Vaccinating a nation:

Ten human factors and ergonomics principles

Chartered Institute of Ergonomics & Human Factors

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Contents

Foreword

This guidance aims to support the safe roll-out of COVID-19 vaccination programmes. Vaccination programmes include a number of work systems, such as manufacturing, filling and packaging for distribution, testing and approval, cold chain delivery, booking systems for vaccination appointments, local administration of the vaccine, and patient follow-up. The challenges and requirements for operating such complex programmes at speed may vary both within a country as well as between countries, but we can offer 10 principles to support systems thinking for vaccination programmes that apply across settings. These HFE principles relate to the identification and description of work systems (Identify), the improvement of work systems and processes (Improve), and the continuous learning from experience to achieve sustainable change (Adapt).

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The CIEHF has assembled expert panels consisting of clinicians and healthcare managers, scientists and engineers, academics and researchers, designers, quality improvement experts, human factors professionals and ergonomists to support the development and review of guidance on a wide range of procedures. **Contact:** Covid19@ergonomics.org.uk

Caveat: This human factors and ergonomics (HFE) advice is offered by Chartered Ergonomists & Human Factors Specialists (C.ErgHF) on a rapid response basis and does not reflect a full HFE analysis. The advice was offered within the Chartered Institute of Ergonomics and Human Factors (CIEHF) scope of practice for a Chartered Registered Member/Fellow
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The human factors and ergonomics (HFE) perspective on COVID-19 vaccination programmes

The delivery of national COVID-19 vaccination programmes to all adult populations is on a scale never attempted previously. Vaccines that typically require years to develop and test have come to market within one year, and several new vaccines with different requirements are still under development. Established supply chains had to increase capacity and deal with specific, ultra-cold storage requirements for some vaccines. Coordination between vaccine logistics, local administration centres and the population had to be tighter than before due to the short shelf lives of vaccines once removed from cold storage.

While some countries, such as Israel, United Arab Emirates, Chile and the UK, have made impressive progress with the roll-out of their vaccination programmes at least in as far as vaccination rates are concerned, the challenges at a global level are enormous. More than one third of WHO member states did not even have an established vaccination programme for adults for any disease prior to COVID-19. In addition, there is an imbalance with regards to vaccine supply, meaning many resource-poor countries who rely on the international COVAX distribution scheme, have little influence over when they will receive what types of vaccines. This makes planning and operation of national vaccination programmes even harder.

Across all countries there is also significant vaccine hesitancy for various reasons including concerns about the safety of the vaccines. It is important, therefore, that vaccination programmes include communication strategies that aim to increase knowledge and awareness of COVID-19 vaccines, and that local communities are involved. It has been suggested that greater emphasis needs to be placed on ensuring that minority groups are adequately included in vaccination communication.

Lastly, populations are incredibly diverse and people have different needs. With the initial focus being on the elderly and vulnerable, it is especially important to understand their requirements, such as transportation, access to internet and mobile phones for accessing appointment booking services, and health literacy. Some people might suffer from phobias and anxieties, and this needs to be accommodated accordingly, e.g., by making vaccination available in accessible and familiar locations.

HFE is an evidence-based scientific discipline that can support the setup and operation of vaccination programmes by providing approaches and methods for identifying and analysing the work systems that make up a vaccination programme, for improving work systems and processes to meet the requirements and challenges across diverse populations and settings, and for achieving sustainable change through continuous learning and adaptation.

The ten principles described in this guide represent an accessible way for including systems thinking in national vaccination programmes. They are:

