, tyrosinemia, inability to synthesise tyrosine, and maple syrup urine disease, inability to break down certain amino acids, were the most common. There were also cases of methionine overproduction and increased levels of phenylalanine, causing higher levels of its metabolites in urine.

They also easily diagnosed more than 30 organic acid disorders, quite a few cases of urea cycle disorders and fatty acid oxidation disorders.

'Our method helps in differential diagnosis and minimises errors,' says Shaik Mohammad Naushad.

Combining liquid chromatography, tandem mass spectrometry and machine learning is a quick and easy way to detect and diagnose, and initiate interventions to save the organs of babies from further damage due to inborn errors in metabolism.

Producing the necessary instruments in India can also bring down the costs of epidemiological surveys for the prevalence of such disorders in the population.

DOI: 10.1007/s11306-023-02013-x

Glaucoma in Ocular Inflammation

A retrospective study

Glaucoma is a condition where intraocular pressure is increased. The increase in pressure can impact the optic nerve, leading to loss of vision. Sometimes, glaucoma happens because of inflammation of the middle layer of the eye, the uvea. Glaucoma due to uveitis can be managed by reducing the intraocular pressure surgically. But surgical management remains challenging due to a low success rate and high post-operative complications. Can we control uveitic glaucoma with adequate anti-inflammatory agents and intraocular pressure-lowering therapies, reserving surgery for difficult cases?

To find out, Niranjana Balasubramaniam and team from the Arvind Eye Care System, Madurai conducted a retrospective study. She collated the data of uveitis patients above 12 years of age who had been referred to the hospital in the last two decades. The most common diagnosis of glaucoma was non-granulomatous uveitis, followed by uveitis characterised by granuloma formation due to eye infections.

As the baseline parameters, the team selected the best corrected visual acuity, intraocular pressure and the extent of optic nerve damage during the first presentation in the glaucoma clinic. They took into consideration the duration of follow-up, representative of the chronicity of the disease condition, and excluded cases with a single resolved episode of uveitis.

Nearly 25% of the patients had been treated with ocular and systemic steroids. For better control of inflammation, 9% of the patients had been given a combination of steroids and immunosuppressive agents. Almost one-third of the patients had undergone surgery to release intraocular pressure.

There was a significant reduction in postoperative intraocular pressure compared to baseline levels. Among 547 eyes, complete success was seen in about 30% of the eyes, and about half the cases were considered qualified successes. The remaining 19% of the eyes were considered treatment failures. Granulomatous uveitis, despite having a lower incidence, was the most common diagnosis for treatment failure.

Eyes treated with topical steroids, either alone or in combination with systemic steroids, accounted for more than half of the total failures. Corticosteroids should always be used judiciously, tapered off and stopped when the inflammation settles, say the researchers.

This retrospective study of the type of treatments provided to glaucoma patients over the last two decades suggests that glaucoma can be managed based on the causative factors and the severity of the symptoms. In refractory scenarios, surgical options

yield better outcomes if inflammation is well under control.

DOI: 10.1080/09273948.2023.2202740

Endoscopic Surgeries
Are antibiotics necessary?

Endoscopic procedures are safe and reduce the chances of infection in patients. Even so, several doses of antibiotics are administered to patients in the perioperative period. This could aggravate the global problem of anti-microbial resistance.

Doctors from the Asian Institute of Gastroenterology, Hyderabad tested the hypothesis that a single dose could work just as well as multiple doses of an antibiotic for the purpose. They recruited patients who had undergone endoscopic surgery to treat achalasia, a condition where the sphincter in the lower oesophagus does not relax. Around 120 consenting individuals were randomly distributed into two equal groups. One group received only a single dose of cefoperazone or sulbactam, drugs which kill bacteria by inhibiting their cell wall formation. The other group received two doses of the same antibiotic for three days, including the day of the surgery.