IDENTIFY

1. Understand people's needs and capabilities.

2. Consider tools and equipment.

3. Assess the physical environment.

4. Describe the tasks people do.

5. Evaluate potential vulnerabilities.

IMPROVE

6. Re-design physical spaces, tools and tasks to enhance performance and reduce risk

7. Develop usable work instructions.

8. Design and deliver suitable training.

ADAPT

9. Monitor work-as-done and adapt to achieve sustainable change.

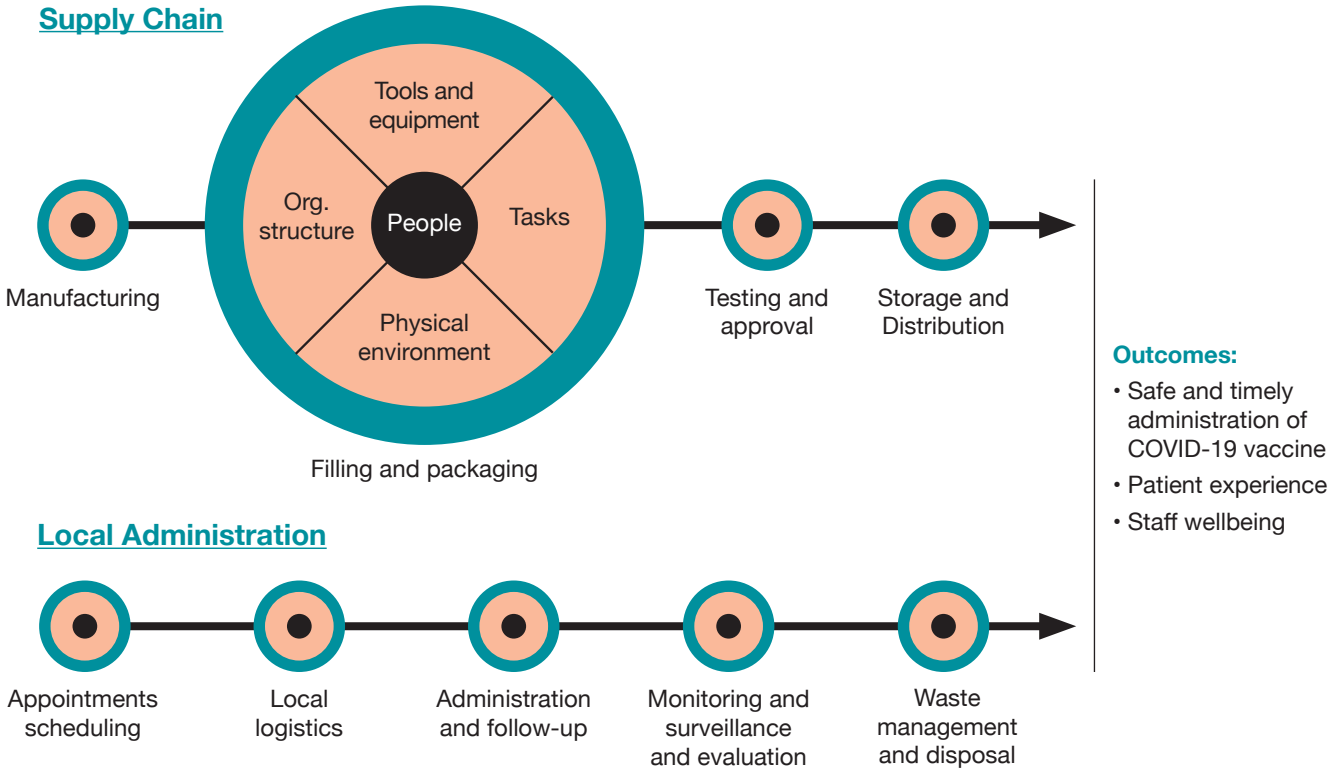
10. Record and learn from incidents.

Read about an ergonomist's personal reflection of their experience with accompanying their elderly family member to a vaccination centre in a blog on Patient Safety Learning: https://www.pslhub.org/learn/coronavirus-covid19/273_blogs/vaccination-centres-minimising-the-risks-to-vulnerable-people-r3875/

Implementing a mass vaccination roll-out

NHS COVID-19 Vaccination Centre

The overall structure of a national vaccination programme is likely to be complex, and includes work systems[1] such as:



Looking more specifically at local vaccination centres, their primary functions include:

- **Planning service delivery.**
- **Managing appointment bookings.**
- **Vaccinating patients.**
- **Monitoring the service delivery.**

There will be auxiliary functions that have to be considered, such as:

- **Cleaning and disinfection.**
- **Security.**
- **Maintenance.**
- **Transport and logistics.**
- **Catering.**
- **Housekeeping.**

Each work system is made up of people that interact with other system elements. Consider:

- **Other people, such as patients and colleagues.**
- **Tools and equipment.**
- **A diverse range of tasks.**
- **The physical environment.**
- **Overall organisational structure.**
- **External influences**

HFE approaches aim to understand and optimise these interactions in order to improve the processes and outputs, such as safety, patient experience, and staff wellbeing.

[1]Carayon P, Wooldridge A, Hoonakker P, Hundt AS, Kelly M. SEIPS 3.0: Human-centered design of the patient journey for patient safety. Applied Ergonomics. 2020;84:103033.

IDENTIFY

1. Understand people's needs and capabilities

The vaccination programmes tie together different work systems and people (e.g. patients, their carers or family members, front line staff in vaccination centres, managers, administrators etc) who have a diverse range of needs and capabilities. These need to be properly understood so that systems can be designed to meet the different needs. At each stage, consider who is involved, what their goals are, and what characteristics people might have.

An intuitive place to start is with vaccination centres, where people will receive the vaccine. Consider that people will have different physical capabilities and requirements, such as: mobility impairments; people might be anxious; some people might need someone else to accompany them; language might be a barrier for some; and there might be people who have visual impairments and struggle to read signs.

Of course, there are also healthcare workers to consider and administrative, managerial and support staff who deliver the processes. There might be outside providers, such as security and cleaning services. People might not have much experience with these types of processes, many might have volunteered and might not yet possess the refined skills and decision-making abilities that come with practice.

Patients:

- Age.
- Sex and gender.
- Mobility.
- Clinical condition.
- Physical and mental wellbeing.
- Physical attributes.
- Attitudes and preferences.
- Communication abilities (e.g. vision and hearing).
- Need for carer support.
- Cultural and language background.
- Health literacy (e.g. around the need for consent to vaccination).
- Location of residence and access to transport.

Staff:

- Hydration and nutrition needs.
- Need for comfort breaks and recovery.
- Sex and gender.
- Physical attributes.
- Pastoral and spiritual support needs.
- Personal safety needs (e.g. protection from aggression and violence).
- Training and experience.
- Familiarity with the process and equipment.
- Confidence.
- Differences in terminology.
- Experience of working in multi-professional settings.
- Availability for shiftwork (e.g. considering childcare responsibility).

There are likely to be many more people and roles in the vaccination programme at different stages. Try to identify them and map out for each of these their requirements and capabilities.

2. Tools and equipment

In order to deliver the vaccination programme people will use a lot of different tools and equipment, some of which might be unfamiliar to users, some might not have been designed for the tasks they are going to be used for but might have been repurposed.

Examples of equipment include:

- **Chairs.**
- **Desks and computer screens.**
- **PPE.**
- **Syringes for administering the vaccine.**
- **Sharps disposal containers.**
- **Bins for masks and used PPE.**
- **Spillage kits.**
- **IT systems for managing appointments and recording vaccines provided.**
- **User interfaces.**
- **Temperature gun / thermometer.**
- **Guidance leaflets.**
- **Sinks and sanitation for hand hygiene.**

Tools and equipment need to be appropriate for the task, they need to be usable, and they need to be properly maintained. For each tool and piece of equipment, we need to consider at the very least:

- **What does it need to be used for?**
- **Who needs to use it?**
- **How will it be used?**
- **How easy is it to understand and use it?**
- **How easily can it be maintained and disinfected or disposed?**

PPE is a recent example, where many healthcare workers have reported problems, such as PPE that did not fit properly and that was not designed for continuous use over long periods of time[2].

[2] https://www.ergonomics.org.uk/Public/Think/CIEHF-survey-confirms-serious-PPE-problems-on-the-frontine.aspx?fbclid=IwAR0rbMvPJ_

3. Assess the physical environment

The design of physical spaces is often overlooked, and people adopt workarounds to get by in poorly fitting spaces. It is also well established that noisy environments can contribute to exhaustion and poor mental health. On the other hand, well-designed physical spaces can improve efficiency and enhance experience.

COVID-19 and infection prevention and control considerations, such as social distancing, make well-designed and sufficiently ventilated physical spaces an even more important element of the work system. During each stage of the process, we need to consider how the physical spaces can contribute to efficient and safe operation.

During arrival:

- Consider spaces for public and for personal transport.
- Consider accessibility of the venue for people with different mobility and physical needs.
- Where possible, ensure spaces are familiar and welcoming to counter anxiety.
- Consider queueing systems and one-way pedestrian flows.
- Create clear signage to help people get to where they should be with clear signage at every navigation decision point.
- Signage should be informative for different user populations with different needs and from diverse backgrounds.
- Stairs and lifts can create bottlenecks and challenge social distancing, so special instructions need to be made available to people if these cannot be avoided.