During this time, the doctors continuously monitored blood parameters like white blood cell count and inflammatory marker levels which indicate infections. There were no significant differences between the two groups. Almost all the individuals were healthy and did not develop any infections. The only significant difference was the increased level of C-reactive protein, an acute phase reactant synthesised in response to inflammation, among those who had developed a fever. Most of them recovered on the second day. However, two people in the multiple dose group and one in the single dose group had persistent fever symptoms. To treat them, further doses of antibiotics were given.

The results suggest that there is no significant difference in patient health after the administration of a single dose or multiple doses of antibiotics after endoscopic surgeries.

The study did not include a control group, which would have received no antibiotics. Would this have impacted the study's results? Should antibiotics be prescribed only to those who have signs and symptoms of infections? Further research is needed to answer these questions.

DOI: 10.1007/s00455-023-10585-y

Treating Diabetic Neuropathy
An antioxidant approach

The cells of people living with diabetes produce free radicals and cause oxidative stress. This can lead to a misfolding of insulin and to the formation of insulin fibrils which, in turn, leads to the deposition of a waxy aggregate or amyloids. Amyloids have toxic effects on cells.

Oxidative damage is a major factor attributed to the development of amyloids and neuropathy in diabetics. To reduce the chances of such complications, lipoic acid, a well-known antioxidant, could be used. But the clinical use of lipoic acid is limited due to its high instability and low solubility.

Priyadarsi De, Arindam Mukherjee and team from IISER Kolkata recently came up with a solution to the problem: package lipoic acid in a hydrophilic polymer.

The reduced form of lipoic acid, dihydroplipoic acid, shows better antioxidant action than lipoic acid. So the researchers decided to use both forms to compare their effect on reducing or inhibiting insulin fibrillation.

The team incorporated lipoic and dihydroplipoic acid into the side-chain of water-soluble poly(polyethylene glycol methyl ether methacrylate).

Using a free radical chemical assay, they found that the reduced form of lipoic acid bound to the polymer had almost double the free radical scavenging activity.

The researchers checked whether the polymers could reduce the haemolytic effect of insulin fibrils on erythrocytes. Haemolysis was reduced from more than 40% to less than 4% by the lipoic acid-bound copolymer and to less than 2% by dihydrolipoic acid bound to the polymer.

The researchers monitored the effect of the polymers on the cell viability of a neuroblastoma cell line. The dihydrolipoic acid bound to the polymer rescued the cells from the toxic effects of reactive oxygen species and increased their viability from about 56% to about 95%.

To test the anti-amyloidogenic potential of the copolymers, the researchers used fluorescence spectroscopy. They observed a significant reduction in fluorescence intensity of thioflavin T dye when insulin under amyloidogenic conditions was incubated with the bound polymers. This suggested a reduction in amyloidogenesis.

In-vivo studies are now required to establish the role of these polymers as safe and effective amyloidogenic inhibitors, say the researchers.

DOI: 10.1002/mabi.202300100

EEG and Machine Learning
To identify neuropathic pain

Stroke damages the central nervous system and the improper use of the affected limbs results in chronic pain in stroke patients. It is difficult to identify whether such pain is caused by nerve damage. Can electroencephalograms be used to diagnose neuropathic pain?

Researchers from the SRM Institute of Science and Technology, the Jerusalem College of Engineering and the Mepco Schlenk Engineering College, Tamil Nadu collaborated recently to develop a brain-computer interface to identify the risk of developing neuropathic pain in stroke patients. They took EEG datasets of paralysed patients with chronic pain, without pain and normal individuals and extracted distinguishing features.

Based on the results of previous research, they used weighted incremental–decremental support vector machine – a machine learning method for classification based on the features extracted. To enhance the efficiency of the classifier, they used the quantum chaos butterfly optimization algorithm to produce a new dataset from the samples with higher weights. The algorithm relies on the chaos theory and quantum computing techniques and has better performance in most tested cases.