Waiting area:

- Consider where people will wait.
- How many people can be safely accommodated to maintain social distancing (including people who are accompanied)?
- Where can facilities be located in order to minimise people movements?
- How easy to clean the spaces are?
- Ensure it is clear how people can exit the waiting area safely in case of an emergency.
- Seating and waiting arrangements should be suitable for people with different physical and mental health requirements.

Vaccination area:

- Staff will be working in this area for long periods of time, so spaces and furniture should provide sufficient comfort and should be adjustable to meet individual requirements.
- Materials and tools should be easily accessible.
- Lighting needs to be adequate (e.g. to enable reading of small print).
- Ensure there is sufficient space for mobility support such as wheelchairs, frames and crutches, including turning circles and storage.

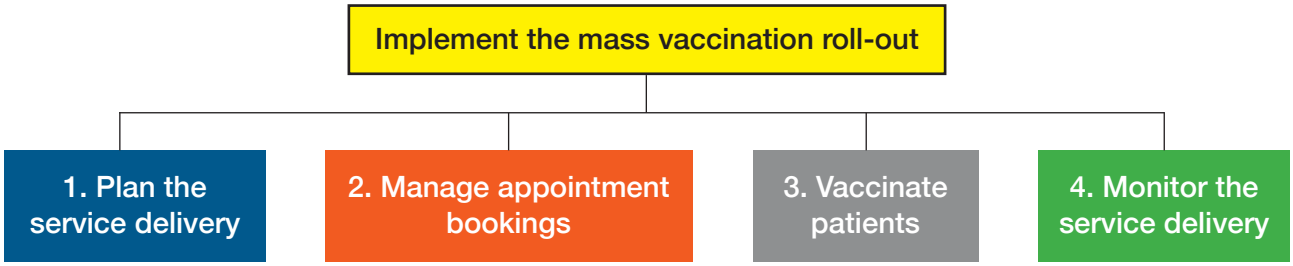
Post-vaccination area:

- This should be physically separate from the vaccination area in order to improve flows while maintaining social distancing.
- It should include seating and standing options to accommodate different needs and preferences.
- The physical layout should make it clear and easy to exit the post-vaccination area safely, and this should be complemented by appropriate signage.

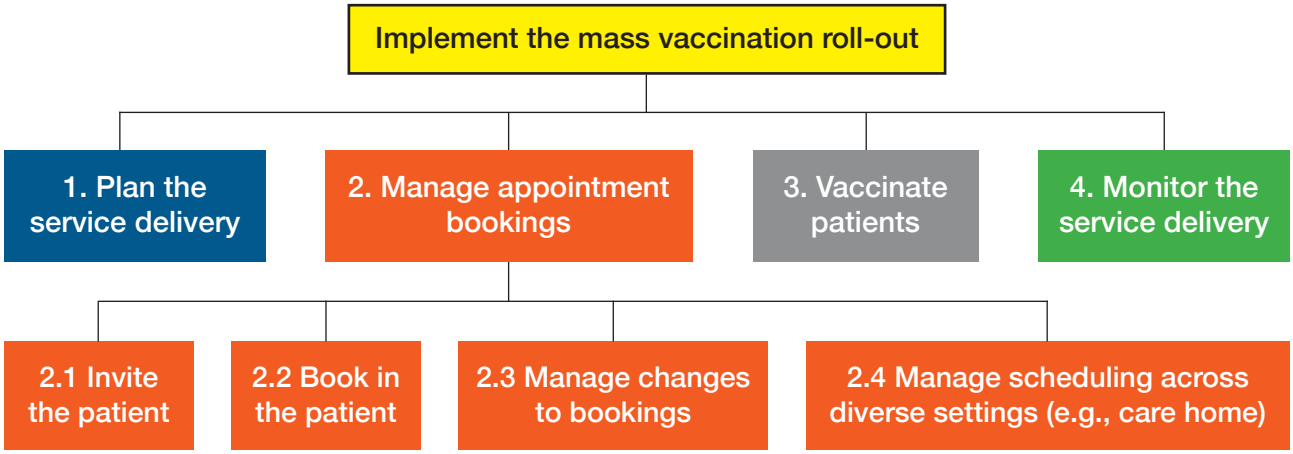
4. Describe the tasks people do

The HFE review of the vaccination programme entails the comparison of what people are supposed to do (work-as-imagined) with what they actually do (work-as-done). Work-as-imagined and work-as-done are not necessarily identical, and it is important to include in the analysis people who carry out the work in practice. In order to improve (clinical) work and help people achieve their aims, we need to understand what people's aims are, how they go about achieving these aims, and how the characteristics of the work system might influence this.

Finding the right level of granularity, or unit of analysis, can be challenging, but tasks can be broken down hierarchically to aid the analysis. In the case of the vaccination centre, a high-level task description might be:



Each of these tasks can be broken down further up to the point where they are well understood. For example, managing appointment bookings might entail:



Having such task inventories will be useful to enable reflection on potential process vulnerabilities, factors in the work system that can affect task performance, and the type of training and support that people might need.

5. Evaluate potential vulnerabilities

Once tasks have been described in a structured way, it is possible to assess systematically potential vulnerabilities and risks[3]. An easy-to-use approach is to consider each task step in turn and pose a range of questions or challenges:

- In what way might this step fail?
- If this step were to fail in this way, what would be the impact?
- How likely is it that this step fails?
- What in the work system makes this step more likely or less likely to fail?
- What safeguards do we already have in place to protect against the consequences of this failure?

In this way, the multi-professional team can build an awareness of potential sources of vulnerability and act before an incident happens.

Vulnerabilities can occur during any task step, for example for managing appointment bookings potential failures might include:

- Wrong patients invited (e.g., non-priority group or patient with active COVID infection in recent past) or patient not invited.
- Patient not booked in or patient booked in for the wrong date/time.
- Changes to booking not recorded or wrong date/time recorded.
- Consent from care home resident not collected at the appropriate time.
- Patient booked into the wrong location (e.g. high-priority patient who is unable to travel might need home vaccination rather than being booked into a vaccination centre).

[3]A generic framework for supporting hospital risk assessment can be found here: https://academic.oup.com/intqhc/article/31/5/393/5089196

IMPROVE

Once we have understood the specifics of the work system including the requirements of different people, and the strengths and weaknesses of the current setup, we can consider how to improve it, for example through re-design, by developing usable and useful work instructions, and by providing suitable training[4].

6. Re-design physical spaces, tools and tasks to enhance performance and reduce risk

The analysis of potential vulnerabilities can highlight weaknesses in the work system and the current setup. This is an excellent starting point for improvement before people are harmed. Often, ideas for improvement to specific issues can be found in the experience of others or in the published literature, or staff might have suggestions based on their prior experience (e.g. during the seasonal flu vaccination periods).

Improvements should be developed with people who are involved in the process and those who will be affected (e.g., healthcare workers administering vaccines and patients). Improvements could target all aspects of the work system, including:

- **Re-design of equipment or use of different equipment.**
- **Changes to the task.**
- **Provision of further training to people.**
- **Changes to the physical work environment.**

Consider these examples:

- **If patients do not receive information prior to their appointment, they will take longer during the consent process – consider starting the consent process when the booking is made (task).**
- **If vaccinators have to be standing for extended periods of time, they are likely to experience physical and mental fatigue, and their task performance will be affected – provide adequate recovery time and suitable spaces for staff (people, organisation, physical spaces). The Canadian Centre for Occupational Health and Safety provides guidance on working in a standing position[5].**
- **If staff arrive at different times because there is no traditional shift system, there is the potential for missing information during changeovers – consider the use of written handover checklists and summary sheets, and / or voice recorded handover messages (tools and equipment, task, people).**

[4]The Royal Academy of Engineering published a report on "Engineering better care", which contains additional useful tips: https://www.raeng.org.uk/publications/reports/engineering-better-care

[5]https://www.ccohs.ca/oshanswers/ergonomics/standing/standing_basic.html

7. Develop usable work instructions

Designing work instructions can be difficult, because a trade-off needs to be struck between completeness and usability. It is unrealistic to expect people to read a lengthy document during time-critical periods. It is useful to distinguish between different purposes of documentation and then design different types of work instructions, job aids and procedures. A work instruction should be a step-by-step description of how to do a task. A job aid can be designed to support specific aspects of a task, for example a particularly critical step or a step where calculations need to be done or which can be demanding on memory. A formal procedure tends to be a more comprehensive document for governance purposes.

CIEHF has issued guidance on developing work instructions[6]. The development of work instructions and job aids should be based on the preceding analysis of tasks. The hierarchical breakdown of a task as part of the analysis can provide the structure for a work instruction. The analysis of vulnerabilities and risks can, in turn, highlight critical steps where a job aid might be helpful. Work instructions and job aids should be developed in collaboration with the people who are doing the work.