The researchers trained and tested the algorithm using several metrics and found that the method achieved an accuracy of about 80%. Though useful for quick screening of patients, further

fine tuning of the method is required before it can be used as a diagnostic tool.

DOI: 10.1002/ima.22882

Menstrual Responses
COVID-19 vaccine effects

Some viral vaccines like the influenza vaccine or the human papillomavirus vaccine are known to impact the menstrual cycle. Recently, COVID-19 vaccination initiatives have been implemented globally. Does the COVID-19 vaccine also cause changes in menstrual patterns?

A team of researchers from the Government Medical College, Srinagar conducted an online survey to find out. The questionnaire included four main domains: history of COVID-19, type of vaccine administered, changes in the menstruation cycle after vaccination and sociodemographic variables – age, gender, marital status and weight.

The researchers administered the questionnaire to 300 women of reproductive age who had received the COVID-19 vaccination. Out of 211 women who had received the Covishield vaccine, 18 reported changes in their menstrual patterns whereas 12 of 89 women who had received Covaxin reported changes in the regularity of their cycles such as delayed cycle, prolonged or missed cycle. Most respondents reported no changes; only 10% of the women reported a change in the regularity of menstruation. Around 11% of the women reported a change in cycle duration such as decreased or increased duration and decreased duration with thick blood clots.

The duration of menstrual pain increased in 18 of the women. Of these, 12 reported more pain but without cramps and 6 reported more pain with cramps.

Changes in menstrual flow such as increased menstrual flow and decreased menstrual flow with or without blood clots were reported by nearly a quarter of the respondents. These changes were transient.

A limitation of the study is that it was based on the recollected self-perception of menstrual changes. Moreover, the stage of the menstrual cycle – before, during or after ovulation – at the time of the vaccination is also a factor that needs to be considered in future studies.

DOI: 10.1002/ijgo.14822

Detecting Doping in Athletes
A quick and easy way

Current methods to detect the use of performance enhancing drugs by athletes are time consuming and complex. This delays the detection of the doping, impacting the fairness of athletic meets. So there is a need for simple equipment to detect doping quickly and accurately.

Image: AFI via Wikimedia Commons

Recently, Murugavel Kathiresan from the CSIR-Central Electrochemical Research Institute, Karaikudi collaborated with researchers from China to develop a method to detect doping from saliva and urine.

They used liquid–liquid extraction, a simple method to separate compounds based on the relative solubility of chemicals in organic and aqueous solvents.

Now the problem was to identify the compounds that were separated. The researchers used surface enhanced Raman spectroscopy for the purpose.

When light falls on a chemical sample, it is modified and scattered by the vibrational modes of the chemical bonds in the molecules. The scattered light reveals the spectral fingerprints of the molecules. This phenomenon, the Raman scattering of molecules, can be enhanced by adsorbing them on metal surfaces or by nanostructures. The researchers used gold sol, a colloidal aggregate of gold atoms of less than one nanometre, for the surface enhanced Raman spectroscopy.

They characterised the Raman scattering spectra of four common performance enhancing drugs: clenbuterol, methadone, oxycodone and chlordiazepoxide. Then, they extracted the drugs from urine or saliva samples using the liquid–liquid extraction method and aggregated them on the metal substrate. This was lit up with a laser to get the Raman spectra. The team then compared their spectra with the reference spectra of the drugs to detect doping.

They achieved a limit of detection of 5–100 nanograms per millilitre of the drugs in the samples. The detection limit is comparable to that of current methods. And test results can be obtained within a minute!

Sports authorities can now use this strategy to conduct doping tests easily and quickly, say the researchers.

DOI: 10.1080/00387010.2023.2206474

Reports by **M. S. Induja, Tanya Jain, Sileesh Mullasseri, Bharati Swamy, Shabnam Basheer, Sheikh Aneaus, Manish Tekam, A. Karthic** and **Amit Kumar.**

ACKNOWLEDGEMENT: NCPOR, Goa for providing access to literature databases.

scienceandmediaworkshops@gmail.com