The level of technical detail of work instructions and job aids should be proportionate to the level of experience of people and the complexity and risk profile of the task. Layout, presentation and usability aspects are as important as the technical content. Work instructions and job aids should be consistent and should be formulated in a way that is accessible to people.

Work instructions and job aids might be particularly important in vaccination centres, where staff are still familiarising themselves with tasks and ways of working. Some staff might be volunteers with little prior experience. This needs to be reflected in the work instructions and job aids.

Some useful tips to consider include:

- **Work instructions should describe the task step-by-step.**
- **High-risk task steps should be clearly marked in the work instruction and a rationale should be provided.**
- **Job aids should be designed for critical task steps.**
- **Signs and displays need to consider visual impairments and use of PPE that might hinder vision.**
- **Signs and displays should be meaningful and usable.**
- **Use text that is easily understood and in plain language.**
- **Use text and images to reinforce messages.**
- **Encourage staff to speak up and seek advice or support if they feel concerned about any of the arrangements or ways of working documented in the work instructions.**

[6] https://www.ergonomics.org.uk/common/Uploaded%20files/Publications/CIEHF-guidance-on-human-centred-design-of-work-procedures-document.pdf

8. Design and deliver suitable training

Training aims to build competence and confidence, which are especially important when people are put into novel contexts and where they have to undertake tasks that are unfamiliar to them. Critical tasks should include both formal training as well as supervised on-the-job training opportunities. Owing to potentially high turnover of staff and people wearing PPE, it could be helpful to include name badges and role designations to enable quick identification of experienced staff who can provide support and guidance. Ideally, the training and the resulting learning are experiential rather than simply the transfer of information from mentor (or online course developer) to trainee. Good design of work systems can contribute to reducing training needs, but people will still need to understand the risks associated with a task, the critical steps that are involved, and how to properly use equipment, especially during non-routine situations. Training requirements are minimised through good user-centred design principles.

Role play and simulations have proven to be useful forms of work-based training (this is also supported by suggestions by bodies such as Public Health England on COVID-19 vaccinator training recommendations[7]). Relevant operational scenarios need to be identified, such as booking in patient appointments, preparing vaccines and administering the vaccine. Training should include critical task steps and should be accompanied by explanation of why these steps are critical. It is also helpful to highlight the impact of performance shaping factors, such as interruptions, distractions and fatigue.

With the anticipated skill-mix and diverse range of prior experience of staff, adequate training for all staff is absolutely essential. This is not only to ensure patient safety, but also to lessen anxiety and stress of staff.

[7] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/942261/Training_for_COVID-19_vaccinators_Appendix_A.pdf

ADAPT

While we can build on previous experiences with delivering vaccinations, the challenges posed by the COVID-19 vaccination are novel (e.g., maintaining social distancing), and it is likely that processes and systems need to be adapted in an agile fashion. It is important that we learn from necessary adaptations that help make the process work as well as from any failures and incidents.

9. Monitor work-as-done and adapt to achieve sustainable change

The scale of the challenge of national vaccination programmes, and the development of new vaccines along with the threat of new variants of the virus mean that health systems require a very adaptive and agile approach to learn and to implement change in order to vaccinate the population safely and efficiently. It is unlikely, and probably unhelpful, that every step of the process can be planned in advance. As circumstances change, the way we work needs to change. Staff usually find good solutions to everyday challenges, and these need to be documented so that lessons are not lost.

CIEHF has developed guidance to support organisations in learning from COVID-19. This guidance on Achieving Sustainable Change[8] frames organisational learning in terms of the mindset with which we approach it, and then in terms of the actions or the process to implement it. The mindset – or learning structure – is about how an organisation approaches organisational learning, e.g., what the learning goals are, who is involved in organisational learning, and what kinds of situations are the focus of learning. The action – or learning process – describes how organisational learning actually takes place in an organisation, or how it is carried out. The guidance puts emphasis on learning from everyday work (rather than just from incidents) in order to understand how workers adapt to situations and changes. It emphasises that workers should have an active role to play in organisational learning in order to ensure that learning is meaningfully related to practice.

[8] https://ergonomics.org.uk/Common/Uploaded%20files/Publications/Sustainable-Change/CIEHF-Achieving-Sustainable-Change.pdf

10. Record and learn from incidents

Even the best systems can fail and potentially cause harm to people. Organisations need to have mechanisms in place to identify such incidents quickly, and to implement changes that address any unacceptable risks.

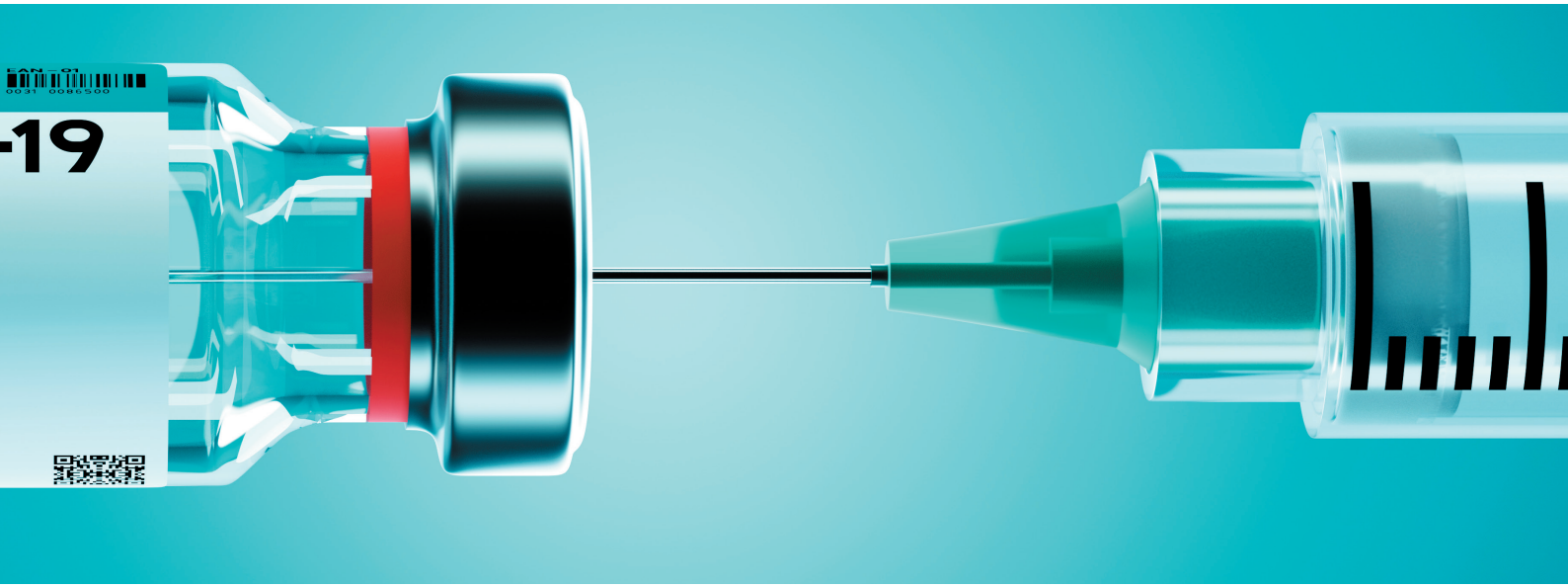
Learning from incidents is a well-established approach and practice in healthcare (as well as in other industries – see CIEHF guidance[9]). Procedures for incident reporting should be explained clearly to staff, and they should be easy to follow. In the UK, this might involve incident reporting systems such as Datix and the MHRA Yellow Card Scheme. There should also be procedures and systems in place to collect patient feedback and to respond to patient concerns or complaints.

Some of the potential incidents you might encounter include:

- **Wrong vaccination documentation.**
- **Vaccination given outside of expiry date.**
- **Wrong diluent used to mix vaccines.**
- **Dilution errors.**
- **Wrong components used to reconstitute vaccine.**
- **Wrong dosage.**
- **Duplication of vaccine administration.**
- **Adverse reaction to vaccine.**
- **Wrong vaccine recorded in documentation.**
- **Delay to the second dose of the vaccine.**

Making it work

This guidance offers 10 principles to support systems thinking in the setup and operation of vaccination programmes. HFE professionals are here to help. CIEHF can support you in connecting with suitably qualified human factors specialists (C.ErgHF).



[9] https://www.ergonomics.org.uk/common/Uploaded%20files/Publications/CIEHF-Learning-from-Adverse-Events.pdf

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